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FINAL REPORT - TASK I

CONTRACT NO. NSR 26-002-083

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MRI REPORT

BIOMEDICAL APPLICATIONS OF AEROSPACE-GENERATED TECHNOLOGY

FINAL REPORT - TASK I
1 June 1968 - 31 May 1969

Contract No. NSR 26-002-083

MRI Project No. 3217-E (A)

For

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

MIDWEST RESEARCH INSTITUTE 425 VOLKER BOULEVARD, KANSAS CITY, MISSOURI 64110 • AREA 816 561-0202

BIOMEDICAL APPLICATIONS OF AEROSPACE-GENERATED TECHNOLOGY

by

David Bendersky
Wilbur E. Goll
Donald E. Roberson

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PREFACE

This report covers the activities of the Midwest Research Institute's Biomedical Application Team (MRI BA Team) during the period 1 June 1968 to 31 May 1969. These activities were conducted under Article I.A through I.F of the Schedule of NASA Contract No. NSR 26-002-083, and constitute Task I of the three-task technical program. The results of Tasks II and III (Aritcle I.G.1 and Article I.G.2, respectively, of the Schedule) will be reported in separate final reports upon their completion.

The technical monitors were Richard J. H. Barnes and James T. Richards, Jr., NASA Technology Utilization Division. Dr. Quentin L. Hartwig, George Washington University, was the Project Coordinator for NASA.

The MRI BA Team was directed by David Bendersky, under the technical management of Paul C. Constant, Jr., Assistant Director of the Engineering Sciences Division and Manager of Technology Utilization. Other MRI technical staff members who contributed to this project are Wilbur E. Goll, Donald E. Roberson, Edward T. Fago, Jr., and James K. West.

The biomedical consultants at the participating medical institutions were Dr. John W. Trank, University of Kansas Medical Center; Dr. William G. Kubicek, University of Minnesota Medical School; Drs. Rick Heber, Robert H. Schwarz, University of Wisconsin; Blair A. Rowley, University of Missouri; and Dr. Marshal P. Reich, Fitzsimons General Hospital.

The very important contributions of the biomedical investigators at the participating medical institutions, whose names are given in connection with each biomedical problem, are gratefully acknowledged.

Approved:

MIDWEST RESEARCH INSTITUTE

Harold L. Stout

Harold L. Stout, Director
Engineering Sciences Division

9 June 1969

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SUMMARY

During the period from 1 June 1968 to 31 May 1969, the Biomedical Applications Team at Midwest Research Institute pursued 70 biomedical problems submitted by five medical institutions. Thirty-six of these problems were carried over from the previous contract period* and 34 of the problems were submitted during this period. As a result of the MRI BA Team's activities, technology which appears to be applicable to the solution of 30 biomedical problems were identified. The identified technology has been successfully used by the biomedical researchers in 10 cases, and there are 20 potential transfers of technology which are in various stages of evaluation.

Members of the MRI BA Team made 18 trips (not counting local trips) to attend meetings in connection with the project activities. Three quarterly reports, two special reports, two papers and four talks were prepared covering the activities of the MRI BA Team. Seventeen requests for general information on the Biomedical Applications Program and 29 requests for specific items were received and answered.

* Contract No. NASr-63(13), 1 May 1967-31 May 1968.

I. INTRODUCTION

The U. S. space program has generated a vast amount of new technology. There are now about 500,000 aerospace related technical documents which have been assembled by NASA and this bank of technical information is growing at a rate of about 70,000 documents per year. The application of this storehouse of new technology by the nonaerospace community is being encouraged and assisted through the multifaceted efforts of the NASA Technology Utilization Office.

One facet of the NASA Technology Utilization Office program is the Biomedical Applications Team Program. The purpose of the Biomedical Applications Team Program is to encourage and assist in the application of aerospace technology to the biomedical field. The first* Biomedical Applications Team was established at Midwest Research Institute (MRI) in 1965. The MRI Biomedical Applications Team is a multidiscipline group consisting of biologists, electrical engineers, mechanical engineers, and physiologists.

The operating procedure being used by the MRI BA Team consists of five basic steps. The first step is to define specific biomedical problems. The problems are obtained from the research staffs at participating medical institutions. The second step is to identify potential solutions to the problems. The identification of potential solutions is accomplished through computerized and manual literature searches, circulation of problem's abstracts to NASA research centers and aerospace contractors, and personal contacts. The third step is to modify the original technology, when required, to adapt it to the specific problem. The fourth step is the evaluation of the technology by the biomedical researcher. The final step is to document and disseminate information on successful technology transfers.

The following medical institutions were served by the MRI Biomedical Applications Team during the period covered by this report: University of Kansas Medical Center, Kansas City, Kansas; University of Missouri Medical School, Columbia, Missouri; University of Minnesota, Minneapolis, Minnesota; University of Wisconsin, Madison, Wisconsin; and the Fitzsimons Army Hospital, Denver, Colorado. The number of institutions served by the MRI BA Team during this contract was purposely kept small in order to concentrate the efforts of the Team.

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* Two additional BA Teams are located at the Research Triangle Institute, Durham, North Carolina, and Southwest Research Institute, San Antonio, Texas.

II. ACTIVITIES ON BIOMEDICAL PROBLEMS

A. Problems For Which Solutions Were Found

Problem No.: MU-8

Title: X-ray Photograph Enhancement

Researcher: Dr. Peter L. Reichertz and Dr. Samuel Dwyer, III; University of Missouri

Date Problem Submitted: December 1967

PROBLEM DESCRIPTION

Dr. Reichertz is engaged in an investigation of equipment and computer techniques to eliminate noise, correct distortions and enhance contrast in x-ray photographs. The ultimate goal of the program is to provide enhanced radiographs and computer processing of radiographs for diagnosis. Dr. Dwyer is in charge of assembling and constructing the hardware, and writing the software to implement the enhancement process.

ACTION TAKEN

A solution for this problem was found during the last contract period, namely the Jet Propulsion Laboratory system for enhancing space probe photographs.[1] During the present contract period, Dr. Dwyer began development of a similar system at Missouri University.

Four additional documents,[2,5] relating to enhancement techniques, were sent to Dr. Reichertz for evaluation.

RESULTS

Dr. Dwyer constructed equipment to scan, digitize, store and reconstruct the radiographic image based on the NASA JPL system. Software for the enhancement process is presently being written. Dr. Reichertz stated that the report on the NASA Spatial filtering technique,[3] "might be a very important tool in reprocessing data for computer analysis." The radiographic image amplifier described in Reference 20 was only remotely related to his research program. The documents discussing pseudo-color processing[4] and facsimile video enhancement[5] were of no use.

Problem No.: MU-19

Title: Simultaneous Electrocardiograph Measurements

Researcher: David A. Douglas, Missouri Regional Medical Program; University of Missouri

Date Problem Submitted: June 1968

PROBLEM DESCRIPTION

The conventional procedure for obtaining electrocardiograms from multiple sets of electrodes is to multiplex the signals, so that the electrocardiogram from each electrode is not continuous. For multiphase testing, wherein a number of physiological functions are monitored at the same time, it is desirable to record six electrocardiograms simultaneously. There is some concern as to whether electrocardiograms collected simultaneously are comparable with electrocardiograms collected by multiplexing.

ACTION TAKEN

Two literature searches of aerospace literature were conducted. The first search was too narrow, so it was rerun using a more general strategy. As a result of a suggestion from the RTI BA Team, Mr. Douglas was informed of research being conducted by a Dr. Boineau of Duke Medical Center on multichannel electrocardiograms.

RESULTS

Mr. Douglas reported that the literature search was "comprehensive and excellent." He ordered nine cited reports. One report described a technique for triggering a cardiotachometer, with which he plans to experiment.[26] A report on magnetocardiograms is pertinent to his problem.[27] The other reports were not applicable.

The information obtained from Dr. Boineau was very helpful. Upon consulting with Dr. Boineau, Mr. Douglas decided to proceed with multiple recording of electrocardiograms without fear of signal degradation. The research project is continuing successfully as a result of the information obtained from Dr. Boineau.

* * * * *

Problem No.: MU-20

Title: Biotelemetry

Researcher: Blair A. Rowley, Missouri Regional Medical Program; University of Missouri

Date Problem Submitted: June 1968

PROBLEM DESCRIPTION

Researchers in the Missouri Regional Medical Program have a general interest in biotelemetry equipment for a wide variety of potential applications. Blair B. Rowley, Research Associate, requested technical information on a subminiature biotelemetry unit developed at the NASA Ames Research Center, Moffet Field, California. A NASA Tech Brief, B64-10171,[8] describes the unit.

ACTION TAKEN

After submitting the problem to the MRI BA Team, Mr. Rowley requested information directly from the Technology Utilization Office at the Ames Research Center. The ARC TU Office furnished details for construction of the telemetry unit.

RESULTS

The biotelemetry unit was constructed for use in research for the Missouri Regional Medical Program.

* * * * *

Problem No.: MU-22

Title: Heart Pump Drive Speed Reducer

Researcher: Alan H. Purdy, Missouri Regional Medical Program; University of Missouri

Date Problem Submitted: February 1969

PROBLEM DESCRIPTION

To operate an artificial implanted heart, the investigator proposes that the energy source be located outside of the body, and that energy be transmitted through the intact tissue wall to the pump drive as electromagnetic energy. To effectively use the energy, a high speed electric motor would be used as the prime mover. A speed reducer is required to operate the pump at the normal heart rate.

The speed reducer requirements are as follows: 250 to 1 speed reduction, 90% efficiency, 110 in-oz of torque power transfer, and a life of 54×10^6 revolutions at the output.

ACTION TAKEN

A computer search of the aerospace literature revealed 15 citations. However, none of the citations was useful. Mr. Purdy suggested that a search of helicopter transmission mechanisms and lubricants might uncover applicable technology. A manual search revealed seven reports; he requested four,[33-36] which were sent to him. A copy of "Solid Lubricants," NASA SP-5059,[37] was also sent. A paper published by the NATO Advisory Group for Aerospace Research and Development seemed to be very pertinent.[38] It discussed large gear reductions for turbine powered helicopters. A copy was sent to Mr. Purdy.

RESULTS

Mr. Purdy reported that the information contained in References 34 and 36 is directly applicable to the problem and would be recommended in specifications for lubrication of the gear train.

Mr. Purdy reported that the AGARD paper on helicopter transmissions was very good and served as a concise restatement of information he had already uncovered. He will use this paper as a reference in a report he is writing on the feasibility and design of power systems to operate an artificial implanted heart.

* * * * *

Problem No.: MU-28

Title: Digital Signal Enhancement Software

Researcher: Alan H. Purdy, University of Missouri

Date Problem Submitted: February 1969

PROBLEM DESCRIPTION

The investigator is recording biological signals by FM tape recording for later analysis. The signals contain low-frequency noise (base time drift) and high-frequency noise. Mr. Purdy is attempting to describe the data by analytical functions. To do this, the signals are converted to digital form and processed by digital computer to generate the analytical functions. Software is needed to preprocess (filter) the data, and apply curve-fitting and interpolation schemes.

ACTION TAKEN

A computer search of the aerospace literature was conducted to identify computer programs to filter or curve-fit digital data. The search cited 40 documents. Mr. Purdy requested 18, 14 of which have been sent to him for evaluation.[40-53] The COSMIC computer program service which listed three programs pertinent to this problem,[54-56] was reviewed. Abstracts of the programs were sent to Mr. Purdy.

RESULTS

The relevance of the literature search was very good. Most of the documents included a complete description of the technology and a program listing. Upon a preliminary examination of the 14 documents, Mr. Purdy reported that the information contained in the documents would most likely solve this problem. Mr. Purdy reported that he did not have the funds to purchase the COSMIC programs.

* * * * *

Problem No.: MU-33

Title: Lubrication for an Artificial Heart Pump Speed Reducer

Researcher: Alan H. Purdy, Missouri Regional Medical Program; University of Missouri

Date Problem Submitted: March 1969

PROBELM DESCRIPTION

This problem arose as a result of information supplied to Mr. Purdy for Problem No. MU-22, "Heart Pump Drive Speed Reducer." The investigator requires lifetime lubrication for a mechanical speed reducer to be employed in the pump drive of an artificial implanted heart. Lifetime is defined as 54 x 10^6 revolutions of the output shaft, where the pump speed (output) is 60 ppm and the speed reduction is 250:1.

ACTION TAKEN

Two documents sent the investigator for Problem No. MU-22 provided a solution to this problem.[33,36]

RESULTS

Mr. Purdy plans to recommend precoating of gear surfaces in his report on the design and feasibility of a power system for an artificial heart. Both documents will be used as references in this report. One document describes the results of precoating gear surfaces to extend gear life, and the performance of a typical synthetic five-centistoke base oil.[33] The second document discusses the use of solid lubricants in helicopter transmissions for emergency operation in the event of an oil failure.[36]

* * * * *

Problem No.: UW-1

Title: Delivery of Medication to the Respiratory Tract

Researcher: Arthur A. Siebens, M.D., Director, Rehabilitation Center; University of Wisconsin

Date Problem Submitted: December 1966

PROBLEM DESCRIPTION

The use of water and water soluble medications is a common treatment for infection of the airways, which occur in both normal and retarded children. The current method for introducing moisture and medication to the respiratory tract of children requires placing the child in a tent

containing airborne droplets. The disadvantage of this system is that the apparatus is bulky and the entire body of the child is subjected to the moist, medicated atmosphere.

ACTION TAKEN

The BA Team conducted two computerized searches of the NASA literature. Because none of the information was found to be relevant to the problem requirements, a system for delivering water and medication to the respiratory tract was conceived by a member of the MRI BA Team as a result of earlier work done on a respirometer helmet system.[135] The basic components of the system consist of a vaporizor, a helmet, and a suction pump. The vapors generated by the vaporizor are drawn through the helmet by the suction pump and discharged. There is no problem of rebreathing because fresh air is continually drawn into the helmet along with the vapors and the exhaled breath is continuously removed from the helmet by the suction pump. A description of the proposed system was submitted to Dr. Siebens for evaluation.

RESULTS

The first search produced only one citation and the second search produced 17 citations with one document being requested for evaluation. Clinical evaluation on a limited number of patients indicated that the system suggested by the MRI BA Team worked satisfactorily. A face mask was substituted for the helmet, due to obscured vision caused by the medicated vapors condensing on the transparent face plate and because some medicants caused irritation of the patient's eyes. Dr. Siebens plans to use the system on a large group of clinical patients.

* * * * *

Problem No.: UW-5

Title: Learning Research Apparatus

Researcher: Rich Heber, Ph.D., Director, Center on Behavioral Disabilities; Universtiy of Wisconsin

Date Problem Submitted: August 1967

PROBLEM DESCRIPTION

There is a need for a functionally flexible apparatus for research on visual learning, memory and other performance characteristics of mentally retarded children. Questions, in the form of visual stimuli, are to be presented on a viewing screen in a variety of preselected arrangements. Multiple choice answers are simultaneously presented and the child will respond by pushing an appropriate button. The child's response is to be automatically recorded. The apparatus must be quiet, easily operated, compact and lightweight so that it can be readily transported.

ACTION TAKEN

A computer search of the NASA literature was made. However, no apparatus was found which would meet the requirements specified by the medical investigator, the major deficiency being the lack of flexibility.

Due to the negative results of the literature search, a design of an appropriate learning research apparatus was conceived by the MRI BA Team. The questions and answers are presented on a ground glass screen, using a film projection system. The film is in strip form, with a code on each frame to indicate the correct answer. Up to 128 separate problems can be presented with each question. There are visual and auditory signals given to indicate to the child whether his answer is correct or incorrect. The responses of the child, including the time it took for the response, are automatically recorded for later analyses.

RESULTS

A search of the aerospace and other literature sources provided the background information which led to the design of appropriate learning research apparatus. Dr. Heber has submitted a proposal to the Social Rehabilitation Service of the Department of Health, Education and Welfare for funds to proceed with development of the learning machine proposed by the MRI BA Team. This problem is considered to be a partial transfer, but is currently inactive pending the availability of funds.

* * * * *

Problems Nos.: UW-10 and UW-11

Title: Temperature Telemetry for Internal Organs

Researcher: Dr. R. K. Meyer, Department of Zoology; University of Wisconsin

Date Problem Submitted: August 1967

PROBLEM DESCRIPTION

Dr. Meyer is doing endocrinology research on monkeys. In connection with this work there is a need for an instrument which can be used to measure and telemeter the temperatures of internal organs and body cavities in the monkey. The instrument must be able to detect temperature changes as small as 0.02°F, and must remain operative inside the animal for several months without adverse reaction to the animal.

ACTION TAKEN

A computer search of NASA literature indicated that a temperature telemetry system developed at the NASA Ames Research Center,[138] and subsequently commercialized by Electro-Optical Systems,[139] was a solution for this problem.

The MRI BA Team contacted the Technology Utilization Officer at the Ames Research Center and through him obtained additional information on the temperature telemetry system. The information was forwarded to Dr. Meyer by the MRI BA Team.

RESULTS

One of the telemetry units has been implanted in an ovariectomized monkey since May 1968, with no apparent tissue reaction. Considerable data have already been accumulated on diurnal temperature changes in response to a controlled light/dark (day/night) environment. Some temperature changes due to drug reactions have also been noted. The second unit is still being tested *in vitro* and will soon be implanted in a monkey having a normal menstrual cycle.

* * * * *

Problem No.: UW-17

Title: Rotary Joint for Small Cannulas

Researcher: B. D. Huneycutt, Center on Behavioral Disabilities; University of Wisconsin

Date Problem Submitted: August 1967

PROBLEM DESCRIPTION

In tests on animals, small tubes are attached to the animal for introducing various liquids to the circulatory system. The animal is permitted to move around while the liquids are introduced through the flexible tubing from an overhead container. Since the animal moves about and the container is stationary, twisting of the tubing occurs which obstructs the liquid flow. A rotary joint is required which will avoid twisting of the tubing. The investigator had been unable to locate an appropriate rotary joint for this application.

ACTION TAKEN

A computer search of NASA literature had not revealed any reports related to small rotary joints. A review of the commercial literature turned up information on a cannula feed-through swivel[141] which appeared to be applicable to the problem. Mr. Huneycutt reported he was familiar with this particular swivel and it was not a satisfactory solution. Continued surveillance of literature sources finally produced information on a swivel[142] which appeared to be a solution to this problem.

RESULTS

As a result of the recent information[142] forwarded for evaluation, Mr. Huneycutt reports the swivel joint described in this document appears to be a solution to his problem.

* * * * *

B. Problems For Which Potential Solutions Were Found

Problem No.: MU-9

Title: Electrocardiogram Electrodes

Researcher: Dr. Peter L. Reichertz, Director, Radiology Computer Research, Missouri Regional Medical Program; University of Missouri

Date Problem Submitted: December 1967

PROBLEM DESCRIPTION

Small electrodes are needed for electrocardiograms which are satisfactory for comparatively long periods, are not affected by movements of the patient and must not cause bedsores even when attached to the back of a motionless lying patient. These electrodes are needed for hospital coronary care units and are to be connected to a central computer network.

ACTION TAKEN

During the past contract period the NASA developed spray-on electrodes[58] were offered as a potential solution. During the present period the MRI BA Team located two additional electrode systems as potential solutions. Information on both systems, one developed by NASA[6] and the other by the USAF School of Aerospace Medicine,[7] was obtained and sent to Dr. Reichertz.

