MEDICAL APPLICATIONS OF AEROSPACE SCIENCE AND TECHNOLOGY

FINAL REPORT
1 May 1967 - 31 May 1968

NASA Contract No. NASr-63(13)
MRI Project No. 3077-E

For

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

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MIDWEST RESEARCH INSTITUTE
425 VOLKER BOULEVARD/KANSAS CITY, MISSOURI 64110/AC 816 LO 1-0202

MEDICAL APPLICATIONS OF AEROSPACE
SCIENCE AND TECHNOLOGY

by

David Bendersky

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PREFACE

This report covers the activities of the Midwest Research Institute's Biomedical Applications Team (MRI BA Team) during the period from 1 May 1967 to 31 May 1968. These activities were conducted under NASA Contract No. NASr-63(13). The contract was under the technical direction of Richard J. H. Barnes, Assistant Director for Dissemination, Technology Utilization Division, NASA, Washington, D. C. Dr. Quentin L. Hartwig, The George Washington University, was the Project Coordinator for NASA.

The MRI BA Team was directed by David Bendersky, under the general supervision of Paul C. Constant, Assistant Director of the Engineering Division. Other MRI technical staff members who contributed to this project are James K. West, Wilbur E. Goll, Dewey Garrett, Edward T. Fago, Jr., Webster D. Wood, Billy L. Rhodes, Lawrence L. Rosine, Thomas R. Castles, Ram L. Levy, Howard W. Christie, Vernon Kline, and Ralph P. Fritz.

Coordinators at the participating medical and bioengineering schools who contributed to the project are Dr. John W. Trank, University of Kansas Medical Center; Dr. William G. Kubicek, University of Minnesota Medical School; Mathew L. Petrovick, Northwestern University Medical School; Drs. Rick Heber, Robert H. Schwartz and Harry Ludwig, University of Wisconsin, Dr. James B. Reswick, Case Western Reserve University, and Blair A. Rowley, University of Missouri.

The all-important contributions of the biomedical investigators at the participating medical and bioengineering schools, whose names are given in the text in connection with each biomedical problem, are hereby gratefully acknowledged.

Approved for:

MIDWEST RESEARCH INSTITUTE

Paul C. Constant Jr.
for
Harold L. Stout, Director
Engineering Division

31 May 1968

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I. INTRODUCTION

A Biomedical Applications Team was first established at Midwest Research Institute in 1965,* under the sponsorship of the Technology Utilization Division, Office of Technology Utilization, NASA Headquarters. The purpose of the MRI BA Team is to assist in the transfer of aerospace-generated technology to applications in the non-aerospace biomedical field. In the course of its concern with the well being and functional capabilities of man in space, NASA has generated an extensive amount of technology which pertains directly to the biomedical field. In addition, the aerospace program has led to the development of a host of technical innovations which may be applicable to biomedical equipment.

To efficiently transfer applicable science and technology from the aerospace program to the medical field requires the establishment and conduct of an orderly and effective procedure. The procedure developed by the MRI BA Team consists of five basic steps. The first step is to define specific biomedical problems. These problems are obtained from the research staffs at participating medical and bioengineering schools. The second step is to identify potential solutions to the biomedical problems. The identification of potential solutions is done through literature searches, circulation of problem abstracts to NASA research centers and aerospace contractors, and personal contacts. The third step is to modify the original technology, as required, to adapt it to the biomedical problem. The fourth step is the evaluation of the technology by the investigators who submitted the problem. The final step is to document and disseminate information on successful transfers.

Eight medical and bioengineering schools are presently participating in the MRI BA Team program. These schools are: the University of Kansas Medical Center, Kansas City, Kansas; St. Louis University School of Medicine, St. Louis, Missouri; the University of Minnesota Medical School, Minneapolis, Minnesota; Northwestern University Medical School, Evanston and Chicago, Illinois; the University of Wisconsin Medical Center, Madison, Wisconsin; Case Western Reserve University, Cleveland, Ohio; University of Missouri Medical Center, Columbia, Missouri; and Wayne State University,** Detroit, Michigan.

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* The activities of the MRI BA Team prior to the present report period are described in References 1 and 2.

** Wayne State University is being served under a separate contract (Contract No. NASr-63(11)).

During this contract period, the MRI BA Team worked on 94 biomedical problems submitted by the participating medical schools. Eighteen problems were for the University of Kansas Medical Center, three problems for the St. Louis University School of Medicine, 28 problems for the University of Minnesota Medical School, four problems for Northwestern University Medical School, five problems for Case Western Reserve University, 18 problems for the University of Wisconsin Medical Center, and 18 problems for the University of Missouri. One special problem was conducted for the International Association of Police Chiefs. Sixty-seven of the problems were new and 28 problems had been carried over from the previous contract. The new problems, those submitted by the school during this report period, are marked with an (N).

Sixty-three computerized NASA literature searches were conducted (through ARAC and ASTRA) in an effort to find solutions to the problems. As a result of these literature searches and other retrieval techniques, the MRI BA Team identified potential solutions for 46 problems. These potential solutions were submitted for evaluation to the medical investigators who had submitted the problems. Twenty-two of these items resulted in successful technology transfers, the technology having been found by the medical investigators to be useful in connection with their problems. These transfers are marked with an asterisk (*).

II. ACTIVITIES ON BIOMEDICAL PROBLEMS

A. University of Kansas Medical Center Problems

Electrocardiogram Electrodes; Problem No. KU-1; Medical Investigators, Drs. R. M. Lauer and J. W. Trank: The problem of obtaining satisfactory electrocardiograms on children under exercise conditions had previously been solved by the MRI BA Team through the application of a spray-on electrode technique developed at the NASA Flight Research Center.[1,2,3]

Two technical papers were published on this application of the NASA spray-on electrodes during this report period. "A Spray-On Electrode for Recording the Electrocardiogram During Exercise," by J. Trank, R. Fetter, and R. M. Lauer, was published in the Journal of Applied Physiology, February, 1968. "A Muscle Accelerometer and Spray-On Electrocardiogram Electrodes," by D. Bendersky, was presented by P. Constant at the International Conference on Medical and Biological Engineering, Stockholm, Sweden, August 18, 1968, and was published in the Digest of the Seventh International Conference on Medical and Biological Engineering, August 14-19, 1968. Copies of these two papers are in Appendix I.

Additional requests* for information on the NASA spray-on electrodes were received by the MRI BA Team from 17 domestic and foreign organizations, listed in Appendix II, during this report period. Over 200 requests for copies of the paper by Trank, Fetter and Lauer have been received at the University of Kansas Medical Center.

A commercial version of these spray-on electrodes, shown in Figure 1, Appendix III, produced by the Hauser Research and Engineering Company, Boulder, Colorado, was evaluated at the University of Kansas Medical Center. The first units were unsatisfactory because of drippage and clogging. The Hauser Company subsequently furnished modified units, which were tested and found to be satisfactory.

* Oxygen and Carbon Dioxide Measurement During Respiration; Problem No. KU-2; Medical Investigator, Dr. R. M. Lauer: In studies of exercise physiology, there is a need for continuous breath-to-breath measurements of oxygen consumption and carbon dioxide generation. Apparatus presently being used is too slow to permit breath-to-breath analysis. Through personal contacts, the MRI BA Team learned that a fast response gas analyses apparatus is being developed for NASA at the University of Minnesota,[4] which will be able to measure oxygen and carbon dioxide on a breath-to-breath basis. Gas analysis is accomplished by means of a quadrupole mass spectrometer which can analyze respiratory gases every 20 ms. The application of this system to this problem was discussed at a meeting of representatives of the University of Minnesota, the University of Kansas Medical Center, and the MRI BA Team. The medical investigator, Dr. R. Lauer, expressed an interest in evaluating the system in connection with his application. The system is expected to be completed soon, at which time arrangements will be made to obtain one for evaluation on this problem.

The presence of water vapor in exhaled breath causes difficulties in obtaining accurate measurement of oxygen concentration. A routine review of NASA Tech Briefs revealed a potential solution to this problem developed for the Manned Spacecraft Center. This instrument determines the oxygen concentration in a gas mixture by measuring the absorption of ultraviolet radiation through a sampling cell at two different wavelengths in order to eliminate the effects of ultraviolet absorption by water vapor. A brief description of the instrument is given in NASA Tech Brief 67-10387, Appendix IV. Additional information, furnished by John Wheeler, TU Officer, Manned Spacecraft, and Perkin-Elmer Company, developers of the device was provided to Dr. Lauer. Dr. Lauer is now in the process of obtaining one of these units from the Perkin-Elmer Company.

* Forty-four requests were received during the previous contract.

Dissolved Gases in the Blood; Problem No. KU-3; Medical Investigator, Dr. R. M. Lauer: Improved methods for measuring pH and the partial pressures of oxygen and carbon dioxide in blood are needed. The present instruments are unreliable, fragile and inaccurate. A manual search revealed a paper by Woldring, Owens, and Woolford[5/] which describes a process in which gases were sampled directly from circulating blood through a membrane at the tip of an intravascular cannular that was connected to the analyzing section of a mass spectrometer. A copy of this paper has been sent to Dr. Lauer for evaluation.

Exhaled Breath Collector; Problem No. KU-5; Medical Investigator, Dr. R. M. Lauer: The respirometer helmet technology transfer, described in a previous report,[2/] was continued to be used successfully at the University of Kansas Medical Center to collect exhaled breath for continuous oxygen analysis.

Inquiries on this helmet were received from the University of Illinois; Texas Medical Center; Pennsylvania State University; Stanford University School of Medicine; the Veriflo Corporation; Richmond, California; Hankscraft Company, Reedsburg, Wisconsin; NASA Ames Research Center; Dr. J. H. Issacs, Beverly Hills, California. The requested information was furnished by the MRI BA Team. Medical researchers at the University of Illinois have fabricated and are using one of these helmets in their Children's Research Center, and the Texas Medical Center have indicated that they are planning to use these helmets in their reduced gravity simulator program. A sample helmet was furnished to the NASA Lewis Research Center for display at the Conference on Aerospace Related Technology for Industry and Commerce, 25 May 1967.

Protection for Athletes; Problem No. KU-7; Medical Investigator, Dr. L. Peltier: A thermoplastic rubber material,[6/] developed at the Jet Propulsion Laboratory, was investigated as a possible method to protect athletes. Consideration was given to spraying the material on to the vulnerable areas of the body. Unfortunately, information received from the California Institute Research Foundation, commercializers of this material, indicated that the material is not adaptable for application to the human body.

Bone Integrity; Problem No. KU-8; Medical Investigator, Dr. L. Peltier: There is a need for a nondestructive technique to test the integrity of bone *in vivo* without the necessity of x-ray observation or surgical procedures. The diagnosis of some forms of hairline and nondisplaced fractures would be greatly facilitated by a reliable method to determine bone continuity or integrity in the region of the suspected injury. In many cases, x-ray visualization are inadequate.

In response to the circulated problem abstract, a suggestion was received from the NASA Marshall Space Flight Center. A hand tool for rapid scanning of bone integrity and density has been devised at the NASA Marshall Space Flight Center. The unit is a small, portable, electrically powered ultrasonic tool, which can be used for scanning small areas of fracture sites. A description of this device is given in NASA Tech Brief 67-10486, Appendix IV. A copy of this Tech Brief has been sent to Dr. Peltier for evaluation.