RESULTS

The electrode system developed by NASA was used in the Mercury and Gemini projects. It consists of a small (2 sq. cm.) silver/silver chloride gelatine matrix imbedded in a methylmethacrylate housing, and a specially prepared electrode paste. Tests have shown that this electrode is remarkably free of artifact and provides a high quality signal. Information supplied by the Manned Spacecraft Center on dermatological and microbiological tests indicate that the paste and electrode are nonirritating and cause insignificant microbial proliferation during 14-day periods.

The USAF School of Aerospace Medicine electrode is an insulated pasteless electrode for use in recording ECG's. The electrode is held in place by a circumferential elastic band, and requires no skin preparation even in the presence of hair. It is purposely electrically insulated from the skin so that the signal pickup is by capacitance coupling. A field effect transistor is built into the electrode to unload the higher input impedance. With no jelly or adhesive being used, skin irritation is minimal.

Dr. Reichertz reported that both electrodes may be satisfactory for long-term monitoring.

* * * * *

Problem No.: MU-11

Title: Tracking of Large Animals

Researcher: Vince W. Zager, University of Missouri

Date Problem Submitted: December 1967

PROBLEM DESCRIPTION

A method is needed for tracking and locating large animals by radio transmission signals. The transmission distance should be up to five miles; power source life should be several years.

ACTION TAKEN

Blair Rowley, the MRI BA Team contact at the University of Missouri, requested technical information on a small telemetry unit developed at the NASA Ames Research Center.8/ The telemetry unit, located during a routine review of Tech Briefs, appeared to be a solution to this problem. Mr. Rowley sent the information to Mr. Zager.

RESULTS

Mr. Zager is evaluating the information.

Problem No.: MU-21

Title: Torso Position Effects on ECG

Researcher: Blair A. Rowley, Missouri Regional Medical Program, University of Missouri

Date Problem Submitted: July 1968

PROBLEM DESCRIPTION

Researchers at the Missouri Regional Medical Program are recording electrocardiograms from subjects sitting in a reclining chair. Mr. Rowley would like information on comparative measurements of human ECG's taken in the supine position to those taken in other positions.

ACTION TAKEN

A computer search of the aerospace literature revealed four pertinent documents, all in Italian.[28-31] Copies of these documents were obtained by the MRI BA Team and sent to Mr. Rowley. A manual search of other literature uncovered five articles which were also sent to him.

RESULTS

Mr. Rowley reported that the Italian documents appeared to be exactly what he needed. He is having them translated. He reported that an article[32] from the manual search may be useful, but that the others were not.

* * * * *

Problem No. MU-23

Title: Telemetry System to Implant in the Ovary Ducts of Small Animals

Researcher: Saul D. Larks, Ph.D., University of Missouri

Date Problem Submitted: February 1969

PROBLEM DESCRIPTION

It is desired to implant a small telemetry package in the ovary ducts of miniature pigs to measure cyclic changes which may occur. The package should contain transducers to measure pH, electrical potentials, pressure, and chemicals. Life span of the unit should be 60 to 90 days, being impervious to, and nonreactive with, the animal's fluids and body tissue.

ACTION TAKEN

A literature search of selected documents from previous computer searches and recent documents was sent to Dr. Larks. Two documents describing NASA developed telemetry units were also sent. One, a Tech Brief,[8] describes a subminiature transmitter suitable for biopotential measurements and operating for 48 days at a 10-ft. range. The other document includes specification sheets of commercial biotelemetry units[39] originally developed by NASA.

RESULTS

Dr. Larks is evaluating the information.

* * * * *

Problem No.: MU-31

Title: Glucose Electrode

Researcher: David M. Klachko, M.D., University of Missouri Medical Center

Date Problem Submitted: February 1969

PROBLEM DESCRIPTION

Continuous on-line monitoring of blood glucose is being performed on diabetes patients at the University of Missouri Medical Center, during both rest and exercise. Current methods of detecting glucose involve drawing a continuous blood sample, processing it chemically, and detecting a color change as an indicator. This technique involves problems such as, preventing clotting, maintaining constant anticoagulant concentration, time delays, and others. A small electrode that could be placed directly in the blood stream to detect glucose would eliminate these problems and simplify the measurement process.

ACTION TAKEN

An investigator at the University of Wisconsin, S.J. Updike, M.D., is developing such an electrode (see Problem No. UW-20). A copy of a paper by Dr. Updike[57] was sent by the MRI BA Team to Dr. Klachko.

RESULTS

Dr. Klachko reported that the electrode was not yet practical for *in vivo* use due to size and other restrictions. He plans to consult with Dr. Updike about the progress of Dr. Updike's research.

* * * * *

Problem No.: MU-35

Title: Medical Data Storage and Retrieval System

Researcher: Dr. Fred Clayton, University of Missouri

Date Problem Submitted: April 1969

PROBLEM DESCRIPTION

In connection with the Missouri Regional Medical Program, the investigator is working in the general area of automated medical data

storage and retrieval systems. Of special interest is the storage and retrieval of microfilmed documents and X-rays, diagnostic information, and pharmacology data. Dr. Clayton requested information on a NASA computer storage and retrieval system which he had seen written up in a trade journal.

ACTION TAKEN

Mr. David Bendersky, MRI BA Team Director, attended a demonstration of the NASA system at NASA headquarters in Washington. Information about the system was obtained from James Richards, NASA Technology Utilization Officer, and forwarded to Dr. Clayton. A contractor's report[59] was also obtained and sent to him.

Two additional documents describing similar systems were sent to Dr. Clayton.[60,61]

RESULTS

Dr. Clayton reported that the NASA system was very good, and that he was in the process of circulating the contractor's report among his associates. The system, developed by Lockheed Aircraft Corporation, Palo Alto Research Laboratory, is an on-line remote terminal and software allowing the user to perform literature searches of the NASA data bank. The user composes and modifies his search strategy at the terminal and receives the results displayed on a screen or printed on a line-printer.

* * * * *

Problem No.: KU-2

Title: Measurement of Oxygen and Carbon Dioxide Concentration in Air

Researcher: Dr. Ronald Lauer, Pediatric Cardiologist, Kansas University Medical Center

Date Problem Submitted: January 1966

PROBLEM DESCRIPTION

A rapid, continuous method for measuring oxygen consumption and carbon dioxide production during respiration is required. It is desirable to measure the breath-to-breath variations in these gases. The conventional apparatus used to analyze breath content are relatively slow in responding to changes and are, therefore, inadequate for this application.

ACTION TAKEN

Through the continuing routine search of aerospace literature, the MRI BA Team located three documents[62,63,64] describing respiration gas analyzers and sent these to Dr. Lauer. Reference 1, describing apparatus manufactured by the Perkin-Elmer Company, is supplemental information to NASA Tech Brief B67-10387 sent to Dr. Lauer during the 1967-1968 contract period.[58]

RESULTS

Dr. Lauer had reported[58] that he was trying to obtain a unit from the Perkin-Elmer Company. However, he has left the Kansas University Medical Center and the MRI BA Team does not know if he has obtained the apparatus.

Dr. Lauer reported that the equipment described in reference 64 is a good solution to his problem, but is too expensive. The apparatus uses a high temperature calcium-stabilized zirconium oxide cell to ionize the oxygen molecules. The emf generated by the cell indicates the partial pressure of oxygen within the cell with respect to a reference outside the cell. The output is not affected by water vapor or carbon dioxide. Dr. Lauer plans to fabricate one of these units for his application.

* * * * *

Problem No.: KU-32

Title: Oxygen Partial Pressure Monitor

Researcher: Dr. Robert F. Hustead, Department of Anesthesiology, Kansas University Medical Center

Date Problem Submitted: March 1969

PROBLEM DESCRIPTION

During surgical anesthesia, the expired air oxygen pressure is a good monitor of the patient's condition. What is needed is a monitor sensitive to oxygen partial pressure in the range 50 to 500 mm. Hg. It should be insensitive to nitrous oxides, carbon dioxide, and halogenated hydrocarbons. A readout of rate of change as well as actual values of oxygen pressure is required.

ACTION TAKEN

A computer search of aerospace literature covering technology in oxygen sensors and oxygen partial pressure was conducted and sent to Dr. Hustead for evaluation. In addition, two documents describing a zirconium oxide cell for making oxygen measurements were sent to him.[63,64] A third document[66] describing the effects of high oxygen tension was sent because he is also interested in oxygen tolerance levels in man.

RESULTS

The two documents describing oxygen sensors are potential solutions to this problem. One document[63] describes a fast-response oxygen analyzer capable of making rapid and continuous measurement of respiration gases. The research was performed at the Colorado University Medical Center under a contract with the Department of Army and HEW grants. The other document describes what appears to be a commercial version of the same instrument.[64]

Dr. Hustead has not yet completed his evaluation of this information.

* * * * *

Problem No.: KU-35

Title: Respiration Volume Flowmeter

Researcher: Dr. Robert F. Hustead, Department of Anesthesiology, Kansas University Medical Center

Date Problem Submitted: March 1969

PROBLEM DESCRIPTION

During surgical anesthesia it is essential that the respiratory state of the patient be under continuous observation. The patient is connected to a closed circuit anesthesia machine in which the machine gas flow directly represents patient flow. The anesthesia machine does not have its own flowmeter. A volume flowmeter sensitive to flows in the range of $\pm$ 5 liters/sec is needed to monitor the patient's respiration. The measurement must be independent of gas temperature, humidity, and gas composition, and should produce a pressure drop of no more than 1 to 2 cm. H_2O. Readouts of instantaneous flow, volume flow per breath, and volume per minute are desirable. Reliability and a minimum of attention during use are essential.

ACTION TAKEN

A search of NASA literature on flow measurement was conducted which yielded a large quantity of documents. Abstracts of documents on applicable technology were sent to Dr. Hustead to review.

The hot-wire anemometer flowmeter is a possible method of making flow and volume measurements for this problem. A document describing such an instrument[69] was sent to Dr. Hustead, also.

RESULTS

The investigator is reviewing the literature search. He is looking into the hot-wire anemometer technique although there are two potential drawbacks: (1) the explosive hazard of a hot-wire in a high oxygen atmosphere, and (2) the direction insensitivity of the measuring technique.

* * * * *

Problem No.: KU-36

Title: Arterial Blood Pressure Monitor

Researcher: Dr. Robert F. Hustead, Department of Anesthesiology, Kansas University Medical Center

Date Problem Submitted: March 1969

PROBLEM DESCRIPTION

During surgery only the patient's head is available to the anesthesiologist. A remote monitor of arterial blood pressure is needed to measure systolic, diastolic, and average pressure. The equipment must be attached to the patient before the final drape is applied and must remain functional without additional attention for periods up to 6 hr. Either direct arterial catheterization or auscultation is acceptable, but simplicity, reliability, and a minimum of attention to the equipment is essential.

ACTION TAKEN

Previous literature searches and the MRI BA Team file of aerospace technology were reviewed to locate applicable blood pressure instruments. Four documents describing applicable technology were sent to Dr. Hustead.

RESULTS

Dr. Hustead is reviewing this material. Three documents, which describe a diaphragm type capacitance transducer to measure intravascular pressures,[70,71,72] offer a partial solution to this problem. The transducer, called an "ultraminiature manometer-tipped cardiac catheter" was developed at the NASA Ames Research Center. The fourth document[73] may provide additional technology for the solution. This document describes a technique for computing blood flow from the aortic pressure pulse on a continuous stroke-by-stroke basis. Good correlation between the computer method and an indicator dilution technique was found on dogs. The research was conducted at the USAF School of Aerospace Medicine.

Problem No.: UM-17

Title: Foot Support Devices

Researcher: Professor John D. Allison, Department of Physical Medicine and Rehabilitation, University of Minnesota

Date Problem Submitted: March 1968

PROBLEM DESCRIPTION

Correction of certain foot disorders in children requires that inserts be placed in the patient's shoe to support the base structure in proper position during growth. Due to frequent changes required, because of the constant growth and corrective action taking place new inserts must be fabricated several times a year at a cost of approximately $50/pair. Professor Allison has had the desired inserts fabricated by an orthopedic appliance company, but their method involved considerable hand labor. It is desired that some material and/or fabrication technique be found to reduce the present costs.

ACTION TAKEN

A computer search of the NASA literature covered "composite" type materials. The investigator subsequently received four documents[86-89] for evaluation. Information on an electronic shoe fitting device[90] was also supplied for evaluation. A MRI staff member suggested the possibility of casting an insert directly in the patient's shoe in order to reduce the present fabrication cost of hand-formed inserts.

RESULTS

The information on composite materials was of interest to the investigator but did not reveal any techniques which would reduce the fabrication cost. Materials costs were already minimal. The electronic shoe fitting device was not suitable since it was used for measuring total length and metatarsal width. Professor Allison must obtain serial casts of the patient's foot in order to evaluate treatment results through changes in the boney and soft tissues of the foot. The suggestion to cast a foot support directly in shoe, while not applicable to children due to frequent

changes required, appears to be useful for older patients and will be further investigated.

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Problem No.: UM-21

Title: Bile Duct Valve

Researcher: Dr. Joseph T. Anderson, Laboratory of Physiological Hygiene, University of Minnesota

Date Problem Submitted: March 1968

PROBLEM DESCRIPTION

Dr. Anderson desires to take periodic samples of bile from a dog under varying conditions of diet and exercise. Present equipment is large and requires the use of control wires. A more satisfactory method would be the use of a surgically implanted valve which could be remotely actuated by a radio signal or a magnetic impulse.

ACTION TAKEN

A computer search of the NASA literature was performed along with a manual search of technical journals. A member of the BA Team conceived an idea involving the use of a special plug which could be surgically placed in the bile duct, near the intestine. A sketch of the proposed technique was forwarded to Dr. Anderson for evaluation as was a copy of the literature search.

RESULTS

The computer search did not produce any relevant information nor was anything located in the technical journals. The investigator has yet to evaluate the special plug proposed by the BA Team.

* * * * *

Problem No.: UM-28

Title: Electrical Sensor for Bacteria Detection

Researcher: Professor Grace Mary Ederer, Department of Laboratory Medicine, University of Minnesota

Date Problem Submitted: March 1968

PROBLEM DESCRIPTION

The mass screening of people for kidney infection now requires a laboratory technician to make a tedious and time consuming count of significant numbers of bacteria in a urine sample. Any technique which could quickly detect counts as low as 10^4 and 10^5 bacteria would greatly reduce the number of laboratory technicians now required to do the counting. Professor Ederer desires to make a clinical application of the aerospace methodology for monitoring the bacterial content of water supplies for spacecraft.

ACTION TAKEN

Results of a computer search of the aerospace literature were forwarded to investigator for evaluation. Information contained in documents reviewed by the investigator[116-117] indicated that work performed by Hazleton Laboratories[118] for Aerospace Medical Research Laboratories is applicable to this problem.

Past attempts to locate the Hazelton equipment were not successful. However, during a recent tour of the Life Detection Laboratory at the Goddard Space Flight Center, a member of the BA Team recognized the equipment which was developed by Hazleton for Wright-Patterson AFB. Additional reports[119-120] were obtained on similar work done by Hazleton for Goddard Space Flight Center and sent to Professor Ederer for evaluation.

RESULTS

The computer search did not produce any relevant information. However, in touring the Life Detection Laboratory, Goddard Flight Research Center, Dr. Norman MacLeod showed several bioluminescent detectors which

had application to Professor Ederer's work. The possibility of loaning one of these detectors was discussed. Professor Ederer contacted Dr. MacLeod and learned that due to the nature of the equipment, it would not be possible to ship one to her for use. She has since learned that DuPont now has a "Biometer" which may be available on a loan basis. The equipment costs some $6,000 but the project cannot support such equipment costs. Professor Ederer reported that the documents supplied here contained much useful information, including construction information,[119] but fabrication costs prevented her from building her own equipment at this time.

* * * * *

Problem No.: UM-30

Title: Detection and Correction of Heart Rhythm

Researcher: Carl S. Alexander, M.D., Chief, Cardiovascular Section, University of Minnesota

Date Problem Submitted: March 1968

PROBLEM DESCRIPTION

There is need for an implantable device that would detect ventricular arrhythmias and automatically administer a DC shock to the heart that would stop the arrhythmia.

ACTION TAKEN

Copies of the abstract cards, identified by a computer search of the NASA data bank, were sent to Dr. Alexander for evaluation. Literature on a piece of commercial equipment[127] was sent along with three NASA Tech Briefs[128-130] and a NASA technical memorandum.[131] An article[132] on "Rhythm Analysis" was located by manual search and forwarded to Dr. Alexander for evaluation.

RESULTS

The computer search produced 57 citations but did not appear to contain a solution to the problem. The Tech Briefs and technical memorandum

appeared to contain relevant information as did the article on "Rhythm Analysis." The investigator has not yet given his evaluation of the information sent him.

* * * * *

Problem No.: UM-35

Title: Cool Suit for Metabolic Studies

Researcher: Dr. Henry L. Taylor, Laboratory of Physiological Hygiene, University of Minnesota

Date Problem Submitted: January 1969

PROBLEM DESCRIPTION

Dr. Taylor is engaged in the development of methods for evaluating the capacity of the cardiovascular system to provide an adequate oxygen supply to the heart during stress conditions. The reliable interpretation of electrocardiograms taken before and after stress requires precise control of the myocardial oxygen consumption, a condition which is not now available.

It is proposed to explore the problem by studying the relationship of skin temperature, as controlled by a "cool suit," to pulse rate and blood pressure under standardized conditions of work. It is expected that data will also be obtained, which will provide insights into the use of "cool suits" for the purpose of studying peripheral circulation. A follow-on course of investigation will involve the degree of cardiovascular stress produced by the effect of heating the subject via the heat exchange mechanism of the "cool suit."

ACTION TAKEN

A member of the BA Team, having prior knowledge of space suit technology, suggested that a water-cooled garment developed for NASA by United Aircraft Corporation[133] and commercialized by B. Welson and Company, Inc.[134] would be an appropriate solution to this problem. Several discussions were held with Dr. Taylor and technical literature was sent for

his evaluation. Also supplied, were instructions concerning the method to officially request loan of a water-cooled suit from the Manned Spacecraft Center at Houston, Texas.

RESULTS

The investigator found the information very relevant and plans to order a "cool suit" for use starting September 1969.

* * * * *

Problem No.: FH-1

Title: Bloodless Perfusion for Amputated Limbs

Researcher: Dr. Marshall P. Reich, Fitzsimons Army Hospital

Date Problem Submitted: September 12, 1968

DESCRIPTION OF PROBLEM

Dr. Reich is engaged in a research program on limb implantation. The ultimate goal of this research is to develop techniques for grafting human arms and legs to soldiers who have lost limbs in combat. At the present stage of the research, amputated dogs' limbs are being kept in a hyperbaric chamber prior to implantation to determine the ability to store amputated limbs. During the storage of the limb in the hyperbaric chamber, a mixture of blood and dextrin solution is continuously circulated through the vascular system to assist in keeping the limb viable. It is desired to avoid the use of blood in the perfusate because of problems associated with the artificial circulation of blood, such as deterioration of the red cells. A bloodless perfusate which will be capable of keeping the amputated limb viable is desired.

ACTION TAKEN

Two computerized searches of the literature on bloodless perfusates were conducted, one of the NASA tapes and the other through the MEDLARS service of the National Library of Medicine. A total of 651 citations were revealed in the MEDLARS literature search. The results of this literature

search were sent to Dr. Reich for his evaluation. No pertinent reports were found in the NASA literature.

RESULTS

Dr. Reich reported that the literature search was extremely comprehensive. Although he had previously reviewed many of the references, 12 articles containing information pertinent to the problem were revealed which he had not previously been aware of.

* * * * *

Problem No.: FH-3

Title: Determination of Nerve Viability

Researcher: Dr. Marshall P. Reich, Fitzsimons Army Hospital

Date Problem Submitted: September 12, 1968

PROBLEM DESCRIPTION

A reliable technique is needed to determine the viability of nerves in an amputated limb. At the present, the viability of the nerves in the limb is determined by observing the actions of the limb after implantation. If a reliable method was available for determining the viability of the nerves in the amputated limb prior to reimplantation it would avoid the work required for implantation of a limb in which the nerves were not viable.

ACTION TAKEN

A computerized search of the NASA literature bank was made, and the results were forwarded to Dr. Reich for evaluation.

RESULTS

Dr. Reich reported that three of the reports revealed in the NASA literature search were pertinent to the problem. One report[166]

describes research done at the Kobe University School of Medicine on the viability of a cat's brain frozen for 777 days. A Russian report[167] contains a survey of the literature devoted to a special study of the development of somatic musculature innervation. Another Russian report[168] describes research done on dogs to determine the effect of pressure changes on hypoxia.

* * * * *

Problem No.: FH-4 and FH-5

Title: Continuous Measurement of Perfusate pH, PO_2 and PCO_2

Researcher: Dr. Marshall P. Reich, Fitzsimons Army Hospital

Date Problem Submitted: September 12, 1968

PROBLEM DESCRIPTION

In his work on limb preservation, Dr. Reich circulates a mixture of blood and dextrin solution through the amputated limb to help keep it viable. The pH of the perfusate is monitored and automatically maintained at a preset level. In addition to monitoring the pH, it is desired to continuously monitor the oxygen content (PO_2) and the carbon dioxide content (PCO_2) of the perfusate. Furthermore, the PH, the PO_2 and PCO_2 in the limb tissues is of interest.

ACTION TAKEN

A search of the NASA literature bank was made and the results were sent to Dr. Reich. Information on a commercial PO_2 and PCO_2 analyzer* was obtained and forwarded to Dr. Reich.

RESULTS

The search of the NASA literature revealed 44 documents. Dr. Reich reported that most of these documents were quite relevant to his

* Medical Mass Spectrometer, Scientific Research Instrument Corp., Baltimore, Maryland.

problem. The medical mass spectrometer manufactured by the Scientific Research Corporation appears to be capable of solving this problem.

* * * * *

C. Other Problem Activities

Problem No.: MU-12

Title: Cardiac Output Measurement

Researcher: Peter L. Reichertz, M.D., and Richard H. Martin, M.D., University of Missouri

Date Problem Submitted: December 1967

PROBLEM DESCRIPTION

A method is needed to evaluate the amount of blood being pumped by the heart from peripheral measurements. Measurements are to be made on critically ill patients where catheterization or dye-injection methods are not acceptable.

ACTION TAKEN

Through a routine search of aerospace literature, the MRI BA Team located a document on a NASA supported study of the vibrocardiogram technique,[9] and sent it to Dr. Reichertz.

Dr. Martin, who is interested in the impedance cardiograph method of measuring cardiac output, was sent two documents[10,11] describing the work of Dr. W. G. Kubicek at the University of Minnesota.

RESULTS

The vibrocardiogram research was conducted at Cedars-Sinai Medical Research Institute, Los Angeles, California, and supported by NASA. The research examined the relationship between heart stroke volume

measured by the standard dye dilution technique and ventricular contraction and ejection time as measured by the vibrocardiogram (taken with a capacitance microphone placed on the chest). From data taken on 21 subjects, it was concluded that the vibrocardiogram provides a simple, nontraumatic method for the estimation of stroke volume. Dr. Reichertz reported that the vibrocardiogram technique seems to be a valuable method, but that clinical experimentation would have to confirm the results.

Dr. Martin has not reviewed the documents on impedance cardiograph. He has acquired new duties at the University of Missouri Medical Center and is no longer able to pursue his research programs.

Dr. Reichertz is also no longer interested in the problem. The problem was closed.

* * * * *

Problem No.: MU-13

Title: Pulmonary and Metabolic Measurement Instrumentation

Researcher: David W. Douglas, Missouri Regional Medical Program, University of Missouri

Date Problem Submitted: December 1967

PROBLEM DESCRIPTION

In connection with the Federal Regional Medical Program at the University of Missouri, there is a need for instrumentation for obtaining pulmonary function and metabolic data in mass screening. Present instrumentation is not satisfactory for mass screening, because of its slow response and lack of flexibility.

ACTION TAKEN

During the previous contract period, a computer literature search was evaluated by Mr. Douglas from which he requested 11 of the citations.

Through the continuing review of aerospace literature by the MRI BA Team, two documents were identified as potential solutions and sent to Mr. Douglas.

RESULTS

A potential solution is a zirconium oxide fuel cell oxygen analyzer[63] developed at the University of Colorado Medical Center. Very fast response (30 msec) makes this analyzer well suited for continuous on-line measurements where good resolution within a single breathing cycle is required. Mr. Douglas reported that this analyzer is "an excellent approach to a difficult task," and plans to use it in a respiratory quotient system (ratio of CO_2 produced to O_2 consumed). A commercial version of a similar unit is available from the Westinghouse Electric Corporation, known as a Pulmonary Function Oxygen Monitor, Model 211.[64] The unit will measure oxygen concentration within 0.5 percent accuracy on a breath-to-breath basis. The output reading is by a rectilinear recording strip chart. Sample flow rate is adjustable from 100 cc/min to approximately 400 cc/min. Mr. Douglas plans to arrange for a demonstration.

Because of the complexity and difficulty of this problem the research on this project has been dropped and the problem has been closed.

* * * * *

Problem No.: MU-14

Title: Storing of ECG Tracing Wave Form

Researcher: Charles Buck, University of Missouri

Date Problem Submitted: January 1968

PROBLEM DESCRIPTION

The investigator desires to store ECG wave forms in digital form for future retrieval and processing by digital computer. Because of storage capacity limitations it is necessary to condense a 5 sec. segment of the ECG signal to 100 characters of hexadecimal information.

ACTION TAKEN

Four documents were sent by the MRI BA Team to Mr. Buck which contains pertinent information on data compression, mathematical methods of data reduction, and analog-to-digital conversion.[12-15]

RESULTS

The investigator reported that the information was helpful, but that the project was several months from the stage during which the technology could be used. He has expressed no further interest in the problem. The problem was closed.

* * * * *

Problem No.: MU-18

Title: Blood Pressure Measurement During Exercise

Researcher: Jack M. Martt, M.D., Heart Station, University of Missouri Medical Center

Date Problem Submitted: February 1968

PROBLEM DESCRIPTION

Dr. Martt is in need of a system for measuring indirect systemic blood pressure during exercise tolerance tests, wherein the subject is walking on a treadmill or riding a bicycle ergometer. Because of motion and noise, the present techniques for recording systemic blood pressure in patients undergoing exercise tests are very awkward and inaccurate.

ACTION TAKEN

Nine documents[16-24] were located through a computer search of NASA technology and sent to Dr. Martt. A report describing an indirect blood pressure sensing technique,[25] developed at Southwest Research Institute, San Antonio, Texas, was sent to Dr. Martt. He requested and

received a demonstration of the unit by Dr. Ray W. Ware from Southwest Research Institute.

RESULTS

One document[16] from the literature search described a blood pressure transducer for the temporal artery. The transducer, developed under a NASA contract at the Stanford Research Institute, is a possible solution. One design uses a differential transformer sensing element with a special mounting to reduce response to accelerations. Another design using a strain-gauge was extensively tested on experimental animals and compared with direct intra-arterial measurements. The readings correlated to within 3-5 percent.

Dr. Martt was favorably impressed by the demonstration of the SwRI apparatus and felt that clinical tests should be conducted. Several other researchers present at the demonstration, however, questioned the correlation between actual blood pressure and readings from this unit. The transducer is an acoustic device using the doppler principle to measure reflected energy, which may be related to systemic blood pressure. It was developed for aerospace vehicle and simulator use for the Aerospace Medical Research Laboratories, Wright-Patterson Air Force Base, Dayton, Ohio.

Dr. Martt is leaving the University this summer and has dropped his research programs. The problem was closed.

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Problem No.: MU-24

Title: Detecting Embryonic Movements

Researcher: Saul D. Larks, Ph.D., University of Missouri

Date Problem Submitted: February 1969

PROBLEM DESCRIPTION

The researcher desires to develop a method for detecting low level mechanical movements such as an embryonic heart beat from the out-

side surface of the maternal skin. Electrocardiograph recordings are currently obtained quite early but information about the mechanical activity of the heart is scarce.

RESULTS

This problem requires further definition.

* * * * *

Problem No.: MU-25

Title: Measurement of Human Heart Magnetic Fields

Researcher: Saul D. Larks, Ph.D., University of Missouri

Date Problem Submitted: February 1969

PROBLEM DESCRIPTION

The investigator would like to measure the magnetic field generated by the human heart to compare field variations with the standard electrocardiogram.

ACTION TAKEN

A computer literature search of the aerospace technology was conducted to locate applicable technology.

RESULTS

Only four citations resulted from the search. However, the documents dealt with the effects of magnetic fields on the heart, not the magnetic field produced by the heart.

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Problem No.: MU-27

Title: Remote Station Signaling

Researcher: Gail Bank, Executive Director, Continuing Medical Education, University of Missouri Medical Center

Date Problem Submitted: February 1969

PROBLEM DESCRIPTION

The investigator has a medical communications telephone network which is used for continuing education and medical problem solving. Normally, one point originates the program. At the end of the program questions are accepted from other points. At present, there is no method employed to electronically signal the originating point that one or more of the other points has a question. Hence, the system tends to become saturated with voice requests.

A method is needed for allowing many individual locations on a single voice grade telephone circuit to individually signal a main point. The signal must register in the presence of voice noise, regardless of the number of locations on the circuit.

RESULTS

This problem requires further definition.

* * * * *

Problem No.: MU-29

Title: Catheter Blockage Detector

Researcher: David M. Klachko, M.D., University of Missouri Medical Center

Date Problem Submitted: February 1969

PROBLEM DESCRIPTION

During continuous on-line monitoring of blood glucose, the catheter which draws the blood periodically blocks, interrupting the measurement. Because of the long line between the patient and the monitor, there is a considerable time lag (minutes) between the occurrence of a blockage and an indication at the output recorder. The blood sample is drawn at the rate of 10 ml/hr by a roller pump through 0.027 I.D. tubing. The present detector uses a manometer to measure pressure and a photocell to activate an alarm. A saltwater solution separating the blood from the manometer fluid tends to dilute the blood sample and contaminates the apparatus if a blockage is not relieved quickly. What is needed is a rapid method of detecting a blockage without diluting or contaminating the blood sample.

ACTION TAKEN

A member of the MRI BA Team has discussed this problem with Dr. Klachko in an effort to define the problem and identify areas of technology which may offer a solution to the problem. A small, inexpensive, and simple pressure transducer would be an ideal solution. A search of the aerospace technology for such a transducer has been initiated.

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Problem No.: MU-30

Title: Blood Sample Catheter

Researcher: David M. Klachko, M.D., University of Missouri Medical Center

Date Problem Submitted: February 1969

PROBLEM DESCRIPTION

In monitoring blood glucose for a long period of time, a small, continuous blood volume is drawn from an artery through a very small catheter (0.042 in. I.D., 0.052 in O.D.). The catheter is actually a coaxial tube, the outer tube supplying anticoagulant, and the inner tube

drawing a mixture of anticoagulant and blood. Because of patient motion, tube flexibility, and the small size of the tube, the tube tends to contact the vessel wall and be drawn to it by the suction pressure. The tube is thus blocked and must be freed from the wall before measurements can be resumed. A catheter is needed that will not obstruct itself against the artery wall.

ACTION TAKEN

A member of the MRI BA Team has discussed the problem with Dr. Klachko to learn what methods he has tried.

RESULTS

Dr. Klachko reported that various catheter tip geometries have been tried with little improvement over the simple open-ended cylindrical geometry. Nylon and Teflon tubes have been used to take advantage of their flexibility, but machining these materials at such small dimensions is very difficult. An attempt will be made to find a catheter having a geometry that prevents the catheter from attaching itself to the vessel wall.

* * * * *

Problem No.: MU-34

Title: Computer Analysis of Electrocardiograms

Researcher: Arthur E. Rikli, M.D., Coordinator, Missouri Regional Medical Program, University of Missouri

Date Problem Submitted: May 1969

PROBLEM DESCRIPTION

The researchers in the Missouri Regional Medical Program wish to introduce computer analysis of ECG's to rural areas via telephone line hookup. The objective is to analyze ECG's for research purposes as well as provide rapid and accurate interpretation of ECG's for rural health care facilities which do not have the equipment or personnel to do the analysis. The investigator has studied medical data analysis methods

developed by C.A. Caceres.* He wishes to survey aerospace technology to determine what additional methods of ECG data analysis have been studied by NASA and the aerospace industry.

ACTION TAKEN

A computer literature search of the aerospace literature was conducted and sent to Dr. Rikli for his evaluation. Thirty-two documents were cited which relate to computer electrocardiogram analysis.

RESULTS

Dr. Rikli is evaluating the literature search.

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* "Nation-Wide Computer Analysis of Medical Signals," Department of Health, Education, and Welfare, Washington, D. C., NEREM Record, pp. 222-223 (1967); "Electronic and Computer-Assisted Studies of Bio-Medical Problems," Charles C. Thomas Publisher (1965); et al.

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Problem No:	KU-8
Title:	Nondestructive Test for Bone Integrity and Density
Researcher:	Dr. Leonard Peltier, Department of Orthopedics, Kansas University Medical Center
Date Problem Submitted:	June 1966

PROBLEM DESCRIPTION

There is a need for a nondestructive method for determining bone density and integrity without the necessity of normal x-ray procedures or surgery. A number of bone anomalies are associated with changes in bone density. Also, in many cases, some forms of hairline and nondisplaced fractures are not readily diagnosed by normal x-ray visualization.

Furthermore, the state of fracture healing may be related to bone density at the fracture site.

ACTION TAKEN

A NASA Tech Brief B68-10140[65] describing a bone density measurement system was located by the MRI BA Team through a routine perusal of incoming Tech Briefs. The document was sent to Dr. Peltier as a possible solution to his problem.

RESULTS

Dr. Peltier has not responded to this information and is no longer interested in the problem. The problem was closed.

* * * * *

Problem No.: KU-30

Title: X-ray Enhancement

Researcher: Dr. Ronald M. Lauer, and Dr. Templeton, Kansas University Medical Center

Date Problem Submitted: January 1968

PROBLEM DESCRIPTION

This problem, originated by Dr. Lauer, is similar to Problem No. MU-8. The researcher wishes to set up a system in which a cardiac x-ray can be enhanced by digital computer processing in a near real-time fashion. X-rays taken for diagnostic purposes would be sent by microwave transmission to the computer center at Lawrence, Kansas, converted to digital form, enhanced by computer, retransmitted to the Medical Center, and reconstructed as an x-ray for viewing. To be effective as a diagnostic tool, the entire process must take only a few minutes.

ACTION TAKEN

The JPL technique[1/] being implemented at the University of Missouri (Problem No. MU-8) was brought to the attention of Dr. Lauer. Members of the MRI BA Team felt that the system as developed at the University of Missouri would be a solution to this problem.

Dr. Templeton is a former member of the University of Missouri medical staff and is familiar with the work being done at MU. He expressed an interest in this problem when Dr. Lauer left KU.

RESULTS

The progress of the University of Missouri x-ray enhancement system is being followed by Dr. Templeton.

* * * * *

Problem No.: KU-31

Title: Electrocardiogram Electrodes

Researcher: Dr. Robert F. Hustead, Department of Anesthesiology, Kansas University Medical Center

Date Problem Submitted: March 1969

PROBLEM DESCRIPTION

During surgery and anesthesia ECG electrodes must be able to function reliably for several hours with no attention. Straps or bands are not suitable for holding the electrodes. The position of the patient may be changed several times during the operation, and it is not practical to make adjustments. The electrode must show no electrical rectification. During surgery there are various sources of severe electrical noise, which, if picked up by the electrodes and rectified, cause serious interference in the ECG recording.

ACTION TAKEN

A member of the MRI BA Team has discussed this problem with Dr. Hustead. The problem requires additional identification especially as to the particular sources of electrical noise and the reasons that they cause interference. It is suspected that some of the noise can be eliminated at the source. Dr. Hustead indicated that he has not looked into this possibility.

RESULTS

The definition of this problem is being improved. Dr. Hustead is looking into causes of the electrical noise.

* * * * *

Problem No.: KU-33

Title: Water Vapor Partial Pressure Monitor

Researcher: Dr. Robert F. Hustead, Department of Anesthesiology, Kansas University Medical Center

Date Problem Submitted: March 1969

PROBLEM DESCRIPTION

The anesthesiologist has the problem of maintaining the patient's water balance during anesthesia. This necessitates that he maintain the partial pressure of water in the inspired gas at the same level as that in the expired gas or in the respiratory epithelium. A rapidly responding, sensitive, and continuous measurement of water partial pressure in the anesthetic gas mixture is required. The pressure range is 0 to 50 mm. Hg.

ACTION TAKEN

A computer search of NASA literature was conducted on water vapor and respiration or water vapor partial pressure.

RESULTS

No pertinent documents were revealed in the NASA literature search. Another literature search will be run using a new strategy in an attempt to locate applicable technology.

* * * * *

Problem No.: KU-34

Title: Indirect Monitoring of Respiration

Researcher: Dr. Robert F. Hustead, Department of Anesthesiology, Kansas University Medical Center

Date Problem Submitted: March 1969

PROBLEM DESCRIPTION

Postoperatively, it is essential that the patient's respiration be monitored with minimal interference with the patient. Direct airway flowmeters are not satisfactory since they subject the patient to discomfort during long periods of time. What is needed is a technique for monitoring respiration without direct placement of flowmeters in the airway. A technique to measure changes in thoracic volume would be most desirable. An additional application for an indirect respiration measurement is to monitor newborn babies.

ACTION TAKEN

A computer search of NASA literature concerning impedance pneumography was run.

In addition two documents concerning impedance pneumography[67,68] were located in a manual search and were sent with the computer search. A composite of the technology presented by these documents could be a potential solution for this problem. One document[67] discussed a method using capacitive coupling electrodes and a higher (300 KHz) frequency of excitation than that which other researchers have used. The other document described a method of improving the output by using a guard ring around the sensing element.[68]

RESULTS

The aerospace literature search netted 48 citations. Upon examining the abstracts Dr. Hustead reported that the questionable accuracy of quantitative data obtained by impedance pneumography, plus the artifact caused by patient movement, rendered this method unsuitable. The method may be usable if electrode artifact can be reduced and accuracy improved to a level of 10 percent or better.

* * * * *

Problem No.: KU-37

Title: ECG Monitoring During Anesthesia and Surgery

Researcher: Dr. Robert F. Hustead, Department of Anesthesiology, Kansas University Medical Center

Date Problem Submitted: March 1969

PROBLEM DESCRIPTION

A reliable technique is needed for monitoring the electrocardiogram during anesthesia and surgery. Numerous sources of interference are present in the operating room, some of which are so severe as to render monitoring with conventional equipment impossible. The most serious source of interference is the electrosurgical unit for making incisions, which produces high voltage (hundreds of volts), and high frequency (10 KHz - 10 MHz) damped oscillatory pulses at 60 Hz repetition frequency. Any electrical noise on the patient's body produces interference in the ECG. Some interference is large enough to cause electrical damage to ECG amplifiers. An amplifier with high differential gain, high common made rejection, and a very high common made dynamic range is a primary requirement.

ACTION TAKEN

This problem has been discussed with Dr. Hustead by a member of the MRI BA Team. The investigator has limited knowledge and experience in this problem area. A search of the aerospace literature for an appropriate amplifier will be made.