Microtools for Ear Surgery; Problem No. KU-10; Medical Investigator, Dr. F. Kirchner: Microtools which can be used for surgery and manipulation in the human inner ear are needed. One of the primary problems in ear surgery is due to the excessive physical size and lack of maneuverability of present tools. Their size not only makes maneuverability a problem, but also makes visualization through the external auditory canal most difficult.

A micromanipulation tool, developed at the Jet Propulsion Laboratory, is described in NASA Tech Brief 67-10004,[7/] Appendix IV, which may be applicable to ear surgery. Information on this device has been sent to Dr. Kirchner for evaluation.

Brain Lesion Device; Problem No. KU-17; Medical Investigator, Dr. C. Brackett: An experimental model of a brain lesion device[8/] was assembled at MRI and subjected to engineering tests. The tests were made with a limited range frequency source, a high-gain pick-up receiver, and a tuner for matching the waveguide to the probe at the test frequencies. The results were negative, with no measureable energy transmitted from the probe. Development of this probe has been terminated.

Fetal Electrocardiograms;Problem No. KU-20; Medical Investigator, Dr. A. S. Wolkoff: Fetal electrocardiogram records obtained by placement of electrodes on the maternal abdomen are contaminated with muscle signals, maternal EKG, etc. A technique for separation of the fetal electrocardiogram from the composite fetal-maternal-noise recorded from the maternal abdomen is required.

A search of the aerospace literature revealed a report by W. A. Welch[9/] which appears to offer a solution to this problem. A copy of this report has been sent to Dr. Wolkoff for evaluation.

* Photographic Techniques for Body Cavities; Problem No, KU-21; Medical Investigator, Dr. A. S. Wolkoff: An article by J. H. Waddell[12/] which describes techniques for photographing internal cavities was found by the MRI BA Team in a manual search and forwarded to Dr. Wolkoff. Dr. Wolkoff reported that the techniques described in this paper are promising for photographing internal body cavities. He plans to use the

technique for intra-uterine visualization for fetal transfusion culdoscopy and pregnant ewe research.

Dr. John Busser, Bioinstrumentation Advisory Council, in responding to Medical Problem Abstract No. KU-21, suggested that Dr. Howard Bolin, Pennsylvania Hospital, Philadelphia, may have a solution to the problem of photographing internal body organs. The MRI BA Team contacted Dr. Bolin and received from him papers which describe his work on pelvic endoscopy[10/] and internal color TV techniques.[11/] Copies of these references were sent to Dr. Wolkoff.

As suggested by Helen Chiaruttini, George Washington University, the MRI BA Team contacted Mr. Harvey Geller, Cancer Control Program, U. S. Public Health Service to determine the status of their work on the development of fiber-optic cameras. The information was obtained and forwarded to Dr. Wolkoff.

<u>Support for Ruptured Eardrums; Problem No. KU-23; Medical Investigator, Dr. F. Kirchner</u>: Perforated eardrums in which the perforation is greater than about 3 mm. will not heal spontaneously and hearing will be permanently impaired. For these cases, a bridging surface is required to provide support for tissue growth over the perforation. At the present time materials such as cigarette paper are used, but these have the disadvantage that they are difficult to remove so that there is a risk that the new membrane will be damaged.

A literature search of aerospace technology on materials which could be used as a support for ruptured eardrum was conducted. No applicable technology was revealed.

Andrew E. Potter, NASA Lewis Research Center, submitted a suggestion. He suggested a Teflon dam be placed against the eardrum to act as a support for new tissue growth. The suggestion was forwarded to Dr. Kirchner for evaluation.

* <u>Cardiac Output Measurement; Problem No. KU-24; Medical Investigator, Dr. R. M. Lauer</u>: There is a need for a more convenient method for determining the amount of blood being pumped by the heart. Two methods, commonly used, the dye dilution technique and the Fick methods, both require taking blood samples for analysis.

A computer search of the aerospace literature revealed work done by Dr. Kubicek, et al., at the University of Minnesota on an impedance plethysmagraphic determination of cardiac output.[13/] A later report on this development[14/] was obtained from Dr. Kubicek and given to Dr. Lauer. The recent work was conducted under contract to the NASA Manned Space

Center. Four special strip electrodes are placed around the neck and chest, as shown in Figure 2, Appendix III. The control system is shown in Figure 3. A controlled electrical charge is induced across the two outer electrodes. The electrical charge produced across the two inner electrodes appears to be related to the amount of blood pumped by the heart.

Arrangements were made to have one of these systems evaluated by Dr. Lauer at the University of Kansas Medical Center. To date, data have been taken on 10 heart patients using the impedance system and the Fick method for comparison. The data are now being analyzed and a report on this work is being prepared by Dr. Lauer.

Blood Pressure Measurement (N); Problem No. KU-25; Medical Investigator, Dr. R. M. Lauer: What was needed was an indirect method for measuring blood pressure, which could be used on subject under exercise conditions. The conventional cuff blood pressure device is not convenient to use for exercising subjects because the subject must be quiet while the Karotkoff sounds are manually heard by the operator through the stethoscope.

A computer search of aerospace literature revealed a blood pressure measuring system,[15] developed for NASA Manned Spacecraft Center for Project Mercury, which was identified by the MRI BA Team as a potential solution to this problem. This instrument is basically similar to the conventional cuff system, employing a standard occluding cuff, a gas pressure source, and a gas-pressure regulator and valve. An electrical output transducer senses the cuff pressure and a microphone positioned on the brachial artery under the occluding cuff monitors the Karotkoff sounds from the artery. The output signals present the conventional systolic (maximum) and diastolic (minimum) pressures in a graphical display. Some of the details of the system are given in NASA Tech Brief 65-10365, Appendix IV.

A unit was obtained from the Manned Spacecraft Center for evaluation by Dr. Lauer at the University of Kansas Medical Center. The results were inconclusive. Satisfactory records were obtained on several subjects and unsatisfactory results on others. Prior to completion of the tests, the unit became inoperative and was returned to the MSC. Unfortunately, the unit was not available for any further tests. Literature was obtained on a commercial unit[16] which operates on the same principle as the MSC unit. The literature on the commercial unit was forwarded to Dr. Lauer.

Chronic Intracranial Pressures (N); Problem No. KU-26; Medical Investigators, Drs. C. Brackett and J. C. Cauthen: Medical investigators at the University of Kansas Medical Center are interested in long-term measurement of the pressures inside the skull of living humans. The transducer must be small since it is to be placed between the inner surface of the skull and the lining of the brain. An abstract of this problem was sent to Dr. Hartwig for distribution.

A computer literature search was conducted. Two NASA items and two commercial items were identified by the MRI BA Team as potential solutions to this problem. One NASA item is a pressure telemetry system developed at the Ames Research Center. This system employs a small, solid state, strain gage pressure cell, designed for body implant applications. This pressure telemetry system is described in NASA Tech Brief 66-10624, Appendix IV. Data on the pressure transducer used in the Ames system were obtained from the Electro-Optical Systems Company, who have commercialized this transducer.

A second NASA Item identified as a potential solution to this problem is a pressure transducer developed at the Jet Propulsion Laboratory described in NASA Tech Brief 67-10020, Appendix IV. Detailed information on this item, received from JPL, indicates that it is presently too large for this application, but miniturization may be possible.

The Schaevitz-Bytrex Company and the Scientific Advances Company manufacture small pressure transducers which appear to be applicable to this problem.

Information on the above items were sent to the medical investigators who are now pursuing these suggested approaches.

Ear Specimen Mounting Material (N); Problem No. KU-27; Medical Investigator, Dr. F. Kirchner: There is a need for an improved material for imbedding ear specimens for microscopic observation. The materials now being used (epoxy) are unsatisfactory because they are too hard, making it difficult to cut thin specimen sections. An abstract of this problem is given in Appendix V.

A computer search of aerospace literature did not reveal any solutions to this problem.

Conversion of Biological Data (N); Problem No. KU-28; Medical Investigator, Dr. R. M. Lauer: Medical researchers at the University of Kansas Medical Center are interested in finding a simplified method for converting biological analog data to digital data for computer application. A computer search was made of the aerospace literature, which revealed a Northwestern University report[17] which contains information which appears to be applicable to this problem. A copy of this report has been sent to Dr. Lauer for evaluation.

* Ear Specimen Bone Removal; Problem No. KU-29; Medical Investigator, Dr. F. Kirchner: In the preparation of specimens of the membraneous inner ear, it is necessary to remove the outer bone structure. This is normally a tedious, time-consuming procedure of dissolving and chipping away the bony structure. A member of the MRI BA Team suggested using a special air-abrasive device (manufactured by S. S. White Company). Dr. Kirchner tried this device and found that it worked very well. A majority of the bone was removed with the air-abrasive unit in a comparitively short time. The remainder of the bone was readily removed with a rapid decalcifying agent, providing an accurate specimen of the cochlea with all the soft tissue within. Dr. Kirchner prepared a paper[18] on his work, which was accepted with highest honors by the Triological Society and the paper will be published in the medical publication Laryngascope.

* X-Ray Enhancement (N), Problem No. KU-30; Medical Investigator, Dr. R. M. Lauer: Plans are being made to apply the JPL technique for x-ray enhancement[29] at the University of Kansas Medical Center. A brief description of this technique is given in Tech Brief 67-10005, Appendix IV. The technique is to be used to enhance near real-time x-rays of the internal heart. The patients will be at the University Hospital in Kansas City, Kansas. The data will be transmitted by microwave to the computer located about 30 miles away at the Lawrence, Kansas, campus of the university. The processed data will be transmitted back to the hospital within a few minutes for observation by the medical investigator. Arrangements to procure the equipment are now in progress.

B. St. Louis University School of Medicine

Tremors and Muscle Reflexes; Problem No. SLU-7; Medical Investigator, Sister M. A. Claire: The application of the muscle accelerometer to the measurement of tremors and muscle reflexes was continued at the University of St. Louis School of Medicine (transfer accomplished and reported[1,2] under previous contracts). Sister Claire has reported that the technique appears to be quite sensitive in picking up pathological conditions. She cited a case in which abnormal tremors were detected with the accelerometer on a girl three weeks after she had suffered a moderate head injury in a bus accident.

Sister Claire loaned one of the accelerometers to a researcher at Washington University (St. Louis) who has obtained promising results in measuring the movement of the larynx during speech.

A paper[58] on the muscle accelerometer was prepared by D. Bendersky and presented by P. Constant at the International Conference on Medical and Biological Engineering, Stockholm, Sweden, on August 18, 1967. A digest of this paper is in Appendix I.

Information on the muscle accelerometer was requested by and furnished to the Rancho Los Amigos Hospital, Downey, California; New York University, New York, New York; University of Illinois, Champaign, Illinois; Automation Industries, Boulder, Colorado; Gulton Industries, Meterchen, New Jersey; Magnaflux Corporation, Chicago, Illinois; and the Vendo Corporation, Kansas City, Missouri.

Measurement of Blood Oxygen; Problem No. SLU-8; Medical Investigator, Dr. A. Richardson: Under a NASA contract, the Beckman Instrument Company developed an optical ear oximeter for measuring the amount of oxygen in the blood.[19] The ear piece consists of a light source, an optical filter and photocell, and a method for occluding the ear so that a bloodless reading could be obtained. Although the performance of the device was not entirely satisfactory, due to calibration difficulties, it appears to offer an approach to the bloodless measurement of blood oxygen. A copy of the report was sent to Dr. Richardson.

The Measurement of Cranial Nerve Potentials; Problem No. SLU-15; Medical Investigator, Dr. A. B. Hertzman: At the NASA Ames Research Center, work has been conducted on the measurement of nerve action potentials.[20] Although the technique has been used only on frogs, the electrode technique may be adaptable to the measurement of cranial nerve potentials in humans. A copy of the report was sent to Dr. Hertzman.

C. University of Minnesota Medical School

* Sterile Operating Rooms; Problem No. UM-1; Medical Investigators, Dr. R. Varco and W. G. Kubicek: Four NASA-related items were identified by the MRI BA Team as potentially applicable to the design and operation of sterile operating rooms. A system for providing clean and sterile air for surgical rooms, based on the system used in the Gemini spacecraft, was submitted by A. Ignatonis of the NASA Marshall Space Flight Center. The suggestion is shown in Appendix V. A Sandia Corporation report[26] describes tests on a laminar flow clean room, and shows the extreme efficiency of this system in reducing airborne viable particles. A NASA-supported study of clean room technology was reported by the School of Public Health, University of Minnesota.[27] An improved atmospheric particle analyzer, developed for the NASA Electronics Research Laboratory, is described in NASA Tech Brief 67-10231, Appendix IV. Information of these four items was sent to the University of Minnesota.

Dr. Kubicek reported that the suggestion from A. Ignatonis, MSFC, is excellent and the Sandia report is good. Dr. Varco, Department of Surgery, University of Minnesota, plans to use the information in the construction of sterile operating and recovery rooms at the University hospital.

Speech Spectrum Analyzer; Problem No. UM-4; Medical Investigator, Dr. W. G. Kubicek: A device is desired which can provide an instantaneous, simplified visual display of speech for use in speech therapy. A search of the aerospace literature did not reveal any satisfactory solution to this problem. Dr. Kubicek reported that he has located a commercial machine (Federal Scientific Corporation) which is a solution to this problem, so that this problem has been closed.

Respiratory Air Flow Measurement; Problem No. UM-6, Medical Investigator, Dr. W. G. Kubicek: Available instruments for measuring respiratory flow rate lack sufficient accuracy and stability for the precision needed in oxygen consumption studies. An air flow rate instrument is desired with an accuracy of $\pm$ 1 percent and capable of maintaining this accuracy over a period of 24 hours of continuous use. A search of the aerospace literature did not reveal a solutuion to this problem.

* Measurement of Bone Distortion and Density; Problem No. UM-8; Medical Investigators, Dr. M. Tascon and M.Masharrafa: An investigaton to measure the mechanical properties of bones in animals and humans has been initiated at the University of Minnesota Medical School by Drs. Tascon and Masharrafa, due largely to references[21-24] supplied by the MRI BA Team. There is a need for a technique to measure the elasticity of bone in vivo. It is known that bones become more brittle with age and certain diseases. If the elasticity of bones were readily measureable this would be an important advance in both research and clinical medicine. Dr. Tascon is also interested in measuring bone density in vivo to study bone fracture healing.

A miniature stress transducer, developed at the Jet Propulsion Laboratory, may be applicable to the measurement of bone elasticity. The transducer consists of a piezoresistive element (silicon splinter) embedded in a high density polyethelene cylinder. The silicon splinter has a crystallographic orientation which provides piezoresistive characteristics along a selective axis. Loading of the transducer cylinder along the sensitive axis changes the electrical resistance of the silicon splinter in direct relation to the amount of stress applied. Various deformation sensitivities are possible by using cylinders of different elastic properties. A description of this transducer is given in NASA Tech Brief 65-10023, Appendix IV. A detailed report on this device[21] was obtained from the Jet Propulsion Laboratory, and transmitted to Drs. Tascon and Masharrafa. Several attempts were made to obtain one of these transducers from the Jet Propulsion

Laboratory. We were informed that the device is undergoing further development and therefore is not yet available.

A search of aerospace literature revealed NASA-supported work done at the University of West Virginia on the dynamic response of bone.[22/] The purpose of the work was to study the mechanical response of bone and muscle tissue to impacts of varying velocity. Special test equipment was developed and load-displacement histories on various materials, including bone, were measured over a wide range of strain rates. A copy of this paper was sent to Drs. Tascon and Masharrafa.

A tool for the measurement of bone integrity and density, without the need for surgery or x-rays, has been devised at the NASA Marshall Space Flight Center. The unit is an electrically-powered ultrasonic device which can be used to scan fracture sights. A description of this device is given in NASA Tech Brief 67-10486, Appendix IV. Information on this device was forwarded to Dr. Tascon and Masharrafa.

* <u>Microcirculation Measurement; Problem No. UM-10; Medical Investigators, Drs. W. G. Kubicek and G. Zaki</u>: In the field of drug research, in many cases conclusions must be made regarding the effect of a drug on the microcirculation. At present these conclusions must be based upon rather crude and indirect methods, because of the lack of convenient and reliable methods for measuring blood flow in capillary beds. The problem stems from the fact that the capillary vessels are very small (5-30 μ) and are an integral part of the surrounding tissue.

A search of the aerospace literature was conducted and sent to Dr. Kubicek. Dr. Kubicek reported that this literature search will be helpful in a pilot study on microcirculation.

Through personal contact by a member of the MRI BA Team, a copy of a Ph.D. thesis by P. D. Harris[25/] was obtained, which describes techniques for the measurement and analysis of red blood cell movement in the microcirculation. The medical investigators reported that the technique described in this report is very good and they plan to use it in their drug evaluation project.

* <u>Muscle Heat Measurement; Problem No. UM-11; Medical Investigator, Dr. W. G. Kubicek</u>: A computer search of aerospace literature did not reveal any satisfactory technique for measuring the heat produced by individual muscles of the arms and legs. Dr. Kubicek reported that the literature search was helpful in reaching a decision to abandon this investigation due to the technical difficulties.

Electrocardiogram Zero Shift Elimination; Problem No. UM-12; Medical Investigator, Dr. A. From: Electrocardiograms are made up of several spectral parts. There is a group of high frequency components due to the electrical activity of the heart, and a much lower frequency signal which is known as a zero or baseline shift. This shift is not related to the cardiac function, but is an unwanted artifact.

A search of the aerospace literature was conducted. No solution to this problem was revealed in the search.

An abstract of this problem was distributed. Two suggestions for possible solution to the problem were received. One suggestion from the NASA Lewis Research Center involved the use of simple electrical filter technique. This suggestion was evaluated but was not considered applicable because of overlapping frequencies involving both zero shift and low frequency components of the cardiac signal. The second suggestion was from the Argonne National Laboratory. A request for details of the suggested technique was sent to the Argonne Laboratory.

A commercial unit (Bio-Instrumentation Amplifier, Model 890, Dynamics Instrumentation Company) appears to be a solution to this problem, if it supports the manufacturer's claim. Literature on this unit was sent to Dr. From.

Dr. A. From, who originally requested assistance on this problem, has left the University of Minnesota and no further work on this problem is planned at the University.

Chest Wall Movement; Problem No. UM-13; Medical Investigator, Dr. A. From: There are movements of the chest wall in the vicinity of the heart which are produced by the activity of the heart, respiration, and general muscle movements. The only signal desired in this application is that due to the activity of the heart. There are suitable accelerometer and capacitance techniques which require the subject to remain quiet in a supine position. These methods are not suitable for measurement of a subject while exercising, which is required in this application.

A computer search of aerospace literature did not reveal any pertinent reports on this problem.

A manual search of the open literature uncovered a report of work done on this problem at the Cedars-Sinai Medical Center, Los Angeles, California, under a NASA grant.[28] A technique is described utilizing a signal averaging method for recording cardiac vibrations during exercise. The method was found useful in obtaining records during conditions in which severe artifacts are normally encountered. A copy of this paper was forwarded to Dr. From. Unfortunately, Dr. From has left the University of Minnesota and no further activity on this problem is planned.

Water Extraction from the Atmosphere (N); Problem No. UM-14; Medical Investigator, Dr. W. G. Kubicek: The problem is to provide a system which can efficiently and economically extract water from the atmosphere under desert atmospheric conditions.

A search of the aerospace literature did not reveal any solution to this problem.

Rotary Damping Device (N); Problem No. UM-15; Medical Investigator, Dr. W. G. Kubicek: There is a need, in the field of physical medicine and rehabilitation, for a small lightweight, biodirectional damping device for controlling the rate of rotation of a limb joint in certain prosthetic devices. An example is where an individual with a particular neurological disorder cannot control the rate of extension or flexion of his elbow.

A search of the aerospace literature did not reveal an answer to this problem. Abstracts of this problem were sent to Dr. Hartwig for distribution to appropriate NASA organizations to solicit suggestions.

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Nineteen additional problems, Nos. UM-16 through UM-34, were recently submitted to the MRI BA Team from biomedical researchers at the University of Minnesota. Personal discussions have been held with the originators on Problems Nos. UM-16, UM-17, UM-18, UM-20, and UM-23, to date, and problem abstracts are being prepared. Discussions with the other problem originators are scheduled.

Eye Transport Proccesses (N); Problem No. UM-16; Medical Investigator; Dr. W. L. Fawlks:

Foot Support Devices (N); Problem No. UM-17; Medical Investigator, Prof. John D. Allison:

Pressure Measurement Between Teeth (N); Problem No. UM-18; Medical Investigator, Dr. C. D. Simpson: A computer literature search has been conducted and sent to the investigator.

Intercardiac Heart Sounds (N); Problem No. UM-19; Medical Investigator, Dr. A. Adicaff:

Gamma Radiation Source (N); Problem No. UM-20; Medical Investigator, Dr. H. Jonas:

Bile Duct Valve (N); Problem No. UM-21; Medical Investigator, Dr. J. T. Anderson:

Mass Spectrometer (N); Problem No. UM-22; Medical Investigator, Dr. N. Lifson:

Chemo-Sensors (N); Problem No. UM-23; Medical Investigator, Dr. D. D. Halperin:

Analysis of Brain Waves (N); Problem No. UM-24; Medical Investigator, Dr. A. S. Marrozzi:

Conversion of Brain Waves (N); Problem No. UM-25; Medical Investigator, Dr. A. S. Marrozzi:

Viewing Box for Visual Perception Tests (N); Problem No. UM-26; Medical Investigator, Dr. A. S. Marrozzi:

* Remote Examination of Patients (N); Problem No. UM-27; Medical Investigator, Dr. B. M. Dornblaser: A report of work done by the Boeing Company on a system for automated patient care[62/] was recently received from the TU Office at the NASA Marshall Space Flight Center. This report was sent to Dr. Dornblaser for Problem No. UM-27. Dr. Dornblaser notified us that this report will be very useful in planning his study.

Electrical Sensors for Bacteria Detection (N); Problem No. UM-28; Medical Investigator, Prof. G. M. Ederer:

Rapid Playback ECG Recorder (N); Problem No. UM-29; Medical Investigator, Dr. C. S. Alexander:

Detection and Correction of Disturbed Heart Rythms (N); Problem No. UM-30; Medical Investigator, Dr. C. S. Alexander:

Continuous Measurement of pH, pO_2 and pCO_2 (N); Problem No. UM-31; Medical Investigator, Dr. G. T. Wier:

Air Velocity/Resistance Measurements in Nose (N); Problem No. UM-32; Medical Investigator, Dr. H. L. Williams:

Pulmonary Function in Small Mammals (N); Problem No. UM-33; Medical Investigator, Dr. W. J. Warwick:

Analysis of Complex Body Fluids (N); Problem No. UM-34, Investigator, Dr. George C. Flora:

D. Northwestern University Medical School

Temporomandibular Joint Action; Problem No. NU-1, Medical Investigator, Dr. R. Cole: A triaxial accelerometer, developed at the NASA Ames Research Center, and described in NASA Tech Brief 66-10534, Appendix IV, had been furnished (during the previous contract period) by Ames Research Center to Dr. Cole for evaluation as a means of measuring temporomandibular joint action. Preliminary tests indicated that a special external mounting system was required. Unfortunately, the grant supporting this work at Northwestern expired and no additional funds were available to continue this investigation.