Problem No.: KU-38

Title: Speech Pathology Simulator

Researcher: Dr. William M. Diedrich, Department of Hearing and Speech Therapy, Kansas University Medical Center

Date Problem Submitted: March 1969

PROBLEM DESCRIPTION

The investigator is interested in obtaining a simulator for clinical training in speech pathology. The device would simulate different speech problems by means of an audio video computer model for the student to treat. The model must be capable of the following characteristics: responding to specific audio or visual stimuli; making an audio or visual response; altering, improving, or reinforcing verbal behavior as a result of a specific stimulus and as a consequence of conditions provided by the clinician; operating on-line and in real time; and performing bookkeeping duties of responses and stimuli for each lesson. The researcher is attempting to define the complexity of such a speech simulator, and to determine the possibility of creating a simulator with today's state of technology.

ACTION TAKEN

A computer search of aerospace literature was conducted to locate technology on speech simulators and machine teaching methods. A manual search was conducted also to augment the computer search. Dr. Diedrich ordered and was sent six documents.[74-79]

RESULTS

Although he has not completed his review of these documents, Dr. Diedrich reported that the documents contain several topics which he had not considered. The technology requested by Dr. Diedrich appears to be more advanced than "the state of the art." For this reason the low return from the computer search (four documents) is not surprising.

* * * * *

Problem No: UM-16

Title: Eye Transport Processes

Researcher: W. L. Fowlks, Ph.D., Department of Ophthalmology, University of Minnesota

Date Problem Submitted: March 1968

PROBLEM DESCRIPTION

Glaucoma or ocular hypertension is a disease of the eye resulting from a pressure build-up within the eyeball. It is not known whether this pressure increase is due to excessive inflow associated with normal outflow or normal inflow associated with a deficiency of outflow. Research activity has involved the simultaneous detection and counting (pulse height analysis) of six different radioisotopes in order to determine the flow rate of body fluids into and out of the eyeball. The problem is mainly one of determining the optimum counting ratio of the six isotopes which will give the most accurate results.

ACTION TAKEN

A computer search of the NASA literature was made and the researcher subsequently received documents which appeared relevant to his problem. Three NASA documents[80-82] were forwarded for evaluation along with information from the commercial literature.[83-85]

Discussion with other MRI scientists concerning the simultaneous counting of six isotopes in intermixed single-label samples revealed that the actual number of variables may range from 36 to 720 instead of one variable for each of the six isotopes. Additional suggestions concerning the use of liquid scintillation counters for pulse height analysis work were also given to Dr. Fowlks.

RESULTS

Because the six simultaneous linear equations involving the six isotopes do involve more than six "unknowns," Dr. Fowlks is now attempting to collect sufficient data by using three isotopes. Although this may

resolve a number of the "unknown variables" the method is quite tedious and time consuming because all the results must be hand calculated. No funds are available in the present grant for program writing and computer service.

The computer search produced 233 citations from which the investigator ordered 11 documents that appear relevant to his problem.

While the information supplied by the BA Team has not provided any solution to the problem, it did give Dr. Fowlks a better understanding as to why he was having difficulty in arriving at an acceptable solution. The problem is still of interest, but activity will continue at a low level pending further data collection by the researcher.

* * * * *

Problem No.: UM-18

Title: Pressure Measurement Between Teeth

Researcher: Charles D. Simpson, D.D.S., M.S.D., University of Minnesota

Date Problem Submitted: February 1968

PROBLEM DESCRIPTION

Dr. Simpson is interested in telemetering information regarding the contact pressure between the teeth of children who have undergone orthodontic treatment. This would enable the dentist to evaluate the need for additional corrective action without waiting until some form of tooth damage indicated the need. This problem has been solved on older people who have missing teeth or a removable bridge where the telemetry transmitter can be installed. Children do not normally have any "vacant" spaces and, therefore, no room for equipment.

ACTION TAKEN

A computer search of the NASA literature was made. A member of the BA Team suggested the use of a pressure-sensitive paint[91] as a

solution to the problem requirement for a "zero-thickness" pressure sensor. Also suggested was a conductive elastomer.[92] Several pieces of commercial literature on subminiature pressure transducer[93] as well as an implantable telemetry system[94] were also supplied.

RESULTS

The computer search did not produce any relevant citations. Although Dr. Simpson originally felt the pressure-sensitive paint would be a possible solution to the problem, he eventually ruled out its use because of the measuring equipment that would be required to detect the pressure/resistance changes.

Information on the subminiature pressure transducers and the implantable telemetry system was of interest for use on older persons but was not suitable for use on children. The investigator is still interested in the problem and is hoping for some sort of "passive" transducer to be used with children.

* * * * *

Problem No.: UM-19

Title: Intercardiac Heart Sounds

Researcher: Arnold Adicoff, M.D., Assistant Professor of Medicine, University of Minnesota

Date Problem Submitted: March 1968

PROBLEM DESCRIPTION

This problem involves the need for a sound transducer which can be inserted through a standard catheter to aid in the intercardiac examination and study of the human heart. Maximum diameter is 1 mm. and maximum length is 1 cm.

ACTION TAKEN

The results of a computer search of the NASA literature were forwarded to Dr. Adicoff for his evaluation. Also, a NASA Tech Brief,[95] which described an "ultraminiature manometer-tipped cardiac catheter," was forwarded for evaluation.

RESULTS

Dr. Adicoff reported that none of the material listed is relevant to the particular problem. The problem is currently inactive.

* * * * *

Problem No.: UM-20

Title: Gamma Radiation Source

Researcher: Herbert Jonas, Ph.D., Department of Pharmacognosy, University of Minnesota

Date Problem Submitted: March 1968

PROBLEM DESCRIPTION

Dr. Jonas is interested in being able to measure the biological action potentials (electrical) in medicinal type "drug" plants resulting from exposure to radiation. The action potentials occur in 1-2 mm. long cells located in the leaf joint adjacent to the stem and are very similar to muscle potentials.

ACTION TAKEN

A computer search of the NASA literature was made and a copy of the abstracts was forwarded to Dr. Jonas for evaluation. A manual search was made which located nine Tech Briefs. These Tech Briefs were sent to Dr. Jonas for consideration.

RESULTS

The computer search produced 30 citations, of which eight were requested by the investigator. Dr. Jonas later reported that one document[96] and the nine Tech Briefs[97-105] would be very useful for a high level instructional course in radio isotopes and also as a valuable reference for future research work.

Unfortunately, Dr. Jonas was transferred to a new field of teaching and funds are not presently available for him to continue with this work. He, therefore, has asked that this problem be considered closed and expressed his gratitude for our past service.

* * * * *

Problem No.: UM-22

Title: Mass Spectrometer

Researcher: Professor Nathan Lifson, Department of Physiology, University of Minnesota

Date Problem Submitted: March 1968

PROBLEM DESCRIPTION

Professor Lifson is trying to determine the percent of O_{18} by a mass spectrometer analysis of CO_2. An accuracy of 1 percent is required, which is beyond the capability of current equipment.

ACTION TAKEN

A manual search for information was made following a computer search of the NASA data bank. Dr. Kubicek was also contacted regarding the capability of his quadrapole mass spectrometer to satisfy the accuracy requirements for measuring oxygen 18.

RESULTS

• The computer search produced two citations which mentioned oxygen 18. However, because the equipment described had only the capability to "detect" oxygen 18 rather than make a "quantitative measurement," it was deemed not suitable for this problem. The quadrapole mass spectrometer being developed by Dr. Kubicek would require special modification to detect the minute concentrations of oxygen 18 to be measured. No other information has been found concerning equipment capable of satisfying the problem requirements.

* * * * *

Problem No.: UM-23

Title: Sensors for Body Functions

Researcher: Dr. Daniel Halpern, Childrens Rehabilitation Center, University of Minnesota

Date Problem Submitted: March 1968

PROBLEM DESCRIPTION

Dr. Halpern is interested in measuring muscle potentials in order to evaluate simultaneous synergistic muscle patterns, and also wants the capability to correlate muscle tension with myographic recordings.

ACTION TAKEN

A computer search of the NASA data bank and a manual search of technical trade journals were made. A copy of the NASA literature search was forwarded to Dr. Halpern along with two pieces of information[106-107] from trade journals as well as a suggestion by a member of the BA team concerning the use of a pressure sensitive paint.[91]

RESULTS

The computer search produced 73 citations with four containing information related to the investigator's field of interest. The investigator has yet to evaluate the information furnished him.

* * * * *

Problem No.: UM-24

Title: Digitized Scope Traces

Researcher: A. S. Marrazzi, M.D., Department of Neuropharmacology, University of Minnesota

Date Problem Submitted: March 1968

PROBLEM DESCRIPTION

Neuropharmacology research involves the monitoring of electrical activity evoked in the brain and modified by drugs. The critical analysis of EEG signals requires much time by senior investigators. A method of data processing is desired which could provide the necessary pattern recognition and signal analysis.

ACTION TAKEN

The investigator was sent a copy of the document abstract cards identified by a computer search of the NASA literature. Two additional documents[108-109] containing information in a related field were also furnished to the investigator by the MRI BA Team.

RESULTS

The computer search produced 131 citations. Two documents[110-111] appear relevant to the problem and have been ordered. References 108 and 109 cover similar applications in analyzing ECG signals and may or may not be applicable to EEG work. Disposition is awaiting an evaluation report from investigator.

Problem No.: UM-25

Title: Digital Conversion of Scope Traces

Researcher: A. S. Marrazzi, M.D., Department of Neurocology, University of Minnesota

Date Problem Submitted: March 1968

PROBLEM DESCRIPTION

There is need of an electro-optic scanner for 35 mm. film, which by using a television camera and appropriate circuitry, could digitize the cathode ray traces and convert them into punched card data. This would eliminate the need for multiple channel FM tape recorders and analog-to-digital converters.

ACTION TAKEN

A computer search of the NASA literature was made and reviewed by the MRI BA Team for applicable information. The search was forwarded to Dr. Marrazzi.

RESULTS

The computer search resulted in 62 citations. Thirteen citations cover the general area of interest and four documents[112-115] appear very relevant to the problem. We are now waiting for search evaluation by Dr. Marrazzi.

* * * * *

Problem No.: UM-26

Title: Distortion of Visual Perception

Researcher: A. S. Marrazzi, M.D., Department of Neuropharmacology, University of Minnesota

Date Problem Submitted: March 1968

PROBLEM DESCRIPTION

Dr. Marrazzi is investigating the behavioral consequences involved with patients having disturbed cerebral functions, when they look into a seven foot open-ended room through a set of distorting lenses. The resulting distortion of visual perception appears as a slope in the wall of the test chamber. The extent of the slope can then be accentuated in a quantitative, diagnostic fashion by small test doses of drugs which have no recognizable overt effect, but which can be readily followed instrumentally. In order to increase the capability of the research project, a miniaturized version of the system is needed for field use.

ACTION TAKEN

The results of a computer search of the NASA data bank have been sent to the investigator for evaluation. Clarification of several problem details have also been requested from Dr. Marrazzi. Further activity will be governed by investigator's response.

RESULTS

The computer search produced 38 citations. Four citations contain information of general interest but would not be a solution to the problem. The investigator is now evaluating the information supplied.

* * * * *

Problem No.: UM-29

Title: Rapid Playback ECG Recorder

Researcher: Carl S. Alexander, M.D., Chief, Cardiovascular Section, University of Minnesota

Date Problem Submitted: March 1968

PROBLEM DESCRIPTION

The treatment of patients having disturbed cardiac rhythm could be greatly facilitated if it were economically feasible to continuously record their ECG for periods up to 24 hours and then monitor the tape at a 60 to 1 playback speed. Commercial equipment[121] is available which could solve this problem, but its acquisition cost is far too expensive for this kind of use, according to Dr. Alexander.

ACTION TAKEN

A computer search of the NASA data bank was made. A manual search was also conducted, which located documents[122-125] of general interest. These were forwarded to the investigator for evaluation.

RESULTS

The computer search did not identify any citations on a rapid playback ECG recorder. The manual search of the technical literature located the commercial equipment[121] which would be a solution to the problem, but the investigator indicates is too expensive. Recently another commercial unit was brought to our attention and effort is being made to procure additional information on this NASA developed unit.[126]

* * * * *

Problem No.: UM-36

Title: Miniature Power Sources

Researcher: Dr. John Tester, Mr. David Gilmer, Department of Ecology and Behavioral Biology, University of Minnesota

Date Problem Submitted:

PROBLEM DESCRIPTION

Mr. Gilmer is working on a NIH project which involves the "radio tracking" of small animals and birds, particularly ducks. Power sources,

weighing some 4.5 to 12 g., are needed to supply miniature telemetry equipment (see Problem UM-37) which will be either attached to or implanted in the test subjects.

ACTION TAKEN

Additional information is now being gathered to provide a more complete definition of the problem. A computer search of the NASA data bank will then be made.

RESULTS

None yet; problem still in definition stage.

* * * * *

Problem No.: UM-37

Title: Miniature Telemetry Equipment

Researcher: Dr. John Tester, Mr. David Gilmer, Department of Ecology and Behavioral Biology, University of Minnesota

Date Problem Submitted: March 1969

PROBLEM DESCRIPTION

Dr. Tester and Mr. Gilmer are working on a NIH project which involves the "radio tracking" of small animals and birds, particularly ducks. Due to size of the animals and birds involved, extremely compact, lightweight telemetry equipment is needed. Information is desired on miniaturized state-of-the-art construction techniques.

ACTION TAKEN

Additional information is now being gathered to provide a more complete definition of the problem. A computer search of the NASA data bank will then be made.

RESULTS

None yet--Problem still in definition stage.

* * * * *

Problem No.: UM-38

Title: Telemetry Recording Devices

Researcher: Dr. John Tester, Mr. David Gilmer, Department of Ecology and Behavioral Biology, University of Minnesota

Date Problem Submitted: March 1969

PROBLEM DESCRIPTION

Dr. Tester and Mr. Gilmer are working on a NIH project which involves the "radio tracking" of small animals and birds, particularly ducks. Information on equipment capable of receiving the very weak telemetry signal and recording the desired data is needed.

ACTION TAKEN

Additional information has been requested from the investigators in order to more clearly define the type of signal information to be recorded. A computerized literature search will be made when the problem definition is completed.

RESULTS

None yet--problem still in definition stage.

* * * * *

Problem No.: UM-39

Title: Potting Compounds

Researcher: Dr. John Tester, Mr. David Gilmer, Department of Ecology and Behavioral Biology, University of Minnesota

Date Problem Submitted: March 1969

PROBLEM DESCRIPTION

A potting compound that can be used for embedding electrical circuits for protection against water immersion and mechanical wear. The cure time should be less than 3 hours at room temperature. Adhesion to metal, teflon wire and polyvinyl-chloride tubing should be good without causing decomposition of any component. Hardness should be approximately 70 shore durometer.

ACTION TAKEN

Information has been obtained from a commercial source regarding capability of any such potting compound to meet the problem requirements.

RESULTS

Preliminary information indicates that nothing meeting the problem requirements will bond with the teflon wire. Additional searching will cover the NASA technology.

* * * * *

Problem No.: UW-2

Title: Eyeblink Measurement

Researcher: Professor Leonard E. Ross, Department of Psychology, University of Wisconsin

Date Problem Submitted: December 1966

PROBLEM DESCRIPTION

The eyeblink response has been used extensively to study classical conditioning, or learning, in adult subjects, and it offers many advantages for work with infants. However, infants and mentally retarded children will not tolerate the attachment of devices to the eyelid. A noncontacting type of sensor is, therefore, required.

ACTION TAKEN

Three different computerized searches were made of the NASA Data Bank.

A manual search for information located a NASA Tech Brief[136] which described an "infrared sight switch." This "switch" is considered to be a potential solution for this problem, but efforts to procure an infrared sight switch for clinical evaluation have been unsuccessful. The Technology Utilization Officer at the Marshall Space Flight Center informed the MRI BA Team that: (1) there are no switches available from NASA; and (2) the Hayes International Corporation is licensed to manufacture and sell the device. Several attempts to get one of the switches from Hayes have not met with any success.

RESULTS

The three literature searches produced 8, 11 and 165 citations respectively. A total of six documents were subsequently ordered, but the information contained in them did not satisfy problem requirements. The infrared sight switch is considered to be a potential solution for this problem, but only a clinical evaluation can prove the capability. The investigator has no funds to fabricate a similar "switch" and because a NASA switch could not be loaned for evaluation, he has now lost interest. The problem has been closed.

* * * * *

Problem No.: UW-4

Title: Measurement of Body Motion

Researcher: Dr. M. E. Kaufman, Center on Behavioral Disabilities, University of Wisconsin

Date Problem Submitted: August 1967

PROBLEM DESCRIPTION

One of the behaviors of severely mentally retarded children is body rocking while seated. This motion involves rhythmic swaying of the torso from front to back and from side to side. Apparatus for the measurement of this body motion is desired.

ACTION TAKEN

A computerized literature search produced only two citations, neither of which contained relevant information.

The MRI muscle accelerometer[137] was considered to be a potential solution and two units were furnished for evaluation.

RESULTS

Dr. Kaufman advised that the muscle accelerometer is not a satisfactory solution to this problem. It seems that the violent and unpredictable movements of the severely mentally retarded children being tested were sufficient to destroy the units. Prior to destruction, it was determined that the information obtained could not be readily interpreted. An observer could do a better job of correlating the subject's motions with other related stimuli and thus get an overall picture of total muscle activity.

The investigator now plans to video tape the subject's body motions from two different angles simultaneously and then reduce the video information to digital form suitable for computer analysis. This method should provide the psychologist with data suitable for determining gross body motion activity.

Any further research on this problem by Dr. Kaufman is dependent on procuring funds for the video tape equipment. This problem is now closed.

* * * * *

Problem No.: UW-6

Title: Auditory Stimulation

Researcher: Rick Heber, Ph.D., Director, Center on Behavioral Disabilities, University of Wisconsin

Date Problem Submitted: August 1967

PROBLEM DESCRIPTION

There is a need for a tamperproof, miniaturized device for transmission of auditory stimulation impinging upon an infant and the infant's vocal response. The recording system should be capable of picking up the signal from a distance of one mile and should be capable of storing up to 12 hours of data.

ACTION TAKEN

A computer search of the NASA literature was made. A member of the BA Team suggested to Dr. Heber that consideration be given to the use of low-frequency carrier current equipment which could operate over the commercial power lines and eliminate some of the problems which would otherwise be associated with the use of radio transmitting equipment. "Leased lines" from Western Union or the Telephone Company could also be used.

RESULTS

Although the literature search produced considerable information on telemetry, most of the equipment was too exotic and did not fit the problem requirements. This problem is currently inactive pending availability of funds and personnel to custom-make the necessary equipment.

Problem No.: UW-16

Title: Urination Detector

Researcher: Professor Wm. I. Gardner, Department of Counseling and Behavioral Studies, University of Wisconsin

Date Problem Submitted: August 1967

PROBLEM DESCRIPTION

In working with mentally retarded children it is necessary to detect the moment of urination or defecation in order to deliver appropriate consequences in behavior shaping of toilet training. Such a detector must be small, light and inexpensive or reusable. Its wireless range should cover up to 50 feet and it must provide for individual identification.

ACTION TAKEN

A computer search of the NASA Technology did not reveal any pertinent documents. Information requested from the TU Officer at the Manned Spacecraft Center indicated that no such detectors were developed for use by astronauts. Through normal scanning of the technical and medical literature, a member of the BA Team identified an article[140] which appears to be a possible solution to this problem. Information was sent to researcher for his evaluation.