Electroencephalogram Telemetry System (N); Problem No. NU-3; Medical Investigator, Dr. H. R. Myklebust: A remote system for obtaining electroencephalograms on several subjects simultaneously is required at Northwestern University Medical School in a study of the responses of children in a group learning environment.

An EEG helmet system, developed at the NASA Ames Research Center and described in Tech Brief 66-10536, Appendix IV, was identified as a potential solution to this problem. Attempts were made to obtain one of these helmets from NASA without success. Because of the lack of NASA equipment, the researchers at Northwestern University are now in the process of assembling their own helmets, based upon an earlier design developed at the University.

Phonocardiograph Microphone (N); Problem No. NU-4; Medical Investigator, M. L. Petrovick: Researchers at the Northwestern University are involved in the development and evaluation of heart sound computer systems. In connection with this work, they are evaluating phonocardiograph microphones. NASA Tech Brief 66-10314, Appendix IV, describes a phonocardiograph microphone which was developed for the NASA Manned Spacecraft Center (MSC). One of these microphones was obtained from the MSC and evaluated at Northwestern University. It was found that this microphone cannot detect heart sounds.

Flexible Tether for Prosthetics and Orthotics (N); Problem No. NU-5; Medical Investigator, Dr. D. S. Childress: A flexible tether is needed for prosthetics and orthotic controls, which can be made rigid or limp.

A tether design, which has been developed under partial NASA at the Missile and Space Division, General Electric Company, Valley Forge, Pennsylvania, may be applicable to the problem. Through personal contact with representatives of GE, a report[30] on this work was obtained and sent to Dr. Childress for evaluation.

A computerized search of the aerospace literature was conducted. No relevant reports were revealed in this search.

E. Case Western Reserve University

* Miniature Motors and Batteries; Problem No. CI-1; Medical Investigator, Dr. R. L. Lorig: Several NASA[31,32] and non-NASA[33] documents on miniature motors and batteries were obtained and sent to Case Western Reserve University for evaluation for implanted prosthetic devices. Dr. Lorig reported that the data presented in Reference 31 applies directly to the problem, although the batteries reported are larger than desired. The data will be useful in the design of miniature rechargeable systems. Reference 33 was reported by Dr. Lorig to be a useful review of the state of the art in implantable energy sources.

Joint Locks for Orthosis; Problem No. CI-2; Medical Investigator, Dr. Crachetiere: Four NASA items[34-37] were identified by the MRI BA Team as potentially applicable to joint locks for orthosis. Copies of these Tech Briefs were sent to Dr. Crochetiere for evaluation. Dr. Crochetiere reported that the information was interesting but could not be directly applied to his problem because the torque and load capacities of the mechanisms described were less than required.

Centrifuge Effects on the Cardiovascular System (N); Problem No. CI-6; Medical Investigator, Mr. Hamilton; Modeling of the Heart Control System (N), Problem No. CI-7; Medical Investigator, Mr. Hamilton; Effects of Posture on the Cardiovascular System (N); Problem No. CI-8; Medical Investigator, Mr. Hamilton: Aerospace literature searches were conducted on Problems Nos. CI-6, -7, -8. A considerable number of reports were revealed in each of these literature searches. The results of these literature searches were sent to Mr. Hamilton.

F. University of Wisconsin

* Delivery of Moisture and Medication to the Respiratory Tract; Problem No. UW-1; Medical Investigator, Dr. A. Siebens: Deposition of water and water-soluble compounds is a relatively common approach to treating infection of the airways. Such infections are a particular problem in children with cistic fibrosis. The current method for introducing moisture and medication to the respiratory tract of children involves placing the child in a tent containing airborne droplets. The system is undesirable because of the bulky nature of the apparatus and the entire body is subjected to the medication.

A system for delivering water and medication to respiratory tract was conceived by the MRI BA Team. This system, shown in Figure 4, Appendix III, utilizes the respiratory helmet previously developed by the MRI BA Team to collect inhaled breath (Problem KU-5). The vapors and fresh air are drawn through the helmet by an air suction pump. There is no problem of rebreathing exhaled air because fresh air is continually drawn into the helmet and exhaled air is continuously removed by the suction pump.

A description of the proposed system was submitted to Dr. Siebens along with an experimental helmet. Dr. Siebens is now in the process of testing this system.

* Eyeblink Measurement; Problem No. UW-3; Medical Investigator, Prof. L. E. Ross: This problem, initiated under the previous contract,[2/] is concerned with the need for a method for measuring eyeblink without attachment of any apparatus to the eyelid.

NASA Tech Brief 65-10079; Appendix IV, describes a photoelectric sensor developed for the NASA Marshall Space Flight Center, which may be applicable to the measurement of eyeblink. The eyelid would be coated with an infrared absorption material. The infrared sensor would be triggered by an eyeblink due to the difference in absorption of the eye and the coated eyelid. Professor Ross expressed an interest in evaluating this system. Several attempts have been made to obtain one of these units for evaluation without success.

A North American Aviation report[38/] describes an eyeblink measurement techniques which is also based on light reflection from the eye and eyelid. This work was conducted under a NASA contract. A copy of this report has been forwarded to Professor Ross.

Measurement of Body Motion (N); Problem No. UW-4; Medical Investigator, Dr. M. E. Kaufman: 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.

The MRI muscle accelerometer, described in Appendix I, previously developed as a solution to Problem SLU-7,[2/] is a potential solution to this problem of measuring body motion. It is proposed to attach one of these units to the chest to measure front and back motion, and another unit is to be attached to the side to measure the sidewise motion. Two of these accelerometers were sent to Dr. Kaufman for evaluation.

Apparatus for Learning Research (N); Problem No. UW-5; Medical Investigator, Dr. R. Heber: There is a need for a functionally flexible apparatus for experiments on visual learning, memory and other performance characteristics of mentally retarded children. This apparatus must be compact so that it can be readily moved from school to school.

A search of aerospace literature was conducted. Although several related references were found in the search, no apparatus was found which would meet the requirements specified.

A proposal to develop the desired apparatus has been prepared by MRI and submitted to Dr. Heber.

Monitoring for Auditory Stimulation and Infant Vocalization (N); Problem No. UW-6; Medical Investigator, Dr. R. Heber: There is a need for a tamperproof, miniaturized device for transmission of auditory stimulation impinging upon an infant and the infant's vocalizations. The recording system should be capable of picking up the signal up to a distance of one mile and should be capable of storing up to 12 hr. of data.

A search of the aerospace literature did not reveal a solution to this problem.

Measurement of Infant Motor Activity (N); Problem No. UW-7; Medical Investigator, R. D. Honeycutt: A small transducer to measure the movement of infants is required. The device is to be attached to the infant wrist or ankle.

The MRI muscle accelerometer, described in Problem No. UW-4, may be applicable to this problem. Information on the muscle accelerometer and two experimental units was sent to Mr. Honeycutt for evaluation. Literature on a small commercial (American Electronics Laboratories) telemeters to transmit the motion signal were also sent to Mr. Honeycutt.

* Timing Devices (N); Problem No. UW-8; Medical Investigator, Prof. L. E. Ross: Professor Ross is interested in obtaining a solid state timing device which will generate a variety of sound stimuli at random or apparently random intervals. The sound stimuli are used in behavioral studies being conducted by Professor Ross.

A search of the NASA literature revealed a report[39] on a solid state timing device developed at the Goddard Space Flight Center, used to control satellite separation sequences. A copy of this report was given to Professor Ross, who indicated that the information will be useful in developing an appropriate timer.

* Temperature Telemetry (N); Problems Nos. UW-10, UW-11; Medical Investigator, Dr. R. K. Meyer: 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.

A NASA literature search revealed work done at the NASA Ames Research Center on a small temperature telemetry system,[40/] briefly described in Tech Brief 66-10057, Appendix IV. This equipment has recently been commercialized by the Electro-Optical Company, Pasadena, California. Information on this NASA temperature telemetry system was sent to Dr. Meyer for his consideration. Dr. Meyer has ordered two of these units from the Electro-Optical Company for use in his monkey applications. The units were recently received and are now being prepared for implantation in test animals.

* Infusion of Fluids Into Animals (N); Problem No. UW-12; Medical Investigator, Dr. R. K. Meyer: A comparatively sophisticated apparatus for infusing various fluids into the blood vessels of experimental animals is needed in the Department of Zoology, University of Wisconsin. The apparatus must be capable of automatically infusing up to four different fluids over a wide range of variable rates and provide a record of the infusion history.

A search of NASA technology revealed an automatic microsyringe for accurately metering small fluid volumes, developed at the Jet Propulsion Laboratory. This item is described in Tech Brief 67-10203, Appendix IV. However, this device in its present form, does not provide variable rates or a record of the infusion history. A proposal to develop the required apparatus is being prepared by MRI for Dr. Meyer.

Sound Receivers (N); Problems Nos. UW-13, and UW-15, Medical Investigator, Professor W. I. Gardner, Electric Shock Apparatus (N); Problem No. UW-14, Medical Investigator, Professor W. I. Gardner: A combined NASA literature search was made on sound receivers and electric shock apparatus for Problems Nos. UW-13, -14, and -15. No pertinent reports were revealed in this first search. Another search was recently conducted which is now being evaluated.

Urination and Defecation Detector (N); Problem No. UW-16; Medical Investigator, Professor W. I. Gardner: A NASA literature search was conducted on this problem. No pertinent reports were revealed. The TU Officer at the Manned Spacecraft Center was contacted to determine whether urination or defecation detectors had been developed for astronauts. The reply was negative.

Rotary Joints for Small Cannulas (N); Problem No. UW-17; Medical Investigator, B. D. Honeycutt: 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.

A search of NASA literature did not reveal any reports related to small rotary joints. However, literature on a commercial cannula feed-through switch (Leheigh Valley Electronics, Fogelville, Pennsylvania) was obtained and sent to Mr. Honeycutt.

Remote Manipulation of Brain Electrodes (N); Problem No. UW-18; Medical Investigator, Dr. C. N. Woolsey: 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 on the head it does not interfere with the animal's behavior.

A NASA literature search revealed a Russian report[41/] which describes a technique for automatic manipulation of brain electrodes. Although the system is too large to be placed on free-roaming animals, it may be possible to miniaturize the system. A copy of the report has been sent to Dr. Woolsey.

Exercise Apparatus for Decorticate Monkeys (N); Problem No. UW-19; Medical Investigator, Dr. C. N. Woolsey: In studies on the effects of brain injury on motor performance in monkeys, there is a need for a motorized, automated apparatus for providing intermittent exercise and physical therapy. A NASA literature search did not reveal any pertinent reports for this problem.

Enzyme Electrode Amplifier and Telemetry System (N); Problem No. UW-20; Medical Investigator, Dr. S. J. Updike: Dr. Updike has developed a special enzyme electrode for use in measuring tissue oxygen and glucose concentration. He needs a miniature, animal implantable, high impedance, DC amplifier and a transmitter for use with the enzyme electrode.

A review of references previously accumulated by the MRI BA Team on telemetry systems revealed two aerospace related items which appear to be applicable to this problem. A report by Mackay[63/] describes an amplifier which appears to be applicable. A subminiature telemetry unit, developed at the NASA Ames Research Center is described in Tech Brief 64-10171,

Appendix IV. A combination of the Mackay amplifier and the Ames telemetry system looks like it should meet the requirements of the enzyme electrode. Information on these two units has been sent to Dr. Updike for evaluation.

G. University of Missouri

* Measurement of Effects of Magnetic and Electric Fields and Currents on Timing Cells (N); Problem No. MU-1, Medical Investigator, B. A. Rowley: As a basis for designing systems for use in rapid healing of injured tissue, there is a need for measurement of changes in metabolic activity of single cell organisms under the influence of electro-magnetic field and currents.

A NASA literature search was made. A NASA report[42] was found which is considered by the investigator to be a good reference source for information on biomagnetic literature.

* Automatic Recording of Heart Sounds (N); Problem No. MU-2; Medical Investigator, A.H. Purdy: A method for automatic recording of heart sounds is desired in order to make correlative studies of pathological conditions with phonocardial frequency spectrums. Present methods require direct contact with the chest wall. In connection with an investigation of a physiological monitor chair, it is desirable to obtain the heart sounds from the subject's back, through several layers of clothing. The investigator requested a literature search on heart sounds recording.

A NASA literature search was conducted, which the investigator has reported as giving good coverage of the subject.

Hemodynamic Impedance of the Vascular System (N); Problem No. MU-3; Medical Investigator, A. H. Purdy: The investigator requested a literature search on the theoretical and experimental work done in the field of hemodynamics (relationship between flow and pressure in the vascular system).

A NASA literature search was made and the results sent to the investigator. The NASA search did not reveal any useful information on this problem.

Automatic Blood Pressure Measurement (N); Problem No. MU-4; Medical Investigator, Dr. A. H. Purdy: Current methods for automatic blood pressure measurement involves the insertion of a pressure transducer into an artery or vein. For mass screening it is desirable to have a method which does require entrance into the body.

Since this problem is similar to Problem No. KU-25, the same literature search was used. Two NASA items were identified as potential solutions to this problem. One is a blood pressure measuring system developed for Project Gemini,[15/] described under Problem No. KU-25. Another potential solution is a blood pressure transducer for the temporal artery developed at Stanford Research Institute for NASA.[43/] Reports describing these two items have been sent to Dr. Purdy for further evaluation.

* Damping in Cardiac Catheters (N); Problem No. MU-5; Medical Investigator, Dr. A. H. Purdy: The calibration and adjustment of damping in cardiac catheters is a problem. The problem arises from the damping of the pressure pulses from the end of the catheter to the pressure transducer at the other end of the catheter.

A NASA literature search did not reveal any pertinent information. Through personal knowledge of a member of the MRI BA Team, information on methods for designing catheter pressure measuring systems was obtained from the Statham Instrument Company and furnished to Dr. Purdy. Dr. Purdy reported that this information is very useful.

Charges on Formed Elements of the Blood (N); Problem No. MU-6; Medical Investigator, Dr. A. H. Purdy: Red blood cells appear to exhibit an electrical charge with respect to the average body potential. Utilizing this property, man-made devices have been built which prevent clot formations when placed in the blood stream. To further explore this approach, it is desirable to know the electrical charges of extra-cellular, extra-particular, and extra-molecular elements.

A NASA literature search was conducted and the results were sent to Dr. Purdy. Dr. Purdy requested two documents[44,45/] from this search, which were obtained and sent to him.

* Differential Pressure Blood Flow Measurements (N); Problem No. MU-7; Medical Investigator, Dr. A. H. Purdy: The investigator requested a literature search on differential pressure methods of measuring blood flow with catheters.

A NASA literature search produced six references,[46-51/] which are considered useful by Dr. Purdy.

* X-ray Photograph Computer Enhancement (N); Problem No. MU-8; Medical Investigator, Dr. P. L. Reichertz: 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.

A NASA literature search was made. Among the documents in this search was the system for X-ray enhancement developed at the Jet Propulsion Laboratory.52/ A brief description of the JPL technique is given in Tech Brief 67-10005, Appendix IV. Dr. Reichertz and others from the University of Missouri, accompanied by J. West of the MRI BA Team, visited the Jet Propulsion Laboratory and obtained firsthand information on the JPL system for enhancing X-rays. Dr. Reichertz is now in the process of setting up a similar system at the University of Missouri.

Electrocardiogram Electrodes (N); Problem No. MU-9; Medical Investigator, Dr. P. L. Reichertz: Dr. Reichertz is interested in obtaining electrodes which can be used to collect electrocardiograms in hospital coronary care units, which are connected to a central computer network. The electrodes must be small, have constant impedance over long periods, must not be affected by movement of the patient and must not cause decubitus even when attached to the back of a motionless lying patient for long periods.

The NASA spray-on electrodes,3/ successfully used in connection with Problem KU-1, offer a potential solution to the problem. Information on the NASA spray-on electrodes was forwarded to Dr. Reichertz for evaluation.

Indirect Monitoring of Animal Blood Pressure (N), Problem No. MU-10; Medical Investigator, Dr. C. E. Short: This problem is the same as KU-25 and MU-4, except that blood pressure is to be measured on animals instead of humans. A review of the aerospace literature did not reveal any solution to this problem.

Tracking of Large Animals (N); Problem No. MU-11; Medical Investigator, V. W. Zager: A method for tracking large animals from an airborne unit or from land is needed. The transmission distance desired is about 5 miles and the unit should be able to operate for a period of 3 to 5 years without a change in the power source.

A review of aerospace technology did not reveal any solution to this problem. A problem abstract is being prepared for distribution.

* Cardiac Output Measurement (N); Problem No. MU-12, Medical Investigator, Dr. P. L. Reichertz: This problem is similar to Problem No. KU-24. In this case the application is for monitoring critically ill patients in a comprehensive care unit.

Information on the impedance cardiograph system,13/ developed at the University of Minnesota for NASA, was sent to Dr. Reichertz. B. Rowley of the University of Missouri, accompanied by J. West of the

MRI BA Team, visited the University of Kansas Medical Center to obtain firsthand information on the impedance cardiograph which is now being evaluated at KUMC for Problem No. KU-24. Dr. Reichertz reported that this technique may be very valuable for this application and is planning to obtain one of these systems.

Another NASA document[53] which was furnished to Dr. Reichertz, which he has found useful in connection with this problem, is a compilation of papers presented at a symposium on the analysis of cardiovascular data using computer methods.

* Pulmonary and Metabolic Monitoring Instrumentation (N); Problem No. MU-13; Medical Investigators, D. W. Douglas and Dr. E. M. Simmons: The investigators have requested a survey of techniques that have evolved in the measurement of pulmonary functions and metabolic rates under adverse environmental conditions and/or mass screening. A NASA literature search was conducted. The search was sent to Mr. Douglas, who reported that one document,[54] dealing with techniques for the measurement of metabolism, was very useful.

Storing of ECG Tracing Waveforms (N); Problem No. MU-14; Medical Investigator, C. Buck: A technique for condensing analog ECG waveforms to a limited number of digital parameters is required. The information is to be used to reproduce the original waveform and to compare the future tracing for significant changes.

A NASA literature search was conducted. Two reports[55,56] were revealed which offer potential solutions to this problem. Copies of these documents have been sent to the investigator for evaluation.

Microfilming X-Rays (N); Problem No. MU-15; Medical Investigator, Dr. F. Clayton. Nitrogen Metabolism in Autotropic Bacteria (N); Problem No. MU-16, Medical Investigator, Dr. R. L. Wixom. Histidine Biosynthesis in Selected Animal Systems (N); Problem No. MU-17; Medical Investigator, Dr. R. L. Wixom. Blood Pressure Measurement During Exercise (N); Problem No. MU-18; Medical Investigator, Dr. J. M. Martt: NASA literature searches were made on Problems MU-15, MU-16, MU-17, and MU-18. The results of the literature searches have been sent to the investigators.

III. MISCELLANEOUS PROJECT ACTIVITIES

A. Project Trips

August 14, 1967 - D. Bendersky visited the University of Wisconsin and met with Dr. R. Heber and other members of the research staff. Sixteen additional problems, UW-4 through UW-19, were submitted by the research staff.

August 18, 1967 - D. Bendersky attended a NASA-SRS meeting in Washington, D. C. The relationships of the MRI BA Team and the SRS-sponsored groups at the University of Wisconsin and Case Western Reserve University were discussed. It was agreed to continue this relationship for another year.

August 22, 1967 - P. Constant and D. Bendersky met with Dr. V. Wilson, Executive Director of Health Affairs at the University of Missouri, Columbia, Missouri, and discussed the possible participation of the University of Missouri in the MRI BA Team Program. Dr. Wilson subsequently notified us that they would like to participate in the program and assigned B. A. Rowley to be the contact man.

October 11, 1967 - D. Bendersky and J. West visited the University of Missouri and met with B. A. Rowley to initiate the BA Team program at that school.

October 30, 1967, November 1, 1967 - D. Bendersky attended the BA Team Conference held at Research Triangle Institute, Durham, North Carolina.

November 13-16, 1967 - Dr. J. Trank and J. West attended the Conference on Engineering in Medicine and Biology, Boston, Massachusetts.

November 28, 1967 - D. Bendersky met with Dr. W. Kubicek and M. Keith at the University of Minnesota, Minneapolis, Minnesota. Arrangements were made for M. Keith to acquaint the entire University biomedical staff with the MRI BA Team and to encourage their participation in the program. Nineteen additional problems have been submitted by the University staff, to date, as a result of this effort.

November 29, 1967 - D. Bendersky visited the University of Wisconsin, Madison, Wisconsin, and met with medical investigators who have submitted problems to the MRI BA Team.

November 30, 1967 - D. Bendersky met with Dr. J. Reswick and J. McCauley at Case Western Reserve University, Cleveland Ohio.

December 21, 1967 - J. West visited the University of Missouri, Columbia, Missouri. Discussions were held with B. Rowley and several medical investigators.

February 1, 1968 - Four representatives of the University of Missouri and J. West of the MRI BA Team visited the Jet Propulsion Laboratory, Pasadena, California, met with Dr. R. Nathan and others at JPL and obtained information on the JPL x-ray enhancement techniques for Problem No. MU-8.

February 12 and 13, 1968 - D. Bendersky attended a conference of the National Institute of Child Health Development (NICHD) and NASA Technology Utilization held at the Manned Spacecraft Center, Houston, Texas. The purpose of the conference was to acquaint the NICHD representatives with the NASA BA Team Program. Bendersky gave a presentation on transfers which had been accomplished by the three BA Teams.

March 20, 1968 - Dr. Q. Hartwig, D. Bendersky and W. Goll visited the University of Minnesota, Minneapolis, Minnesota, met with Dr. F. Kottke, Dr. W. Kubicek and M. Keith and discussed the relationship of SRS activities and the BA Team program. Also met with individual medical investigators who had submitted problems to the MRI BA Team.

March 21, 1968 - Dr. Q. Hartwig, D. Bendersky and W. Goll visited the University of Wisconsin, Madison, Wisconsin, met with Dr. R. Heber and discussed the relationship of the SRS activities and the BA Team program. Also met with several medical investigators who had submitted problems to the MRI BA Team.