RESULTS

Until recently, activity on this problem has been nil due to lack of relevant information. Professor Gardner's evaluation of the technology will determine future course of action.

* * * * *

Problem No.: UW-18

Title: Remote Manipulation of Brain Electrodes

Researcher: Dr. C. N. Woolsey, Dr. J. F. Brugge, Laboratory of Neurophysiology, University of Wisconsin

Date Problem Submitted: August 1967

PROBLEM DESCRIPTION

In the recording from single neurons in the brain of animals, there is a need for a reliable device to advance and withdraw a microelectrode over a distance of several millimeters. The drive unit must be small enough so that when it is mounted on the head it does not interfere with the animal's behavior.

ACTION TAKEN

A computer search of the NASA literature had revealed a Russian report[143] which described a method for the automatic manipulation of brain electrodes. Followup information indicated that the Russian system did not lend itself to miniaturization and therefore would not be usable for free roaming animals.

A manual search of the technical literature revealed an article on work done at the Johns Hopkins Medical Center on a depth gauge for microelectrodes[144] which appears to be a possible solution. Another article describes a probe to monitor electroanesthesia current density,[145] conducted at the Polytechnic Institute of Brooklyn. Copies of these two references were forwarded to Dr. Brugge for evaluation.

RESULTS

Researcher has not found the time to evaluate information. Problem currently on inactive status.

* * * * *

Problem No.: UW-20

Title: Enzyme Electrode Amplifier

Researcher: Stuart J. Updike, M.D., Department of Medicine, University of Wisconsin

Date Problem Submitted: December 1967

PROBLEM DESCRIPTION

Dr. Updike has developed a special enzyme electrode which he intends to use for the continuous monitoring of oxygen and glucose concentrations in living animal tissues. He needs a very stable, high-impedance amplifier in order that changes in the amplifier will not mask the signal he is attempting to measure.

ACTION TAKEN

A computer search of the NASA literature was made and a copy of all the abstracts were sent to Dr. Updike for his evaluation. Dr. Updike requested four documents[146-149] which were obtained by the MRI BA Team and forwarded along with four articles[150-153] located through routine scanning of the NASA and open literature by the BA Team.

Personal discussions were held with the investigator regarding project goals and equipment limitations.

RESULTS

The computer search produced 132 citations with little of the information being relevant to the problem requirements. Dr. Updike reported that references 147 through 149 contained background information useful for other projects.

Fabrication of an amplifier per reference number 153 indicates that temperature drift and linearity are still major problems. A commercial amplifier was also tried with similar negative results. Effort is now being expended by Dr. Updike to develop his own special circuitry by improving on current design information.

Problem No.: UW-21

Title: Foot-to-Floor Force Measurements

Researcher: Robert J. James, Graduate Student, University of Wisconsin

Date Problem Submitted: March 1968

PROBLEM DESCRIPTION

This problem involves the measurement of forces exerted by the human foot against the walking surface in order to analyze the gait of mentally retarded children.

ACTION TAKEN

A computer search of the NASA literature was made and then followed up with a manual search. The technical and commercial literature was also searched and the results were forwarded to investigator for his evaluation.

RESULTS

The computer search did not produce any relevant information. The manual search turned up a NASA document[154] containing technology directly applicable to problem requirements. The technical literature[155-158] also contained relevant information and the commercial literature[159] contained data on the load cells necessary to construct equipment described in References 155 and 156. When the investigator failed to acknowledge receipt of the above information, it was learned that he had left the University. This problem is now closed, but had excellent potential as a transfer.

* * * * *

Problem No.: UW-22

Title: Attention Measurement Mechanism

Researcher: Rick Heber, Ph.D., Howard L. Garber, Center on Behavioral Disabilities, University of Wisconsin

Date Problem Submitted: November 1968

PROBLEM DESCRIPTION

This problem is concerned with the need to measure the time course phenomena and fixation points of a subject's eyes while attending to various stimulation. Mentally retarded children are considered to have an attentional deficiency which directly affects their learning capability. Present research has shown that their learning can be enhanced if the nature of this deficiency can be determined through eye movement phenomena related to various exteroceptive stimulation.

Other investigators[160-161] have used methods which require the test subject's head to be clamped in place so that the associated optical equipment can function. This method works fine with a normal adult but not with a mentally retarded child.

ACTION TAKEN

A meeting was held to further define limitations involving the testing of mentally retarded children. Four documents[162-165], located by the BA Team, were left with the investigator for his evaluation. Manual searching of NASA and the open literature is continuing.

RESULTS

Although the information supplied to Mr. Garber has yet to be fully evaluated, it is doubtful that it will provide the necessary solution.

* * * * *

Problem No.: FH-2

Title: Automatic Limb Weighing System.

Researcher: Dr. Marshall P. Reich, Fitzsimons Army Hospital

Date Problem Submitted: September 12, 1968

PROBLEM DESCRIPTION

Dr. Reich is engaged in a research program on limb implantation. The ultimate goal of the research is to develop techniques for grafting human arms and legs to soldiers who have lost limbs in combat. At the present stage of the research, amputated dog's limbs are being kept in a hyperbaric chamber to determine the ability to store amputated limbs. One indication of the viability of the amputated limb is to monitor its weight. The weight of the limb is recorded before it is placed in the hyperbaric chamber and when it is removed from the chamber just prior to implantation. It is desired to be able to continuously monitor the weight of the limb while it is in the hyperbaric chamber.

ACTION TAKEN

A computerized search of the NASA literature tapes was made. The references listed in the search were reviewed by a member of the MRI BA Team and the researcher. Also, a number of manufacturers of weighting equipment were contacted.

RESULTS

No existing apparatus was located which would meet the specifications of this problem. However, several commercial organizations expressed an interest in designing a special unit for this application. This information was given to Dr. Reich.

* * * * *

Problem No.: FH-6

Title: Microsurgical Suturing

Researcher: Dr. Marshall P. Reich, Fitzsimons Army Hospital

Date Problem Submitted: September 12, 1969

PROBLEM DESCRIPTION

In microsurgery, such as is involved in limb implantation, the suturing of small vessels requires precise and difficult manipulation of the surgeon's hands. A devise which could assist the surgeon in microsurgical suturing would be very desirable.

ACTION TAKEN

A computerized search of the NASA literature bank was conducted and sent to Dr. Reich.

RESULTS

Dr. Reich reported that the literature search revealed good review material, but did not relate directly to his problem.

* * * * *

D. Problems Closed

During the year, periodic reviews were made of all the problems which have been submitted to the MRI BA Team. The purpose of these reviews was to eliminate those problems which are no longer considered active. The criteria used for closing out a problem are as follows:

(a) Transfer accomplished.
(b) Researcher has no further interest in the problem.
(c) Researcher found his own solution.
(d) The researcher has left the institution.
(e) No present or anticipated NASA technology applicable.

The problems that were closed are listed below. The reason for closing each problem is letter coded in accordance with the above criteria list.

University of Kansas Medical Center

KU-1	EKG Electrodes That Will Function Adequately During Vigorous Exercise.	(a)
KU-2	A Method of Continuously Measuring Respiratory Oxygen Consumption and CO_2 Production During Exercise.	(d)
KU-3	A Method for Making Direct Intravascular Measurements of pH, P_{O2}, and P_{CO2} During Exercise.	(d)
KU-4	Reasonably Priced Apparatus for Telemetering EKG's and Other Physiological Data.	(d,e)
KU-5	Masks and/or Mouthpieces for Respiratory Monitoring During Exercises.	(a)
KU-6	A Technique for Rapid Measurement of Lactic and Pyruvic Acids in Tissue and Blood.	(d,e)
KU-7	Improvements in the Protective Clothing Used in Athletics.	(e)
KU-8	A Device for Nondestructive Testing of the Integrity and/or Density of Bone In Vivo.	(b)
KU-9	Powered Prosthetic Devices and Control Systems.	(e)
KU-10	Microsurgical Instruments for Middle and Inner Ear Surgery.	(e)
KU-11	Miniature Transducers That Can Be Used to Measure the Compliance of the Acoustic Transmission System in the Middle Ear.	(e)
KU-13	A Miniature Sensor Which Can Be Placed in the Nasal Cavity to Monitor the pH of Nasal Mucosa Secretion.	(e)

KU-14	A Frequency Converter for Transposing Frequencies from the Lower Audible Range Into a Higher Range.	(e)
KU-15	A Nasal Pack to Arrest Bleeding.	(e)
KU-16	Miniature Accelerometers to Detect Muscle Movements During Neurosurgery.	(b)
KU-17	A Device for Producing Lesions of Well-Defined Shape and Size in Neurosurgery.	(e)
KU-18	An Endoradiosonde Method for Measuring the pH of Colonic Contents.	(e)
KU-19	A Micro-Assay Technique for ATP.	(e)
KU-20	A Technique for Separation of the Fetal EKG From the Maternal EKG and from Noise.	(b)
KU-21	An Intrauterine Camera, Perhaps Employing Fiber Optics.	(a)
KU-22	Techniques for Determination of Biological Steroids by Gas Chromatography.	(e)
KU-23	Support to Assist Healing of Eardrum Rupture.	(c)
KU-24	Cardiac Output Measurements.	(a)
KU-25	Blood Pressure Measurement During Exercise.	(d)
KU-26	Chronic Intracranial Pressure Measurement.	(b)
KU-27	Ear Specimen Mounting Material.	(e)
KU-28	Conversion of Biological Data.	(d)
KU-29	Ear Specimen Bone Removal.	(a)
KU-30	X-Ray Enhancement Real-Time X-Rays of the Internal Heart.	(d)

University of Wisconsin

UW-1	Delivery of Water and Medication to the Respiratory Tract.	(a)
UW-2	Eyelid Closure Recording.	(b)
UW-3	Miniature Equipment for Presenting Auditory Stimuli.	(b)
UW-4	Movement of Various Large Muscle Groups.	(c)
UW-17	Rotary Joint for Small Tubing.	(a)
UW-21	Foot-To-Floor Force Measurements.	(d)

University of Minnesota

UM-1	Sterile Atmosphere for Surgical and Postsurgical Procedures.	(a)
UM-3	A Device to Store Electrical Energy with the Smallest Possible Size and Weight Per Unit of Stored Energy.	(e)
UM-4	A Rapid Scanning Frequency Spectrum Analyzer for the Audio Range of Frequencies.	(a)
UM-6	An Improved Instrument to Measure Respiratory Air Flow Rates.	(b)
UM-7	A Method for Measuring the Flow of Blood in Bones.	(e)
UM-9	New Approaches to the Indirect Measurement of Arterial Blood Pressure.	(e)
UM-10	Microcirculation Measurement.	(a)
UM-11	Muscle Heat Measurement.	(a)
UM-12	EKG Zero Shift Elimination.	(d)
UM 13	Chest Wall Movement.	(d)

UM-14	Water Extraction from the Atmosphere.	(e)
UM-15	Rotary Damping Device.	(e)
UM-17	Foot Support Devices.	(e)
UM-20	Compact Gamma Radiation Source.	(b)
UM-22	Mass Spectrometer.	(j)

University of Missouri

MU-1	Measurement of Effects of Magnetic and Electric Fields and Currents on Living Cells.	(a)
MU-2	Automatic Recording of Heart Sounds.	(a)
MU-3	Hemodynamic Impedance of the Vascular System.	(e)
MU-4	Automatic Blood Pressure Measurement.	(a)
MU-5	Damping in Cardiac Catheters.	(a)
MU-6	Charges on Formed Elements of the Blood.	(e)
MU-7	Differential Pressure Blood Flow Measurements.	(a)
MU-10	Indirect Monitoring of Arterial Blood Pressure.	(e)
MU-11	Tracking of Large Animals.	(b)
MU-12	Cardiac Output Measurement.	(d)
MU-13	Pulmonary and Metabolic Monitoring Instrumentation	(b,e)
MU-14	Storing of ECG Tracing Waveforms.	(b)
MU-20	Biotelemetry.	(a)

III. OTHER PROJECT ACTIVITIES

A. Project Trips

June 4-6, 1968: Paul Constant, Jr., attended the NASA Conference on Technology Utilization, held at Langley Research Center, Hampton, Virginia. The activities of the Biomedical Applications Teams were discussed during this conference.

June 25-26, 1968: Wilbur E. Goll visited the University of Wisconsin, Madison, Wisconsin, and discussed the status of the various biomedical problems submitted by the investigators at this school.

July 3, 1968: James K. West visited the University of Missouri, Columbia, Missouri. Discussions were held with investigators relative to the biomedical problems submitted from this school.

July 9 and 10, 1968: David Bendersky attended a meeting in Washington, D. C. Representatives of NASA, George Washington University and the three Biomedical Applications Teams reviewed the papers to be given at the AAMI (Association for the Advancement of Medical Instrumentation) meeting in Houston, July 17, 1968.

July 17, 1968: David Bendersky attended the AAMI meeting in Houston, Texas. Two papers concerning the MRI BA Team were presented by Mr. Bendersky at this meeting. Copies of these papers are given in Appendix II.

September 8, 1968: David Bendersky visited the Becton-Dickinson Company, Rutherford, New Jersey, and met with E. J. Cosgrove, Manager of Product Development, and other representatives of the Bard-Parker Division. Mr. Bendersky described the Biomedical Applications Team Program and how industry can benefit from participation in this program, on a fee basis. Mr. Cosgrove stated that they will give consideration to participation on a corporate level.

September 8, 1968: David Bendersky visited Ethicon, Inc. (a Division of Johnson and Johnson Company) Somerville, New Jersey, and met with Mr. Robert T. Quade, New Products Manager. Mr. Bendersky described the Biomedical Applications Team Program and how industry can benefit from participation in the program, on a fee basis. Mr. Quade indicated that they would give consideration to participation on a corporate level.

September 9, 1968: David Bendersky visited Dyna Magnetic Devices, Inc., Hicksville, New York, and met with Mr. George J. Sebesta, President. The Biomedical Applications Team Program was described and Mr. Sebesta was invited to have his company participate, on a fee basis. Mr. Sebesta indicated that they are not interested in participating in this program.

September 9, 1968: David Bendersky visited the Hallmark Dental Studio, Inc., New York, New York, and met with Mr. E. T. LaRocca, Manager. The Biomedical Applications Team Program was described. This is a small company and is not in a position to participate in the BA Team Program. However, Mr. LaRocca is interested in finding better plastics for dentures. It was suggested that he contact the NASA Regional Dissemination Center at the University of Connecticut or the University of Pittsburgh for a literature search on this subject.

September 10, 1968: David Bendersky visited the B. Welson and Company, Hartford, Connecticut and met with Messrs. S. Welson, President, and J. J. Kelly, Executive Vice President. Mr. Bendersky described the BA Team Program. This is a comparatively small company which is involved in the development and manufacturing of undergarments for astronauts. Because of their size and special products area, they are not interested in participating in the BA Team Program.

September 12, 1968: David Bendersky visited the Fitzsimons Army General Hospital, Denver, Colorado, and met with Capt. Marshall P. Reich, Director of Clinical Research. This visit was made at the suggestion of Dr. Quentin Hartwig, George Washington University. Capt. Reich is working on a research program concerned with the development of techniques for limb replantation. The ultimate aim of the project is to develop techniques for grafting human arms and legs to soldiers who have lost limbs in combat. Six problems associated with this project were obtained for processing by the MRI BA Team.

September 30, 1968: David Bendersky, Midwest Research Institute; Dr. Rose, University of Kansas Medical Center; John Ryberg, Kansas City Art Institute; and Dr. John Trank, University of Kansas Medical Center met at the University of Kansas Medical Center, Kansas City, Kansas. The purpose of the meeting was to discuss the participation of the MRI BA Team in several biomedical research projects being jointly planned by Dr. Rose and Mr. Ryberg. A proposal to conduct research and development on several devices to assist physically handicapped people has been submitted to NIH by Dr. Rose and Mr. Ryberg.

November 26 and 27, 1968: Wilbur Goll, MRI BA Team, visited the University of Wisconsin, Madison, Wisconsin, and met with seven biomedical researchers to discuss problems which they have submitted to the MRI BA Team.

November 27, 1968: David Bendersky and Donald Roberson, MRI BA Team, visited the University of Missouri, Columbia, Missouri, and met with six biomedical investigators who had submitted problems to the MRI BA Team.

February 5, 1969: Donald Roberson, MRI BA Team member, visited the University of Missouri, Columbia, Missouri, and met with five biomedical investigators who had submitted problems. Discussed in these meetings were status of current problems, new problems, and hardware development, which are presented elsewhere in this report.

February 11, 1969: David Bendersky presented an invited lecture on the NASA Biomedical Applications Team Program at Bradley University, Peoria, Illinois.

February 13, 1969: David Bendersky and Wilbur Goll attended the SRS/NASA Interagency Conference at the Goddard Space Flight Center in Greenbelt, Maryland. Representatives from participating rehabilitation centers, SRS, HEW, NASA, George Washington University, and the three Biomedical Applications Teams discussed ways and means for improving the Interagency effort. The Goddard clean room facility and Life Detection Lab were also toured. This tour proved very interesting and fruitful because information and equipment relevant to a current medical problem (Problem No. UM-28) were located.

April 7 and 8, 1969: David Bendersky and Paul Constant, Jr., attended a conference on the Biomedical Applications Team Program which was held at NASA Headquarters, Washington, D. C.

April 26, 1969: David Bendersky attended the Illinois Medical Technologists Association Annual Convention, Peoria, Illinois, and presented an invited lecture on the application of aerospace technology to the needs of medicine.

B. Reports, Presentations, and Papers

Three quarterly reports[169-171] covering the activities of the MRI Biomedical Applications Team during the periods 1 June - 31 August 1968, 1 September - 30 November 1968, and 1 December 1968 - 28 February 1969, were prepared and distributed.

Two papers describing the activities of the MRI Biomedical Applications Team activities were prepared by David Bendersky and presented at the Association for the Advancement of Medical Instrumentation (AAMI) Meeting, Houston, Texas, on July 17, 1968.[172-173] Copies of these papers are contained in Appendix II. Both papers have been accepted for publication in the Journal of the AAMI.

A summary of the activities of the MRI BA Team since its inception was prepared and sent to Lynn S. Wilson, George Washington University, for inclusion in the compendium of the Biomedical Applications Team Program.[174]

In response to a request from Lynn S. Wilson, George Washington University, a special report on Problem No. UW-11 was prepared and sent to Mr. Wilson.

David Bendersky presented three invited lectures[175-177] on the NASA Biomedical Applications Team Program to the Institute of Electrical and Electronics Engineers, Kansas City Chapter, Kansas City, Missouri, January 2, 1969; Bradley University Engineering Lecture Series, Peoria, Illinois, February 11, 1969; and the Illinois Medical Technologists Association Annual Convention, Peoria, Illinois, April 26, 1969.

The activities of the MRI Biomedical Applications Team were presented by Wilbur Goll in talks to the Kansas City Chapter of the Zonta International (professional women's organization), January 22, 1969, and to the Kansas City Chapter of the Kiwanis International.

C. Miscellaneous Activities

Mailings were made to the biomedical research staffs at the University of Kansas Medical Center and the University of Missouri to stimulate the submission of additional problems to the MRI BA Team. These mailings resulted in the submission of 17 additional problems and more are anticipated.

In response to a request from Dr. Q. Hartwig, NASA BA Team Project Coordinator, a respirometer helmet and spray-on electrodes were furnished by the MRI BA Team to Dr. R. T. Mosley, NASA Headquarters, Washington, D. C. Dr. Mosley is using this equipment in a medical study of NASA executives.