March 27, 1968 - P. Constant and D. Bendersky met with G. Howick, P. Barnes, Dr. Q. Hartwig and R. Bevins at NASA TU Headquarters in Washington, D. C., and discussed the MRI BA Team Activities.

May 20, 1968 - J. West visited the University of Missouri and discussed details with the investigators on three problems. Preliminary information on two new problems were obtained.

B. Police Uniforms

At the request of NASA-TU Headquarters, the MRI BA Team conducted an investigation of police uniforms for the International Association of Police Chiefs, Field Service Division, Washington, D. C. The results of this investigation are reported in a special report,57/ copies of which were sent to NASA-TU Headquarters for distribution.

C. Reports

Three Quarterly Progress Reports,59-61/ one Special Report,57/ six Monthly Progress Reports (May, June, August, September, November and December 1967) and 14 Technology Transfer Reports, were prepared and distributed during this contract period.

D. NASA-TU Transfer Film

A documentary film showing NASA transfers is being prepared by a Boston TV station. A representative of the TU station visited MRI on May 2 and 3, 1968, and was furnished information on the MRI BA Team activities. Visits were arranged to the University of Kansas Medical Center and St. Louis University to obtain information on several NASA transfers in progress at these schools.

E. Industrial Participation

A program for industrial participation in the MRI BA Team activities has been formulated. A brochure outlining the program was prepared and mailed to about 1,600 companies now manufacturing biomedical equipment. To date, 23 companies have expressed an interest in the program. Two companies, Litton Industries, Minneapolis, Minnesota, and Veriflor Corporation, Richmond, California, have sent representatives to MRI to discuss the program. Arrangements for meetings with the other interested companies are now in progress.

F. Program Inquiries

General information on the BA Team was requested by and sent to Dr. W. McGonnagle, Elmhurst, Illinois; Cox Coronary Heart Institute, Kettering, Ohio; Indiana University, Cardiopulmonary Laboratory, Wright-Patterson Air Force Base, Ohio; Raytheon Company, Sudbury, Massachusetts; Paul D. Jones, Raytheon Company, recently presented a paper64/ containing information, in part, supplied by the MRI BA Team.

G. Literature Searches to Other BA Teams

Literature search strategies on all NASA searches made by the MRI BA Team sent to the RTI and the SWRI BA Teams. The results of 10 literature searches were requested by and sent to Dr. James Brown, Director of the RTI BA Team.

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APPENDIX I

PAPERS ON NASA SPRAY-ON ELECTRODES AND MUSCLE ACCELEROMETER

JOURNAL OF APPLIED PHYSIOLOGY
Vol. 24, No. 2, February 1968. *Printed in U.S.A.*

A spray-on electrode for recording the electrocardiogram during exercise[1]

J. TRANK, R. FETTER, AND R. M. LAUER
Department of Physiology, University of Kansas Medical Center, Kansas City, Kansas; Midwest Research Institute, Kansas City, Missouri; and the Department of Pediatrics, University of Kansas Medical Center, Kansas City, Kansas

TRANK, J., R. FETTER, AND R. M. LAUER. *A spray-on electrode for recording the electrocardiogram during exercise.* J. Appl. Physiol. 24(2): 267–268. 1968.—A convenient electrode for monitoring heart rate and the electrocardiogram during exercise is described. A study of the electrical characteristics of these electrodes shows that their impedance falls during exercise allowing improved recording with time.

monitoring; electrode impedance

DURING A MASS TEST of physical working capacity it was found desirable to be able to apply and remove precordial electrodes quickly to measure heart rate from an electrocardiographic signal. A number of different electrodes had been described for measuring the electrocardiogram during vigorous exercise. These include modified EEG electrodes (4), spring-loaded skin clips (3), metal-backed Mylar foil (6), floating wire-mesh electrodes (2), and commercially manufactured plastic cup electrodes.

The National Aeronautics and Space Administration has developed a system of spray-on electrodes (5) that has been found useful in monitoring electrocardiographic signals during flight testing. The purpose of this report is to describe an adaptation of the application method of this electrode system for use in recording the electrocardiogram of exercising children.

METHODS

The electrode consists of a 1-inch disk of conductive lacquer sprayed in place. Electrical contact is made to the electrode by including a wire connection within the lacquer disk. The electrode material is composed of a mixture of 50 ml (one tube) of Duco household cement, 25 g of powdered silver, and 125 ml of acetone.

The skin over the manubrium and apex of the heart is prepared by cleaning with acetone and applying a very small amount of electrocardiographic electrode paste. A length of no. 25 vinyl-insulated multistrand wire is stripped for 1 inch. The strands are splayed over the surface of the skin and sprayed in place with the electrode material with a modified Jet-Pack (Sprayon Products, Inc., Bedford Heights, Ill.) paint sprayer (Fig. 1). The free ends of the wires are connected to an ECG cable and tracings recorded. The electrodes are removed by gentle wiping with a gauze soaked with acetone.

In order to determine the characteristics of the spray-on electrodes, a series of 18 electrodes were tested. Measurements of electrode impedance magnitude were taken before and after a modified Balke test (1). An equivalent circuit adequate to describe the effective electrode system characteristics is shown in Fig. 2. Physically, the conductive electrode material is separated from the conductive subcutaneous structures by relatively nonconductive layers of the superficial epithelium. The value of shunt capacity (Cs) is primarily determined by the electrode area and its separation by a nonconducting dielectric layer from the deeper conductive structures in the skin. The resistive component (Rs) is a function of the number and size of the conductive pathways passing through the outer skin layers.

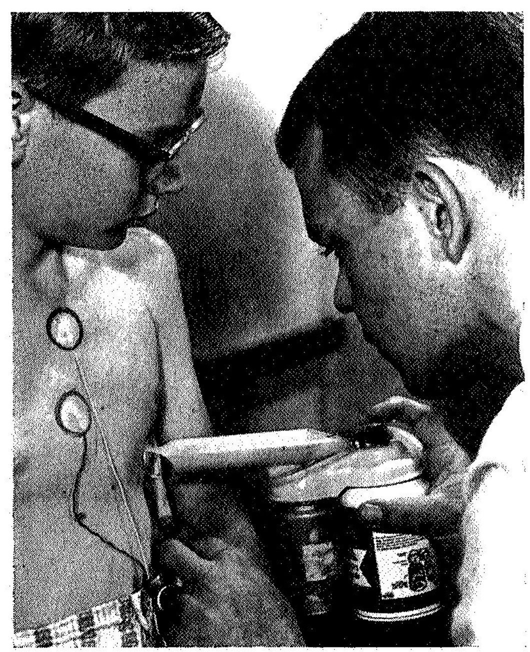
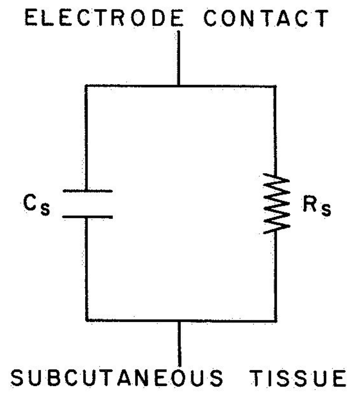


FIG. 1. Method of applying conductive lacquer electrodes.

Received for publication 26 July 1967.
[1] This work was supported by Public Health Service Grant HD00997, and by National Aeronautics and Space Administration Technology Utilization Contract NASr-63(11).



Cs = ELECTRODE SHUNT CAPACITY

Rs = ELECTRODE SHUNT RESISTANCE

|Z| = ELECTRODE IMPEDANCE MAGNITUDE

$$|Z| = \frac{Rs \dfrac{1}{2 \Pi f c}}{\sqrt{Rs^2 + \left(\dfrac{1}{2 \Pi f c}\right)^2}}$$

f = IMPEDANCE MEASUREMENT FREQUENCY

FIG. 2. Equivalent circuit of electrode system.

TABLE 1. *Shunt capacity (Cs) and skin resistance (Rs) in 18 electrodes*

	Mean Cs, μf	Range	Mean Rs, ohm	Range
Before exercise	0.04	0.01–0.06	77,000	7,500–385,000
After exercise	0.05	0.02–0.08	21,000	10,000–60,000

Experimentally, the magnitude of the electrode impedance ([Z]) was determined by measuring the electrode voltage drop produced when a constant alternating current was passed through the electrode system. At a frequency of 1 kHz or above, the impedance was essentially all reactive. Thus, the value of the equivalent shunt capacitance could easily be calculated from the 2 kHz [Z]. The [Z], at a frequency of 100 Hz or less, was found to be essentially resistive and, from this value, the equivalent low-frequency shunt resistance could be calculated.

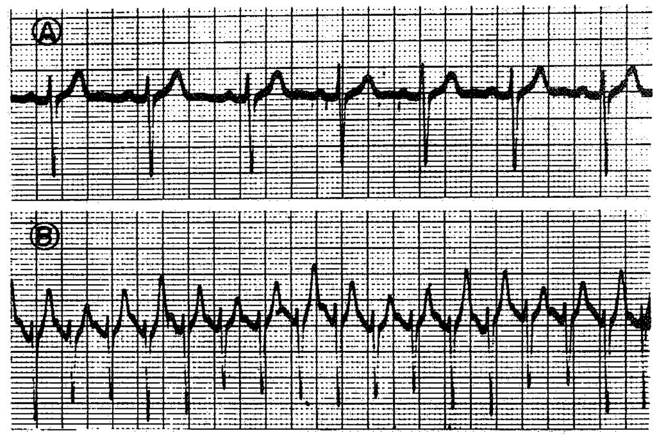


FIG. 3. ECG of 15-year-old boy recorded with conductive lacquer electrodes on a Sanborn model 100 electrocardiograph. *A*: resting ECG; *B*: exercise ECG at 19th min of Balke treadmill test.

RESULTS

The results of the Cs and Rs measurements are shown in Table 1. Representative ECG recordings are shown in Fig. 3.

DISCUSSION

The most impressive finding in this study was that the electrode impedance falls with time and exercise, actually indicating an improvement in electrode performance. The greatest change was seen in Rs, a 3.6:1 reduction during exercise. The change in Cs was only a 1.25:1 increase. Both of these changes contribute to the impedance reduction with exercise; however, the greatest contribution is made by the decreasing Rs. One possible interpretation of the change seen is that the saline perspiration during exercise provides more conductive pathways through the superficial epithelium and thus decreases its resistance. The increased capacity can be related to the effective reduction of dielectric thickness as the dry epithelium absorbs more conductive fluid during the process of perspiration. It is significant to note that amplifier input impedance should be greater than 500,000 ohms to insure undistorted measurements of ECG signals. An amplifier input impedance lower than 100,000 ohms will produce gross accentuation of the high-frequency components (QRS) and attenuation of the low-frequency (P, T) components of the electrocardiogram. The lower input impedance could be useful when rate phenomenon alone is to be monitored, because of the accentuation of the QRS complexes. The input impedance of current, standard, ECG recorders is 1 megohm or more when used in the lead I, II, or III input mode.

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31–7 A Muscle Accelerometer and Spray-on Electrocardiogram Electrodes

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Kansas City, Missouri, U.S.A.

Two medical instrumentation problems were recently solved by the application of engineering technology originally developed for the U.S. space program. The first problem was to provide an accurate and convenient method for measuring limb muscle reflexes. The second problem was to provide electrocardiogram electrodes which will give "clean" records under exercise conditions.