A muscle accelerometer was furnished by the MRI BA Team to Dr. Robert Greenfield, National Institutes of Health, Bethesda, Maryland. Dr. Greenfield is evaluating this accelerometer as a means for detecting chest movement due to the heart beat.

John Johnson, George Washington University, Washington, D. C., requested the MRI BA Team to submit abstracts of unsolved biomedical problems for use in a project at the Goddard Space Flight Center. Copies of Problems Abstracts Nos. KU-3, KU-6, KU-11, KU-25, UM-3, UM-7, UM-18, UW-16, MU-11, and MU-22 were sent to Mr. Johnson.

D. Inquiries

Information on the general activities of the MRI Biomedical Applications Team was requested by and furnished to:

Robert Bell	NASA Technology Utilization Office, Washington, D. C.
Donald Eubert	Sandia Corporation, Albuquerque, New Mexico
Dr. Marshall P. Reich	Fitzsimons Hospital, Denver, Colorado
Dr. F. T. deDombal	General Infirmary, Leeds, England
M. J. Hermanoff	Fellows Medical Manufacturing Company, Detroit, Michigan
Dr. R. E. Herron	Texas Institute for Rehabilitation and Research, Houston, Texas
Dr. John W. Webster	University of Wisconsin, Madison, Wisconsin
Jack Bickert	Denver Research Institute, Denver, Colorado
James E. Burnett	Lewis Research Center, Cleveland, Ohio
Dr. F. E. Russell	O'Fallon, Missouri
James E. Freeman	Denver Research Institute, Denver, Colorado
Dr. Edward H. Miller	Cincinnati General Hospital, Cincinnati, Ohio
Dale Zeh and Dick Sloan	Jet Propulsion Laboratory, Pasadena, California
Joseph P. Desmond	Cornell Aeronautical Laboratory, Buffalo, New York
Dr. J. A. Rinaldo	Mount Carmel Mercy Hospital, Detroit, Michigan
Dr. J. Hermann Ludenberg	University of Texas, Galveston, Texas

Requests from outside organizations for information on specific items related to the MRI Biomedical Applications Team activities were received from and furnished to:

Ames Research Center, Moffett Field, California	Flexible tether, muscle accelerometer
Research Triangle Institute, Durham, North Carolina	Respirometer helmet, cardiac output measurement, sterile operating rooms, police uniforms, EEG telemetry
Research Triangle Institute, San Antonio, Texas	An ultrasonic energy coupling unit, gas measurement
Radio Corporation of America, Trenton, New Jersey	Muscle accelerometer
Veterans Administration Hospital, Kansas City, Missouri	Pressure transducers
Brooke Army Medical Center, Houston, Texas	Respirometer helmet
McDonnell Douglas Corp., St. Louis, Missouri	Valve technology
National Institutes of Health, Bethesda, Maryland	Muscle accelerometer
Dr. M. Spector, Philadelphia, Pennsylvania	Head movement measurement
Siemens Medical of America, Addison, Illinois	Spray-on electrodes
Dr. J. H. Isaacs, Beverly Hills, California	Spray-on electrodes and respirometer helmet
Dr. S. J. Updike, Madison, Wisconsin	Spray-on electrode
Lewis Research Center, Cleveland, Ohio	X-ray enhancement system

University of Missouri, Columbia, Missouri	NASA information retrieval system, hyperbaric chamber instrumentation
Montefiore Hospital, New York, New York	Respirometer helmet and spray-on electrodes
Continental Research Institute, New York, New York	Spray-on electrodes
Mennan-Greatbatch Electronics Company, Clarence, New York	Spray-on electrodes
Marshall Space Flight Center, Huntsville, Alabama	Gas analysis
University of Kansas Medical Center, Kansas City, Kansas	Spray-on electrodes
Sigma Educational Films, Studio City, California	Respirometer helmet
Methodist Hospital, Dallas, Texas	Respirometer helmet

IV. CONCLUSIONS AND RECOMMENDATIONS

The following four conclusions are based upon the experiences of the MRI Biomedical Applications Team during this contract period:

1. There are numerous biomedical engineering problems which handicap the progress of life science research in this country. Many of these problems can be solved through the application of aerospace-generated technology. The Biomedical Applications Team is an effective method for determining existing biomedical problems and assisting the application of aerospace-generated technology to the solution of these problems.

2. It is desirable for the Biomedical Applications Teams to serve as many medical institutions as possible, instead of concentrating on a small number of institutions. More transfers of technology can be expected if the number of appropriate biomedical problems is increased.

3. The MRI Biomedical Applications Team has been able to identify technology which appears to be applicable to about 50 percent of the biomedical problems investigated.

4. Judging from the number of requests for information on the Biomedical Applications Teams Program, there is considerable interest being generated in this program.

It is recommended that the Biomedical Applications Team Program be continued and expanded.

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APPENDIX I

LITERATURE SEARCH REPORTS

Problem Number:	MU-19	Search Number:	ASTRA 1091
Search Title:	Electrocardiography		
Date Search Initiated:	August 28, 1968		
Search Terms:	Electrocardiography		
Date Search Received:	September 20, 1968		
Number of Citations:	438		
Relevance of Search:	Comprehensive and excellent		

* * * * *

Problem Number:	MU-22	Search Number:	ASTRA 1103
Search Title:	Speed Reducer		
Date Search Initiated:	January 22, 1969		
Search Terms:	Reduction Speed Mechanical Gear Transmission		
Date Search Received:	January 24, 1969		
Number of Citations:	15		
Relevance of Search:	Poor		

* * * * *

Problem Number: MU-25 Search Number: ASTRA 1110

Search Title: Heart Magnetic Fields

Date Search Initiated: March 13, 1969

Search Terms: Electromagnetic field
Heart
Electromagnetic measurement
Magnetic field

Date Search Received: March 17, 1969

Number of Citations: 4

Relevance of Search: Poor

* * * * *

Problem Number: MU-28 Search Number: ASTRA 1108

Search Title: Digital Filter Software

Date Search Initiated: March 13, 1969

Search Terms: Computer program
Filter
Fitting
Polynomial
Curve
Computer programming

Date Search Received: March 17, 1969

Number of Citations: 40

Relevance of Search: Very good.

* * * * *

Problem Number: MU-34 Search Number: ARAC C3919

Search Title: Electrocardiogram Analysis

Date Search Initiated: April 28, 1969

Search Terms: Electrocardiogram
Computer program
Computer
Computers
Data Processing

Date Search Received: May 16, 1969

Number of Citations: 32

Relevance of Search: Investigator is evaluating search.

* * * * *

Problem Number: KU-32 Search Number: ASTRA 1117

Search Title: Oxygen Partial Pressure

Date Search Initiated: April 17, 1969

Search Terms: Partial pressure
Oxygen breathing
Oxygen sensor
Oxygen detector
Oxygen tension
Respiration
Gas analyzer

Date Search Received: April 4, 1969

Number of Citations: 104

Relevance of Search: Investigator is evaluating search.

* * * * *

Problem Number: KU-33 Search Number: ASTRA 1118

Search Title: Water Vapor Partial Pressure

Date Search Initiated: April 17, 1969

Search Terms: Partial pressure
Water vapor
Respiration

Date Search Received: April 22, 1969

Number of Citations: 0

Relevance of Search: Poor

* * * * *

Problem Number: KU-34 Search Number: ASTRA 1120

Search Title: Impedance Pneumograph

Date Search Initiated: April 17, 1969

Search Terms: Pneumography
Pneumograph

Date Search Received: April 22, 1969

Number of Citations: 48

Relevance of Search: Investigator is evaluating search.

* * * * *

Problem Number: KU-35 Search Number: ASTRA 1116

Search Title: Flowmeter

Date Search Initiated: April 9, 1969

Search Terms: Flow measurement
Flow meter
Flowmeters
(A general search)

Date Search Received: April 9, 1969

Number of Citations: 456

Relevance of Search: Investigator is evaluating search.

* * * * *

Problem Number:	KU-38 Search Number: ASTRA 1119
Search Title:	Speech Simulator
Date Search Initiated:	April 17, 1969
Search Terms:	Learning system Speech Simulator Teaching machine Video equipment Tape recorder Simulators Learning machines Teaching machines
Date Search Received:	April 22, 1969
Number of Citations:	4
Relevance of Search:	Fair, documents contain some topics that investigator had not considered.

* * * * *

Problem Number:	UM-16 Search Number: 1057-ASTRA
Search Title:	Optimum Response Conditions
Date Search Initiated:	4-29-69
Search Terms:	Simultaneous Linear Equation
Date Search Received:	6-28-68
Number of Citations:	233
Relevance of Search:	Good reference information, but contains no solutions to the problem.

* * * * *

Problem Number: UM-17 Search Number: 1058- ASTRA

Search Title: Fabrication of Foot Support Devices

Date Search Initiated: 4-29-68

Search Terms:
Lightweight
Fabrication
Material
Casting
Orthopedics
Foot
Support

Date Search Received: 6-28-68

Number of Citations: 34

Relevance of Search: Low

* * * * *

Problem Number: UM-19 Search Number: 1059-ASTRA

Search Title: Heart Sounds

Date Search Initiated: 4-29-68

Search Terms:
Phonocardiography
Heart
Sound Detector
Phonocardiogram

Date Search Received: 6-18-68

Number of Citations: 27

Relevance of Search: Poor

* * * * *

Problem Number: UM-20 Search Number: 1060-ASTRA

Search Title: Gamma Source

Date Search Initiated: 4-29-68

Search Terms: Radiation Source
Gamma Radiation
Radioactive Material

Date Search Received: 6-18-68

Number of Citations: 30

Relevance of Search: Good; documents will be used for class instruction and future research work.

* * * * *

Problem Number: UM-21 Search Number: 1061-ASTRA

Search Title: Blue Duct Valve

Date Search Initiated: 4-29-68

Search Terms: Urology
Prosthetics
Valve
Remote Control
Magnetic Control
Biotelemetry

Date Search Received: 6-18-68

Number of Citations: 12

Relevance of Search: Poor

* * * * *

Problem Number: UM-22 Search Number: 1062-ASTRA

Search Title: Mass Spectrometer

Date Search Initiated: 4-29-68

Search Terms: Oxygen 18
Mass Spectrometer
Mass Spectrometry
Mass Spectroscopy

Date Search Received: 6-18-68

Number of Citations: 2

Relevance of Search: Poor

* * * * *

Problem Number: UM-23 Search Number: 1063-ASTRA

Search Title: Chemo-Sensors for Body Functions

Date Search Initiated: 4-29-68

Search Terms: Biosensor
Bioassay
Sensor
Biochemistry

Date Search Received: 6-18-68

Number of Citations: 73

Relevance of Search: Poor

* * * * *

Problem Number: UM-24 Search Number 1064-ASTRA

Search Title: Analysis of Scope Traces

Date Search Initiated: 4-29-68

Search Terms: Image Correlation
Automatic Pattern Recognition

Date Search Received: 6-18-68

Number of Citations: 131

Relevance of Search: Two documents appeared to contain relevant information.

* * * * *

Problem Number: UM-25 Search Number: 1065-ASTRA

Search Title: Digital Conversion of Scope Traces

Date Search Initiated: 4-29-68

Search Terms: Analog-to-Digital Converter
Scanner
Scanning Device
Optical

Date Search Received: 6-18-68

Number of Citations: 62

Relevance of Search: Investigator is evaluating search.

* * * * *

Problem Number: UM-26 Search Number: 1066-ASTRA

Search Title: Visual Perception Box

Date Search Initiated: 4-29-68

Search Terms: Visual Perception
Equipment
Apparatus
Spatial Perception
Depth Perception
Vertical Perception
Test Chamber
Pattern Recognition

Date Search Received: 6-19-68

Number of Citations: 38

Relevance of Search: Investigator is evaluating search.

* * * * *

Problem Number: UM-27 Search Number: 1067-ASTRA

Search Title: Remote Patient Monitoring

Date Search Initiated: 4-29-68

Search Terms:
Patient
Monitor
Remote
Electrocardiography
Electroencephalography

Date Search Received: 6-18-68

Number of Citations: 15

Relevance of Search: One document is directly applicable to problem.

* * * * *

Problem Number: UM-28 Search Number: 1068-ASTRA

Search Title: Bacteria Detection

Date Search Initiated: 4-29-68

Search Terms:
Electromotive Force
Electrode
Bacteria
Microorganism

Date Search Received: 6-20-68

Number of Citations: 8

Relevance of Search: Very Low.

* * * * *

Problem Number: UM-29 Search Number: 1069-ASTRA

Search Title: Portable ECG Recorder

Date Search Initiated: 4-29-68

Search Terms:
Tape Recorder
Arrhythmia
Electrocardiogram
Electrocardiography

Date Search Received: 6-20-68

Number of Citations: 0

Relevance of Search: Poor

* * * * *

Problem Number: UM-30 Search Number: 1070-ASTRA

Search Title: Arrhythmic Heart Correction

Date Search Initiated: 4-29-68

Search Terms:
Arrhythmia
Fibrillation
Seismocardiography
Electric Stimulus
Heart Rate
Pulse Rate

Date Search Received: 6-20-68

Number of Citations: 57

Relevance of Search: Investigator is evaluating search.

* * * * *

Problem Number: UW-20 Search Number: 1055-ASTRA

Search Title: High Impedance Amplifier

Date Search Initiated: 4-29-68

Search Terms: Bioinstrumentation
Biotelemetry

Date Search Received: 6-24-68

Number of Citations: 132

Relevance of Search: Low

* * * * *

Problem Number: UW-21 Search Number: 1056-ASTRA

Search Title: Foot to Floor Measurement

Date Search Initiated: 4-29-68

Search Terms: Pedal
Force Distribution
Foot
Pressure Transducer

Date Search Received: 6-24-68

Number of Citations: 99

Relevance of Search: Researcher left school; problem closed.

* * * * *

Problem Number: FH-1 Search Number: 130160 (MEDLARS)

Search Title: Bloodless Perfusion in Tissue Preservation

Date Search Initiated: 11-15-68

Search Terms: Perfusion
Isolation Perfusion
Limbs
Muscles
Organs
Blood Vessels

Date Search Received: 1-20-69

Number of Citations: 651

Relevance of Search: Extremely comprehensive; at least 12 articles are pertinent to the problem.

* * * * *

Problem Number: FH-2 Search Number: 1094

Search Title: Weight Measurement

Date Search Initiated: 9-20-68

Search Terms: Measuring apparatus weight

Date Search Received: 10-8-68

Number of Citations: 34

Relevance of Search: Fair. No specific solution to problem.

* * * * *

Problem Number: FH-3 Search Number: 1093

Search Title: Nerve Measurements

Date Search Initiated: 11-1-68

Search Terms: Nerve
Measurement
Measuring Apparatus
Measuring Instruments

Date Search Received: 11-13-68

Number of Citations: 10

Relevance of Search: Poor

* * * * *

Problem Number: FH-4 and UM-31 Search Number: 1071

Search Title: Continuous Measurement of pH, PO_2, PCO_2

Date Search Initiated: 5-31-68

Search Terms:
Oxygen Detector
Oxygen Analyzers
pH
Carbon Dioxide
Partial Pressure
Measuring Instruments

Date Search Received: 6-17-68 (for Problem UM-31)

Number of Citations: 44

Relevance of Search: Most of the material is quite relevant to the researcher's problem.

* * * * *

Problem Number: FH-6 Search Number: 1095

Search Title: Microsurgical Techniques

Date Search Initiated: 11-1-68

Search Terms:
Surgery
Miniaturization
Subminiaturization

Date Search Received: 11-13-68

Number of Citations: 173

Relevance of Search: Researcher considered this good review material, but not directly applicable to the specific problem.

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APPENDIX II

Papers presented at the Annual Meeting of the Asociation for the Advancement of Medical Instrumentation, Houston, Texas, 17 July 1968.

"Recent Successes Utliizing Aerospace Technology"

"Evaluating Aerospace Technology on the Medical Setting"

RECENT SUCCESSES UTILIZING AEROSPACE TECHNOLOGY

by

David Bendersky
Director, MRI Biomedical Applications Team

The Biomedical Applications Team at Midwest Research Institute is working with six midwest medical institutions to solve biomedical engineering problems through the application of aerospace technology. The medical institutions with who we are working are the University of Kansas Medical Center, the University of Missouri Medical School, St. Louis University School of Medicine, the University of Minnesota Medical School, Wisconsin University, and Northwestern University Medical School.

I would like now to describe several of our recent successes.

X-Ray Enhancement

In connection with a study of equipment and techniques for processing and diagnosing x-rays, medical investigators at the University of Missouri Medical School asked us to assist them in the problem of enhancing the contrast in x-ray films. A search of the NASA literature revealed a technique for enhancing x-ray photographs, developed at the Jet Propulsion Laboratory, which was derived from techniques developed

Presented at the Annual Meeting of the Association for the Advancement of Medical Instrumentation, Houston, Texas, July 17, 1968.

in the Mariner space program.[1] In brief, the basic technique is to first convert the original photograph into digital form, then a computer program is applied to enhance the data, and finally the enhanced data is converted back into a photograph (Figure 1). The x-ray on the left is an original angiogram of a human skull, taken to show the blood vessels in the head. The photograph on the right is the same x-ray after it had been processed by the JPL system. Note how much clearer the blood vessels stand out in the enhanced photograph.

The University of Missouri Medical School is now considering setting up an x-ray enhancement system based on the JPL system. Consideration is also being given to setting up such a system at the University of Kansas Medical Center. In the later institution, the data will be transmitted from the hospital in Kansas City to the computer located at Lawrence, about 30 miles away, processed and transmitted back to the hospital in a matter of a few minutes.

Ear Specimens

The internal ear, called the labyrinth (because of its complicated structure) consists of two parts, a series of cavities within the temporal bone, and the membranous labyrinth, which is a series of communicating sacks and ducts contained within the bony cavities. The inner ear of a cat with the surrounding bone is shown in Figure 2. In the preparation of specimens of the membranous labyrinth, it is necessary to remove the

outer bone without injuring the delicate internal structure. This is normally a tedious, time-consuming task of dissolving and chipping away the bony structure. The MRI BA Team suggested using a special air abrasive device. Dr. Fernando Kirchner, University of Kansas Medical Center, tried this device and found that it worked very well.[2] Figure 3 shows the operation. A majority of the bone is removed with the air-abrasive device in a comparatively short period of time. The remainder of the bone is removed with a decalcifying agent. Accurate specimens of the inner ear have been successfully obtained in this manner. Figure 4 is a specimen of a cat's inner ear, and Figure 5 is a human inner ear, both obtained with this new technique, by Dr. Kirchner at the University of Kansas Medical Center.

Temperature Telemetry

At the University of Wisconsin, a long-range study of the reproductive process is being conducted. In connection with this work, there is a need to measure the temperature of the internal organs in monkeys. Temperature changes as small as 2/100°F must be detected, and the instrument must remain operative inside the animal over a period of several months.

A search of the NASA literature revealed work done at the NASA Ames Research Center, California, on a tiny temperature telemetry unit,[3] shown in Figure 6. Information on this unit was forwarded to the

investigators at the University of Wisconsin. Two of these units were obtained through a commercial source, and are now being tested inside monkeys. The last report indicated that the units are working very satisfactorily after being implanted for over three months.

Remote Examination of Patients

As a part of the health system in the proposed university of Minnesota Experimental City Project, consideration is being given to a system which will permit a patient to be examined in the home by a physician at a remote location, such as a neighborhood health center. The idea is that such a system would encourage citizens to cooperate with the health care program on a preventative "stitch in time saves nine" basis. A search of the literature revealed a system for monitoring patients remotely, which has been developed by the Boeing Company for the NASA Marshall Space Flight Center.[4/] The system consists of a central control station and a number of battery-operated patient units, consisting of small strap-on electronic packages, shown in Figure 7. The patient units are designed to ensure minimum encumbrance and discomfort to the patients. A complete unit, including batteries, weighs less than 1 lb. The system, which has now undergone feasibility tests, is capable of collecting 6 channels of data, including electrocardiograms, tempeatures, blood pressure, etc., from up to 64 patients.