Muscle Accelerometer. In earlier postural reflex studies,[1] difficulty was experienced in accurately and conveniently measuring limb reflexes To overcome this problem, a special muscle accelerometer was developed, using a piezo beam design (Fig. 1) similar to that used in a micrometeorite detector.[2] A steel ball is fixed to the free end of a piezo crystal cantilevered beam. Changes in velocity cause the piezo beam to deflect, creating an electrical signal proportional to the beam deflection. The unit is tied to the subject's middle finger and the signal is recorded on a conventional pen recorder (Fig. 2).

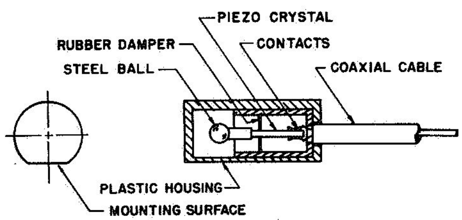

Fig. 1. Construction of muscle accelerometer.

Fig. 2. Experimental system for measuring arm reflex movements. A muscle accelerometer is mounted on each hand.

This muscle accelerometer was used on both normal subjects and neurological patients to measure the reflex movements of their arms. Preliminary results show that the reflex movements of the arms are reproducible, the position of the head effects the arm movement pattern, and neurological patients produce distinct individual patterns which may be of considerable importance in the diagnosis of neurological disorders.

Spray-on Electrocardiogram Electrodes. Under rigorous exercise conditions, difficulty is often experienced in obtaining good electrocardiograms due to motion artifacts generated by conventional disk electrodes. A new technique for applying electrodes, originally developed for instrumenting NASA test pilots,[3] was recently evaluated on children. The technique consists of spraying a conductive mixture over the end of the electrocardiograph wires and onto the skin. A solvent in the mixture evaporates quickly leaving a thin, flexible layer of conductive material which firmly holds the lead wire in contact with the skin.

The technique was tested on 1,000 children (Fig. 3). A simple spray device was developed to apply the electrodes. The children rode bicycle ergometers and ran on treadmills while electrocardiograms (Fig. 4) were taken without difficulty due to motion artifacts.

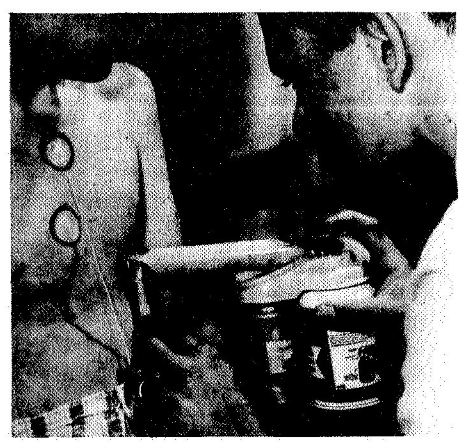

Fig. 3. Spray-on electrocardiogram electrodes being applied.

Fig. 4. Electrocardiogram taken with spray-on electrodes.

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APPENDIX II

ORGANIZATIONS WHICH REQUESTED INFORMATION
ON THE SPRAY-ON ELECTRODES

ORGANIZATIONS WHICH REQUESTED INFORMATION ON THE NASA SPRAY-ON ELECTRODE TRANSFER

1. Madison General Hospital
   Madison, Wisconsin

2. Dalhousie University
   Halifax, Nova Scotia

3. NASA Flight Research Center
   Edwards, California

4. Texas Institute for Rehabilitation and Research
   Houston, Texas

5. Medical Electronics News
   Pittsburgh, Pennsylvania

6. University of Lund
   Lund, Sweden

7. Research Institute for Medical Electronics
   Prague, Czechoslovakia

8. University of Cape Town
   Cape Town, South Africa

9. University of Illinois
   Champaign, Illinois

10. Imperial College of Science and Technology
    London, England

11. Royal Childrens Hospital
    Parkville, Australia

12. NASA Ames Research Center
    Moffett Field, California

13. Karlinska Hospital
    Stockholm, Sweden

14. State University
Utrecht, Netherlands

15. Karl Marx University
Leipsig, East Germany

16. Pegasus International Company
New York, New York

17. Dr. J. H. Issacs
Beverly Hills, California

APPENDIX III

FIGURES

Figure 1 - Commercial Model of Spray-On Electrodes

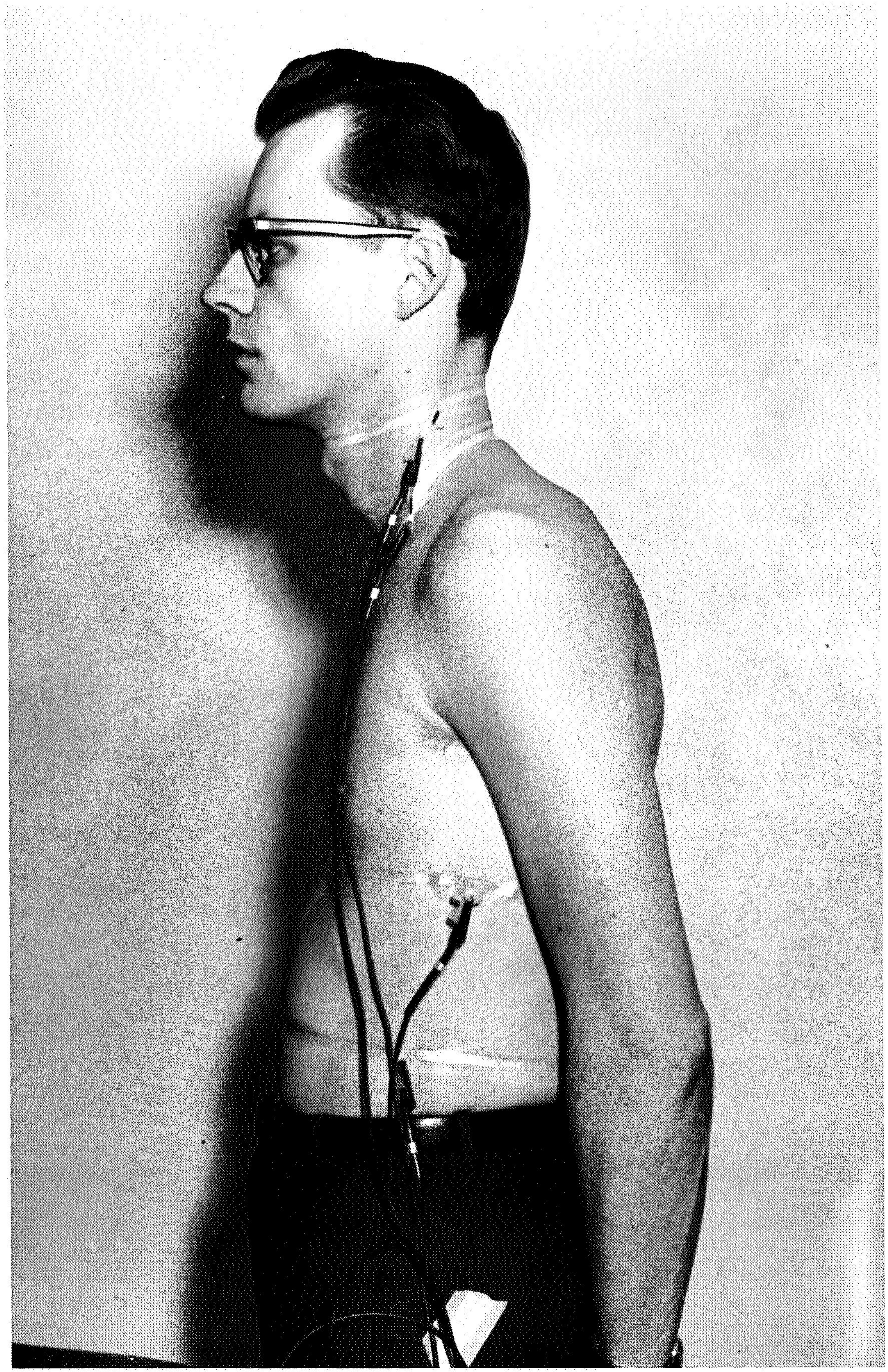


Figure 2 - Impedance Cardiograph Electrodes

IMPEDANCE PLETHYSMOGRAPH

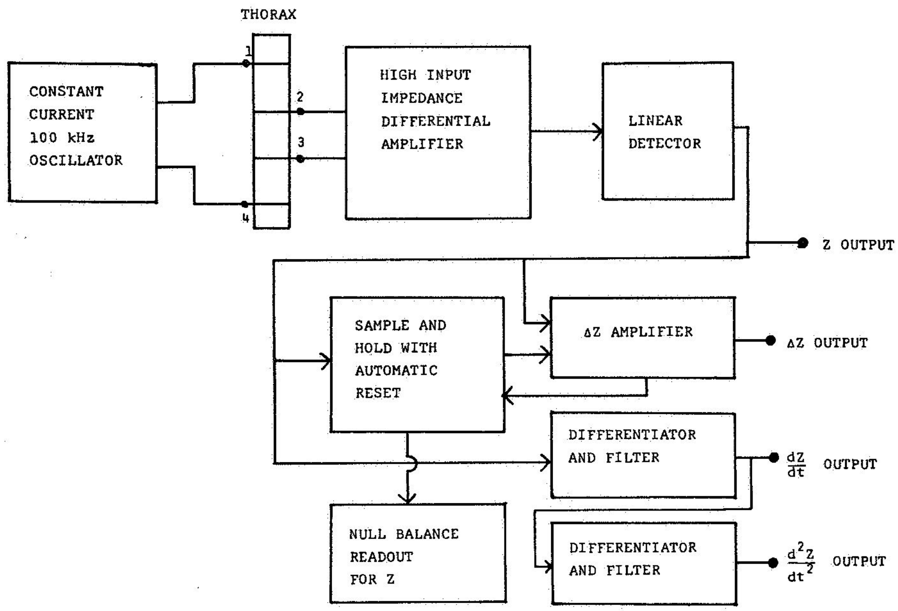


Figure 3 - Impedance Cardiograph Schematic (above) and Control Recorder (below)