Other recent transfers, which have been completed or in progress, include:

1. Non-intrusive method to measure cardiac output.
2. Respiratory gas analyses, on a breath-to-breath time basis.
3. Sterile operating and post-operative rooms.
4. Measurement of bone distortion and integrity.
5. Micro-circulation measurement.
6. A flexible/rigid tether for prosthetics.
7. An improved system for deliverying medication to the respiratory tract.

In summary, the MRI Biomedical Applications Team is very active in applying aerospace technology to bioengineering problems. Although the program has been in operation for a comparatively short period of time, there have already been a considerable number of successes and more are on the way.

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LIST OF FIGURES

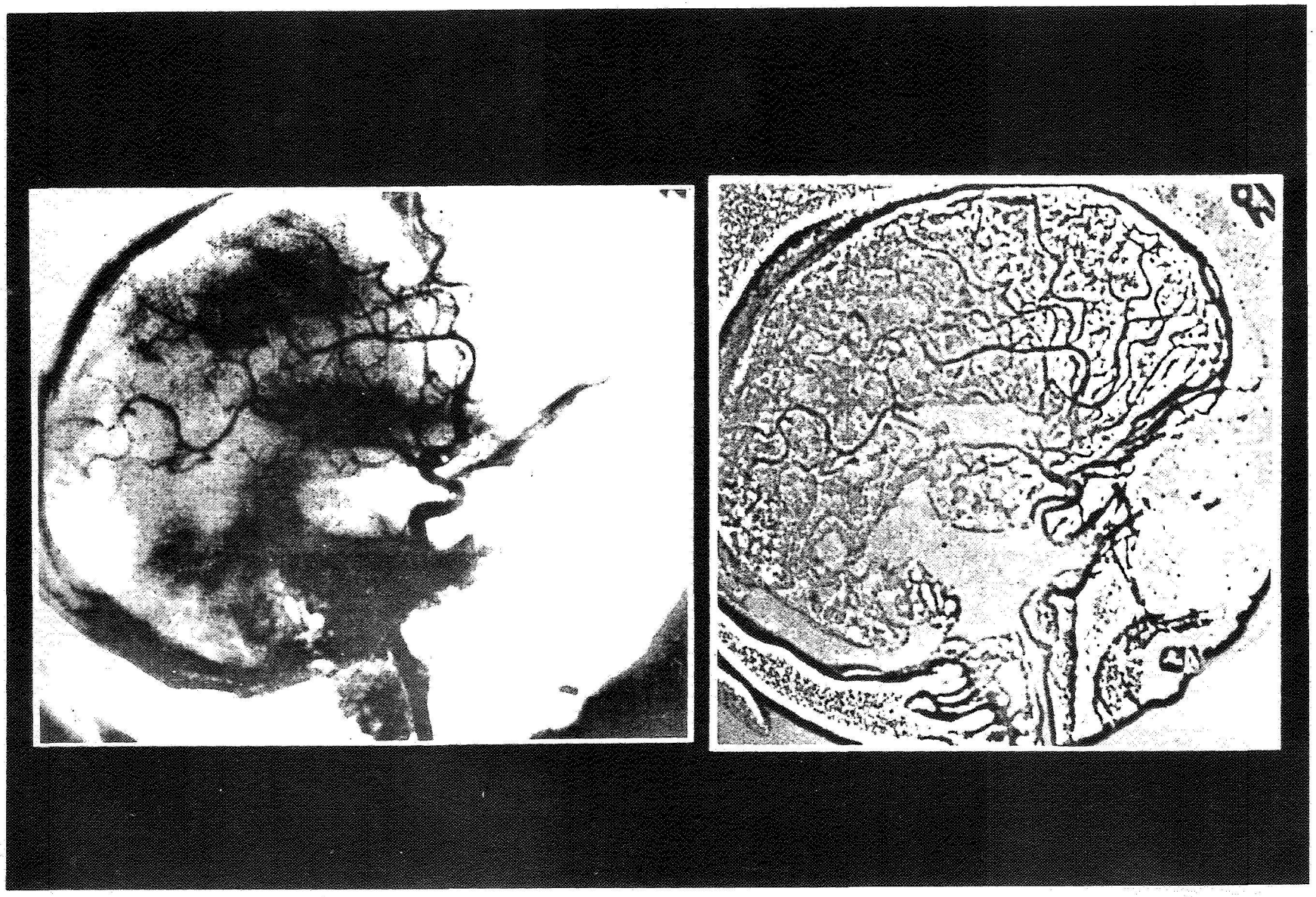


Fig. 1 - Left: Angiogram of Skull Prior to Processing
Right: Same Angiogram After Processing
(Ref. 1)

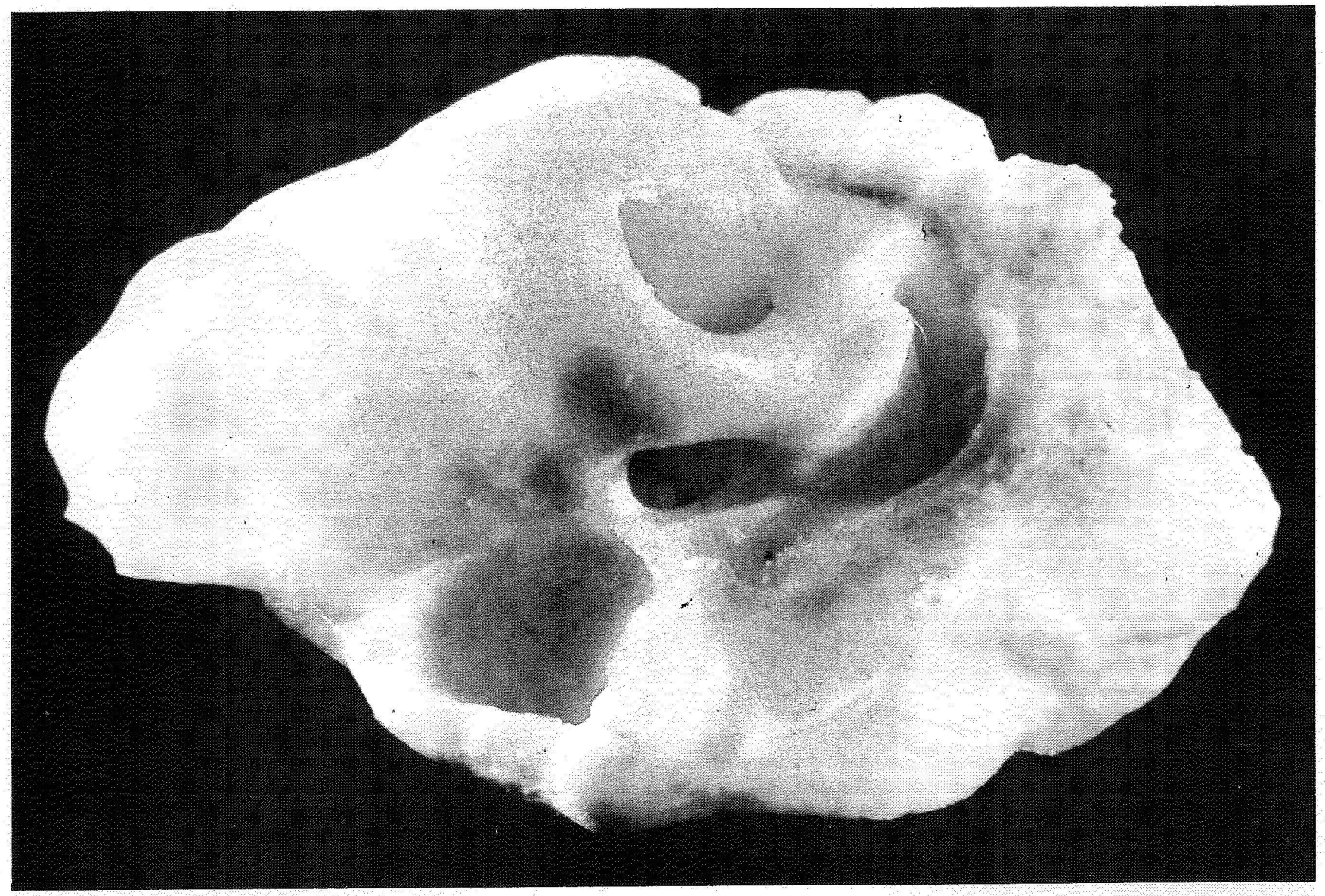


Fig. 2 - Inner Ear of Cat with Surrounding Bone (Courtesy Dr. F. Kirchner, University of Kansas Medical Center)

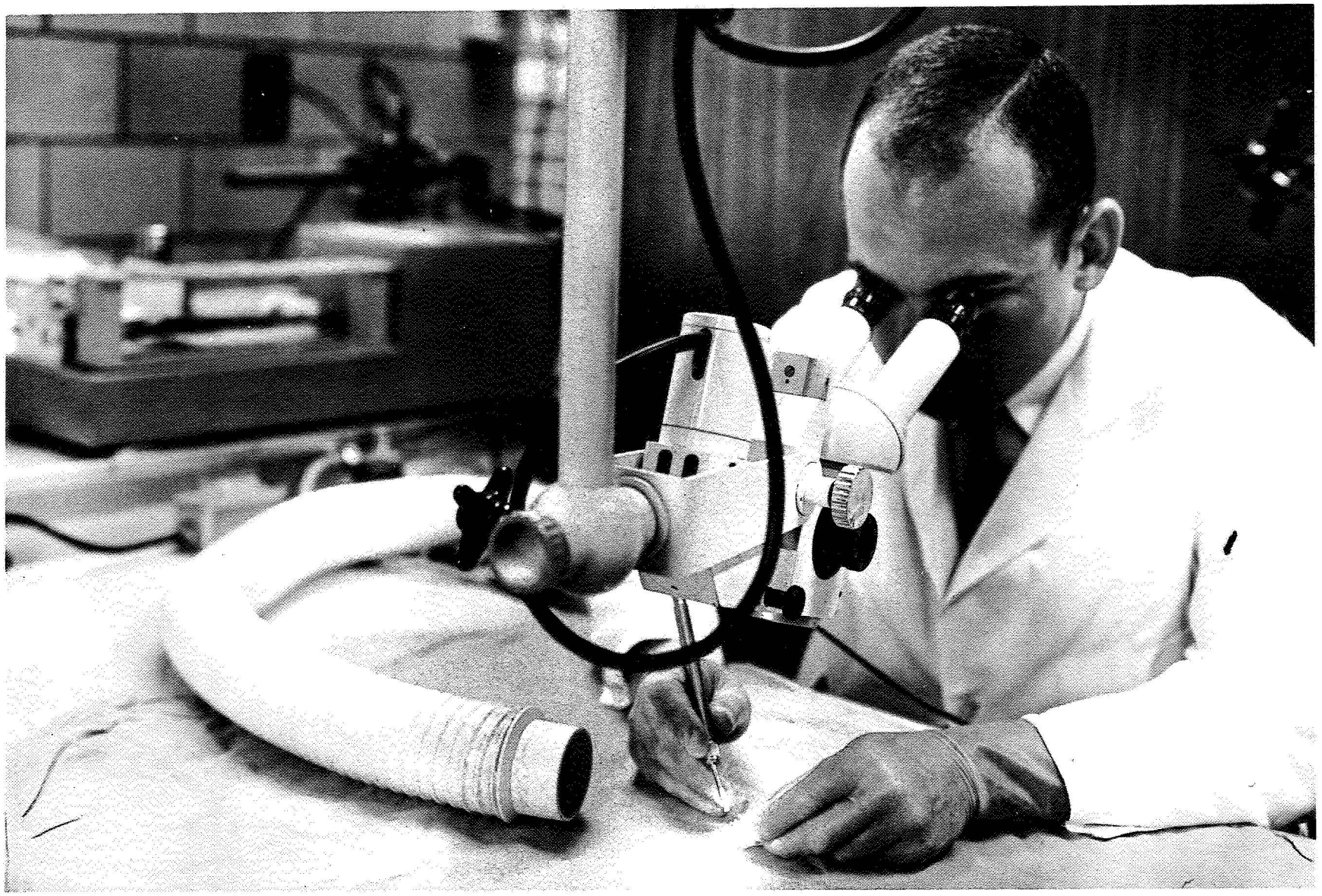


Fig. 3 - Inner Ear Bone Being Removed with Air Abrasive Device (Ref. 2)

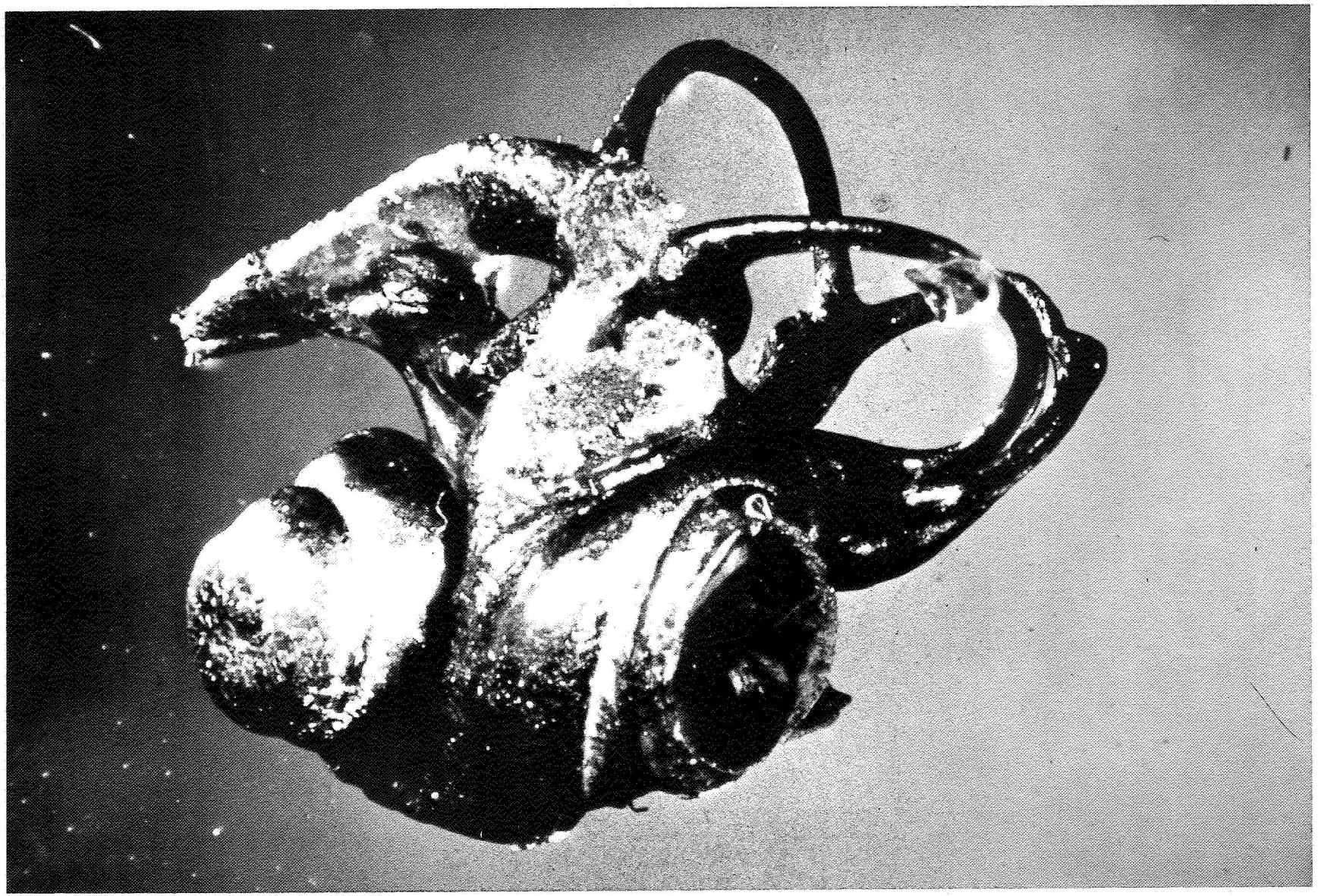
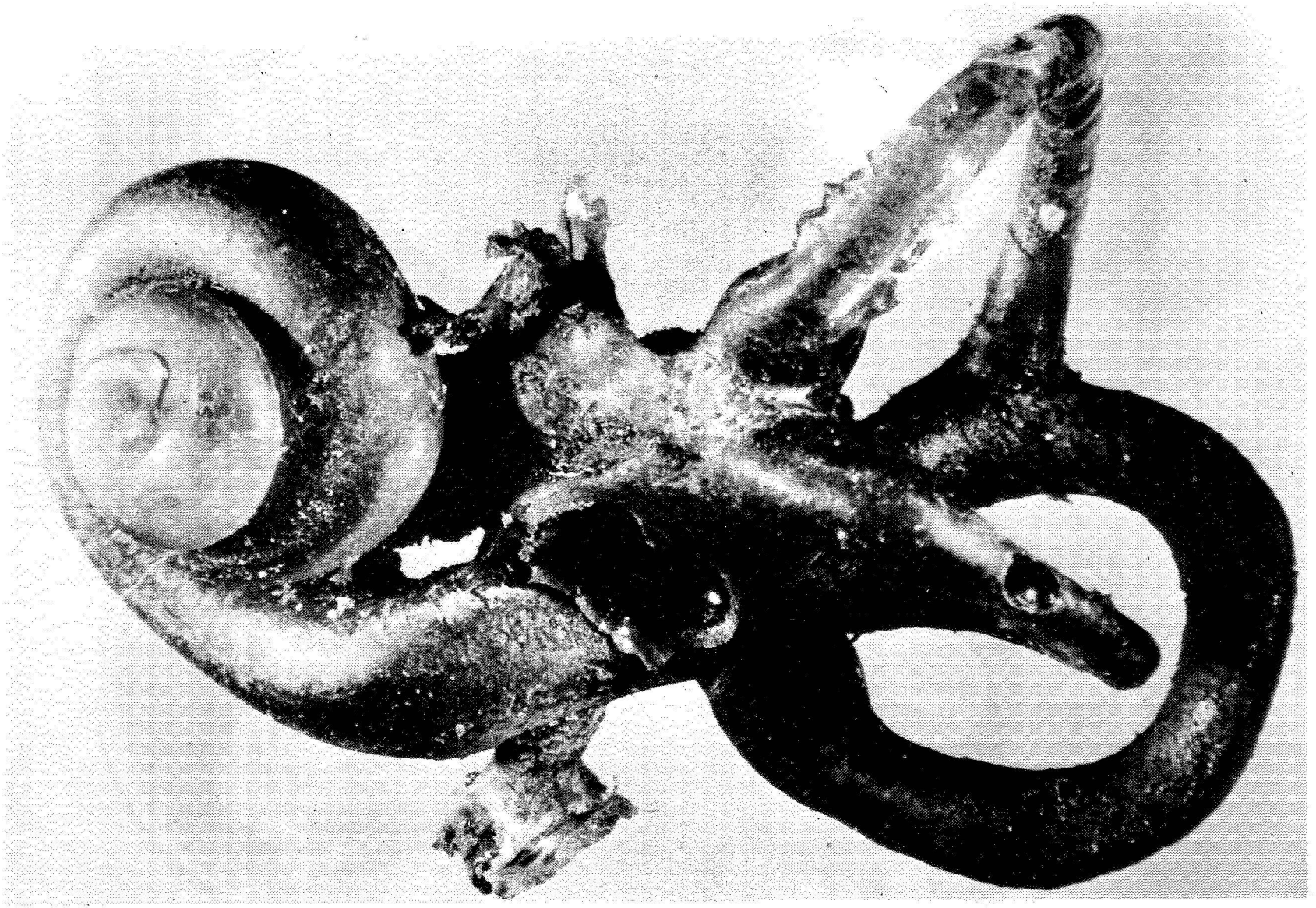


Fig. 4 - Inner Ear Specimen of Cat After Bone Removal (Courtesy Dr. F. Kirchner, University of Kansas Medical Center)



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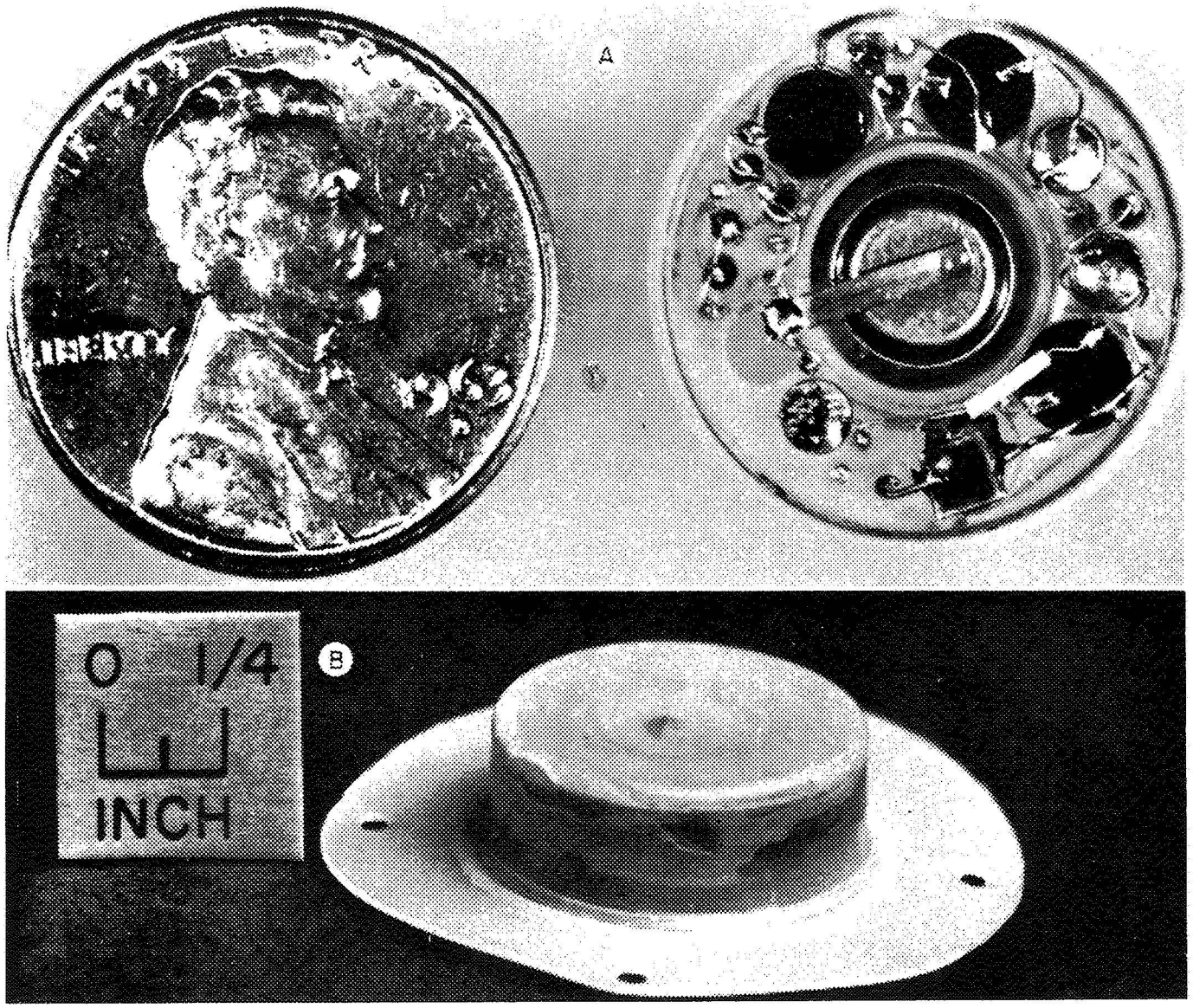

Fig. 6 - Temperature Telemetry System (Ref. 3)

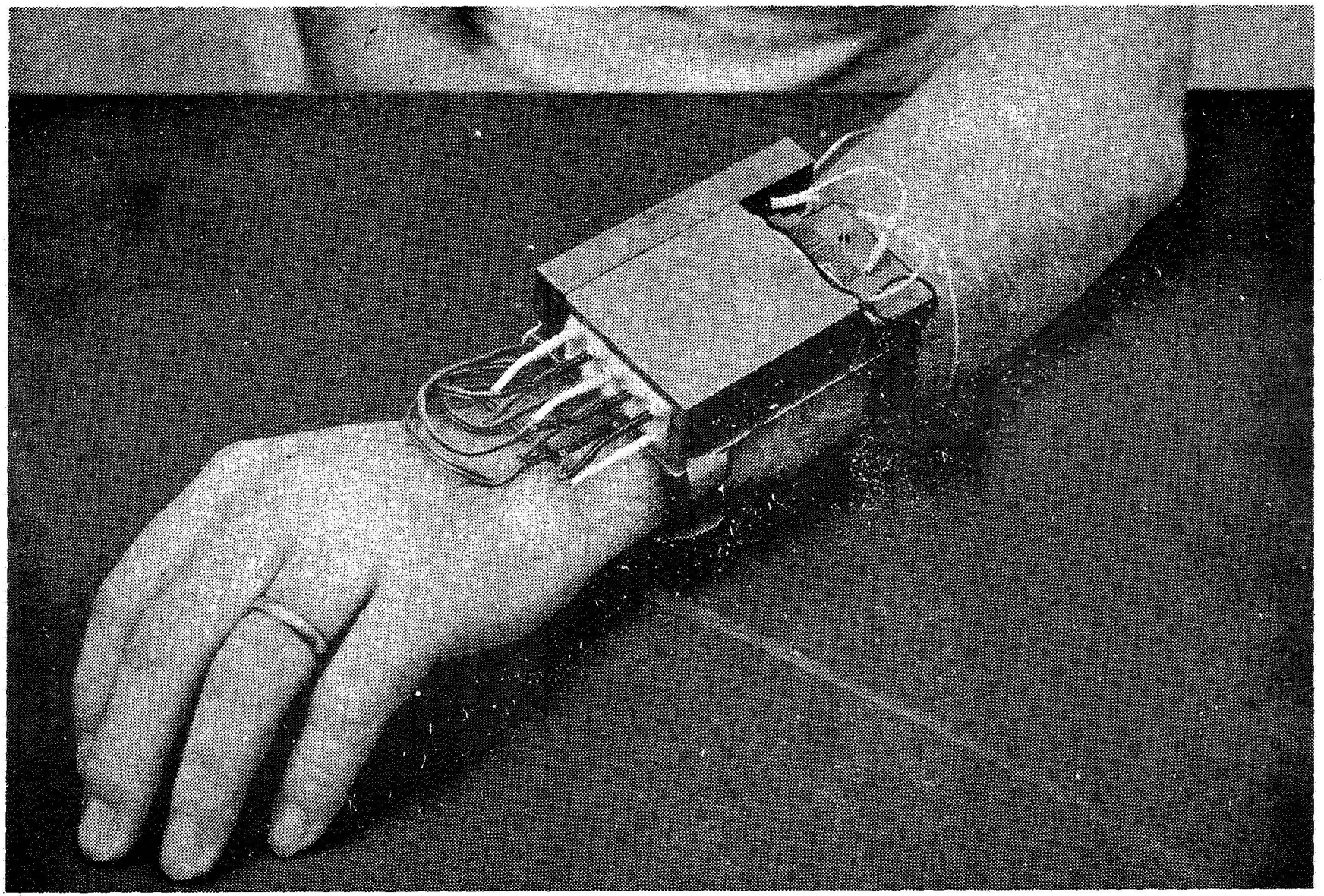

Fig. 7 - Strap-on Biotelemetry Wrist Unit (Ref. 4)

EVALUATING AEROSPACE TECHNOLOGY IN THE MEDICAL SETTING

by

David Bendersky
Director, MRI Biomedical Applications Team

One of the most important and critical steps in the process of transferring aerospace technology to the medical field is the evaluation of the technology in the medical setting. This is where potential solutions are proven or disproven. The success or failure of the evaluation is dependent on a number of factors, including the quality of the particular technology being considered, good communications between all parties involved, a thorough understanding of the capabilities and limitations of the technology, the procurement of appropriate hardware, the adaptation and modification of the original technology to the medical application, and adequate time, funds and personnel to properly evaluate the technology.

When an aerospace literature search or other information retrieval procedures revealed a potential solution to a medical equipment problem, all possible information about the technology is obtained by the Biomedical Applications Team. All available published and unpublished reports on the technology are obtained from the NASA research center or the NASA contractor who was responsible for developing the technique. If the

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reports appear promising, they are furnished to the medical investigator for his consideration. When appropriate, the medical investigator and the Biomedical Applications Team members visit the NASA installation or NASA contractor for personal discussions with the people who developed the technology.

If the evaluation of the information appears promising, the next step is usually the procurement of "hardware" for tests. In some cases a test model can be furnished by NASA. The Biomedical Applications Team will assist the medical investigator in procuring items from NASA, when such items are available. When hardware is not available through NASA, the medical investigator must make other arrangements to procure the hardware. Low cost items may be purchased directly from the investigator's resources. In the case of expensive equipment, funds are usually applied for through a grant.

In many cases, some modification of the original aerospace technology is required to adapt it to the specific medical application. If the medical investigator requires engineering assistance, each of the BA Teams represent organizations which are in a position to provide such services.

The medical investigator is entirely responsible for evaluating the aerospace technology for his particular application. He must determine the conditions under which the technology is to be tested and must make all arrangements for the tests. Furthermore, he is responsible for analyzing and interpreting the results of the tests. The BA Team will

assist the medical investigator during the evaluation tests, on a consulting basis, when requested.

At the conclusion of the evaluation tests, the medical investigator is obliged to report the results to the BA Team. If the results are positive, the medical investigator is encouraged to prepare a paper for publication in an appropriate medical journal so that the technique can be considered by others in the medical field.

Several items of NASA technology which have been successfully evaluated for non-space medical applications under the NASA Biomedical Applications Program, are shown in the Figures 1-3. The three items are (1) a respirometer helmet which was developed to replace the conventional rubber mouthpiece, (2) a muscle accelerometer which is being used to measure muscle reflexes and tremors, and (3) spray-on electrodes for electrocardiograms.

I am pleased to be able to report that each of these NASA originated items is now being routinely used in non-space medical applications. The respirometer helmet has been used to collect respiratory data on over 400 children at the University of Kansas Medical Center alone, and is now being used in several other medical institutions. The muscle accelerometer is being used not only to measure muscle reflexes but is being used to measure tremors in a study of neurological problems at the St. Louis University. At Washington University Medical School, the instrument is being used to measure larynx movement. And, the spray-on electrodes have proven themselves on thousands of subjects and is now available commercially.

REFERENCES

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2. "A New Method for Measurement of Maximal Oxygen Consumption in Children," by D. Hattan, K. R. Shankar and R. M. Lauer, University of Kansas Medical Center, presented at the Midwest Society of paper published in Journal of Pediatrics, February 1967.

3. "Muscle Accelerometer," by Sister A. Claire and Dr. L. L. Tureen, presented at the Aerospace Medical Association Annual Meeting, Washington, D.C., April 10, 1967.

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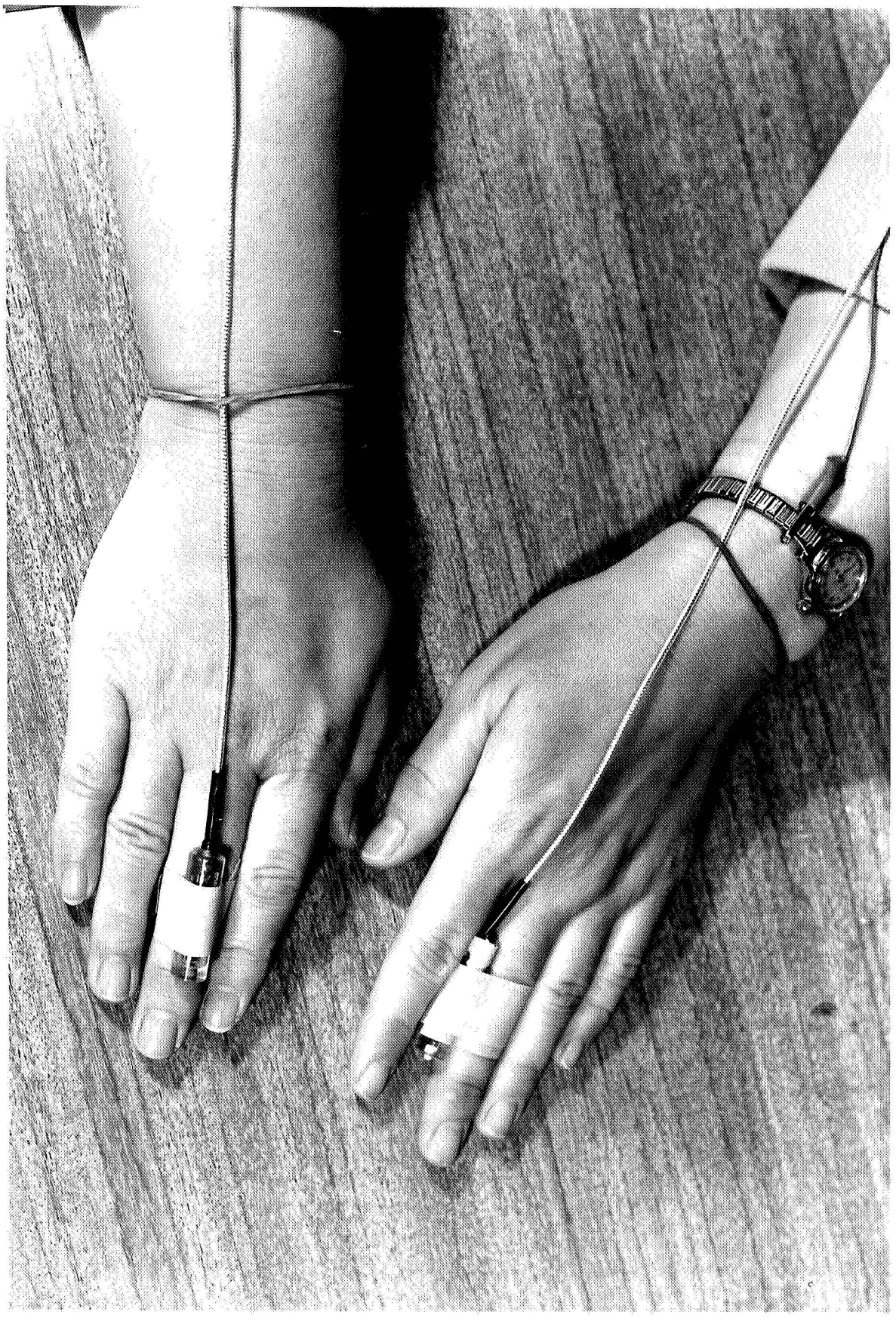

Fig. 2 - Muscle Accelerometers Used to Measure Arm and Hand Motions

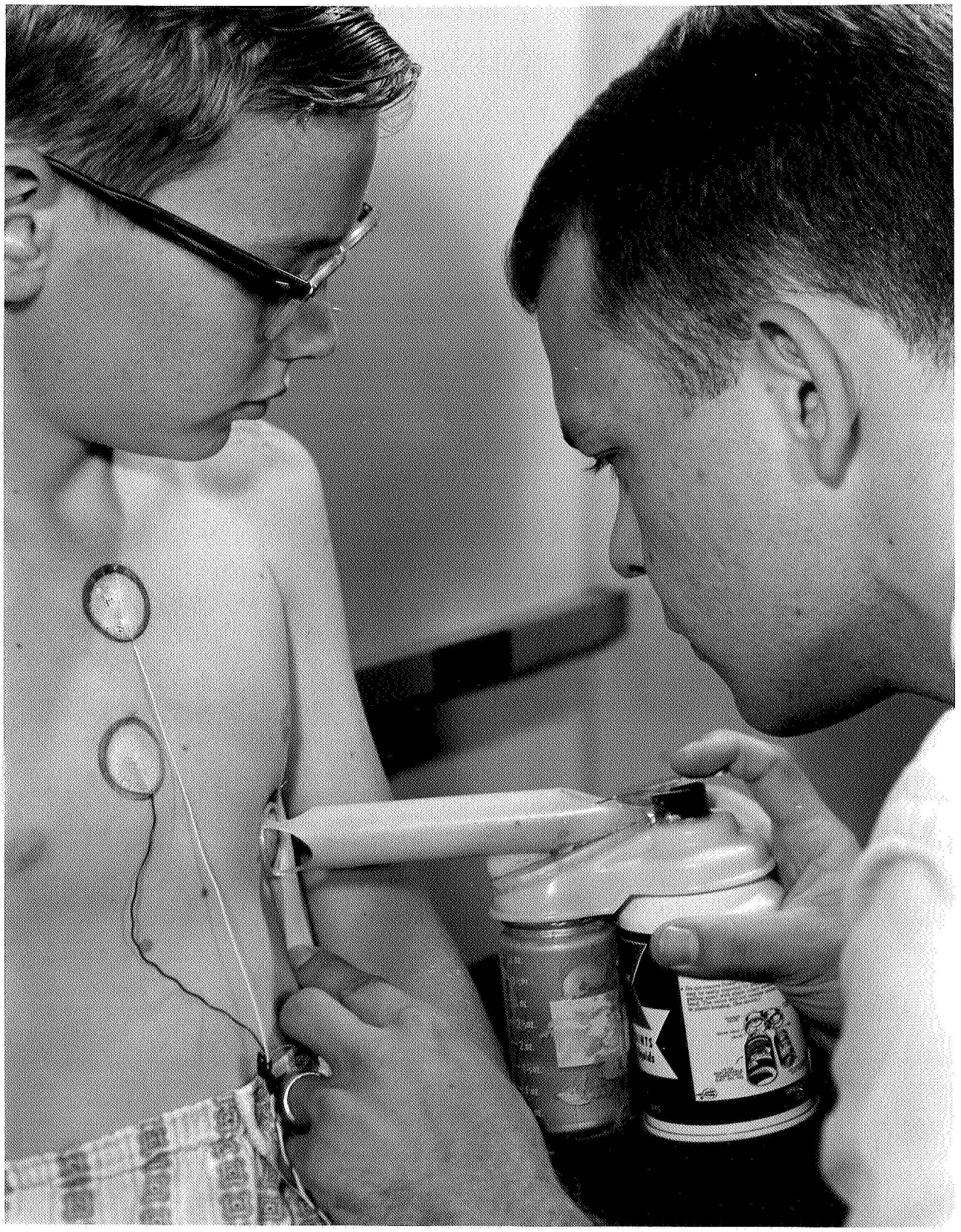

Fig. 3 - NASA Spray-On Electrocardiogram Electrodes Being Applied

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