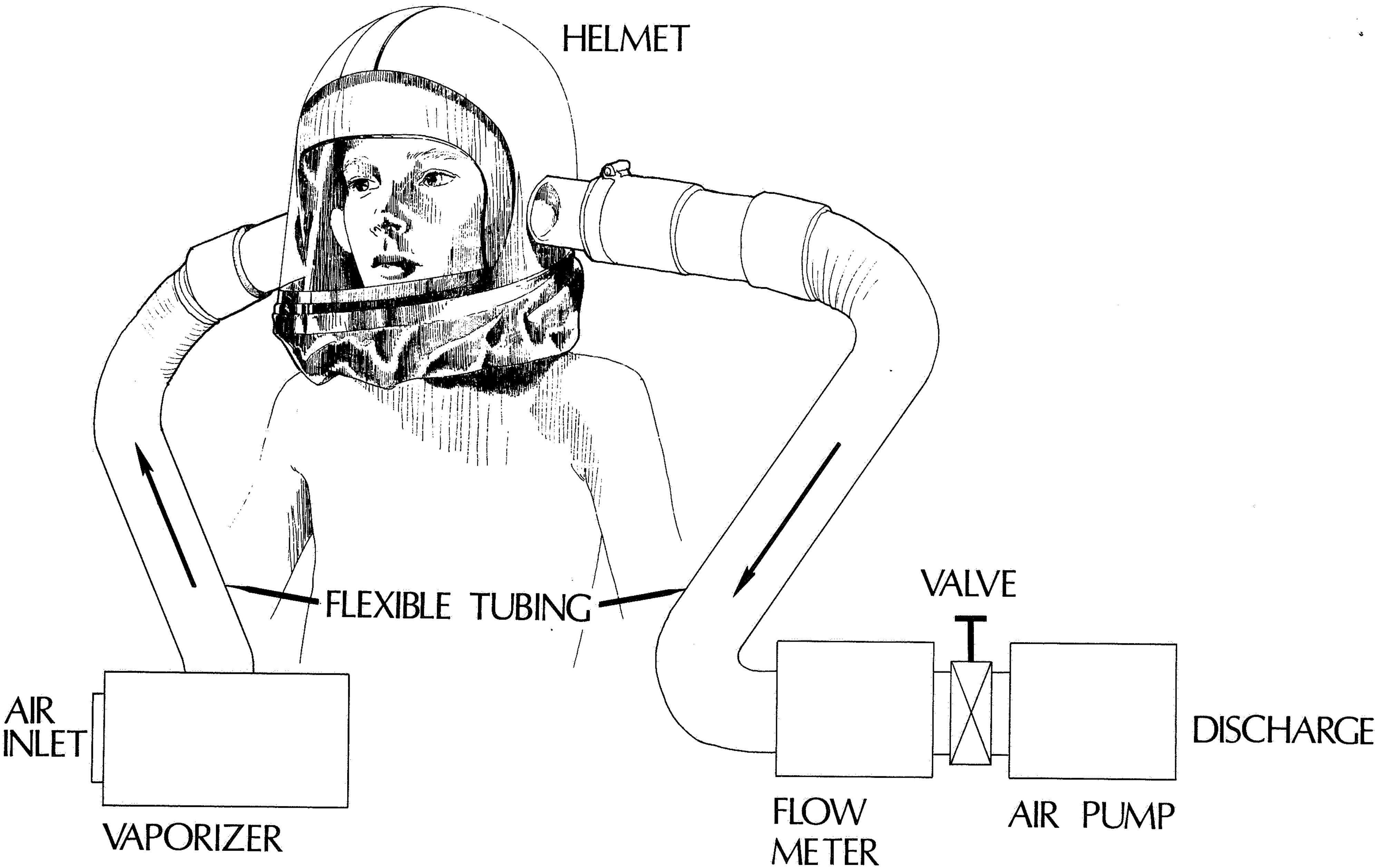


Figure 4 - System for Medicating the Respiratory Tract

APPENDIX IV

NASA TECH BRIEFS

NASA TECH BRIEF

Lamp Enables Measurement of Oxygen Concentration in Presence of Water Vapor

The problem:

To design an ultraviolet source lamp that will radiate sufficient energy at 1800 angstroms and 1470 angstroms for use in a double-beam, dual-wavelength oxygen sensor. This instrument determines the oxygen concentration in a gas mixture by measuring the absorption of ultraviolet radiation through the gas sampling cell at the two different wavelengths in order to eliminate the effects of ultraviolet absorption by water vapor. The source lamp was required to have the characteristics of small size, low input power, low-temperature operation, inherent ruggedness, and long life.

The solution:

An open-electrode lamp filled with xenon at a pressure of 100 mm of Hg. At this pressure, the lamp gives optimum output at 1800 angstroms and a sharp peak at 1470 angstroms. This sharp peak is useful in aligning the slits of the optical system.

Note:

Inquiries concerning this development may be directed to:

Technology Utilization Officer
Manned Spacecraft Center
Houston, Texas 77058
Reference: B67-10387

Patent status:

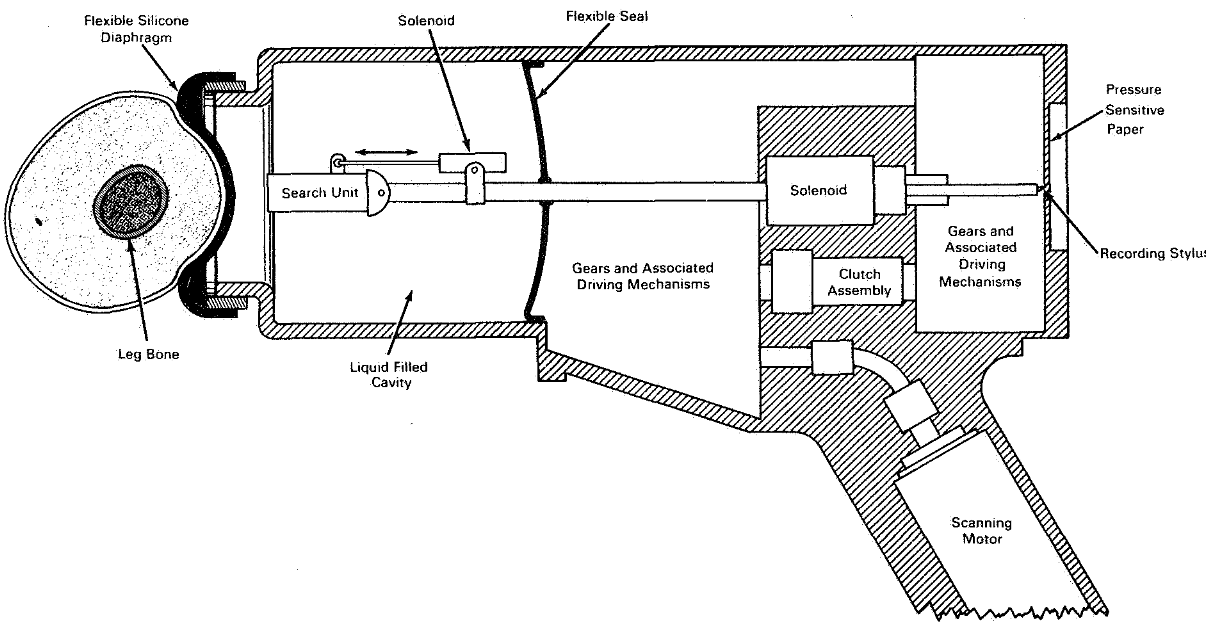
Inquiries about obtaining rights for the commercial use of this invention may be made to NASA, Code GP, Washington, D.C. 20546.

Source: F. J. Brisco, J. E. Moorhead, and W. S. Paige
of the Perkin-Elmer Corporation
under contract to
Manned Spacecraft Center
(MSC-10043)

Category 01

NASA TECH BRIEF

Ultrasonic Hand Tool Allows Convenient Diagnostic Scanning of Bone Integrity



The problem:

To devise a hand tool for the rapid and mechanical scanning of bone integrity and determination of density without the need for surgery or X-rays. Current ultrasonic techniques do not allow convenient scanning of areas that are not readily accessible to bulky equipment.

The solution:

A small, portable, electrically powered ultrasonic hand tool which, coupled with auxiliary ultrasonic equipment, can be used for scanning small areas and fracture sites conveniently. This Tech Brief is a modification of NASA Tech Brief 66-10289, "Ultrasonic Hand Tool Allows Convenient Scanning of Spot Welds." It should be noted that due to the pulse echo ultrasonic technique used (reflection from the bone surface), the use of this equipment is limited generally to bone surfaces not hidden behind other bones, i.e., arm, leg, skull.

How it's done:

The hand-held tool consists of an ultrasonic search unit that carries a housing assembly accommodating a solenoid. The solenoid plunger is fitted with an extension and a recording stylus which records upon the pressure sensitive paper located in the cavity at the rear of the unit. In operation, the front end of the scanner is fitted with the proper body-fitting silicone rubber diaphragm, a couplant of water or grease is applied, and the scanner is placed on the area to be

(continued overleaf)

examined. The spiral scanning motion of the ultrasonic search unit is recorded as a spiral pattern on the pressure sensitive paper. Discontinuities appear as breaks in the spiral pattern.

The scanning motor causes the mechanism to rotate about the centerline of the main cylindrical body. While rotating, the clutch assembly causes an outward translation in a radial direction, thus producing a spiral motion. The search unit is rotated a short distance back and forth by a solenoid as shown. This produces a curvilinear motion of the ultrasonic search unit, which enables the beam to hit the bone perpendicular to the bone surface, and thus reflect the maximum amount of signal and record the maximum area of the curved bone surface. This type of search unit motion is called "compound motion."

The best interrogation frequency for inspection of bone integrity is between 500 kHz and 1 MHz. To determine bone density, lower frequencies may be required.

Notes:

1. A variety of flexible silicone diaphragms will be required to form fit the hand tool to various portions of the body. It may prove more practical and time saving to have the equipment on a multiposition adjustable stand during the scanning operation with the patient's body member strapped rigidly in place.
2. Inquiries concerning this invention may be directed to:

   Technology Utilization Officer
   Marshall Space Flight Center
   Huntsville, Alabama 35812
   Reference: B67-10486

Patent status:

Inquiries about obtaining rights for the commercial use of this invention may be made to NASA, Code GP, Washington, D.C. 20546.

Source: James B. Beal
(MFS-14102)

December 1965

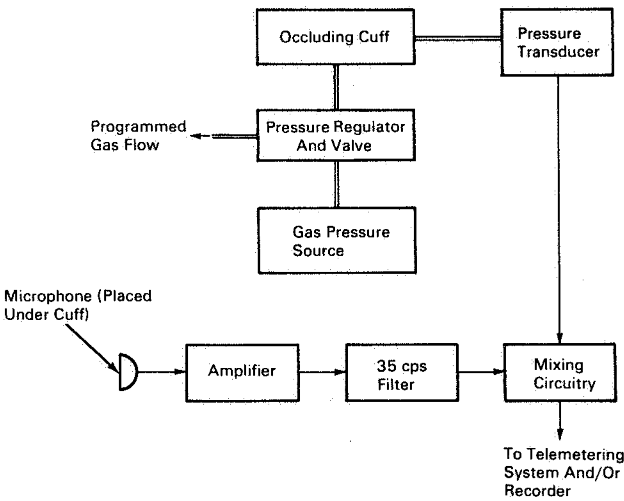
Brief 65-10365

ASTRA

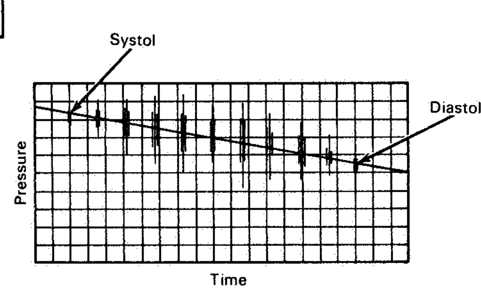
NASA TECH BRIEF

NASA Tech Briefs are issued by the Technology Utilization Division to summarize specific technical innovations derived from the space program. Copies are available to the public from the Clearinghouse for Federal Scientific and Technical Information, Springfield, Virginia, 22151.

Blood-Pressure Measuring System Gives Accurate Graphic Output



SYSTEM SCHEMATIC



TYPICAL OUTPUT TRACE

The problem: To develop an instrument that will provide an external (indirect) measurement of arterial blood pressure in the form of an easily interpreted graphic trace that can be correlated with standard clinical blood-pressure measurements. From sphygmograms produced by conventional sphygmographs, it is very difficult to differentiate the systolic and diastolic blood-pressure pulses and to correlate these indices with the standard clinical values. It is nearly impossible to determine these indices when the subject is under physical or emotional stress.

The solution: An electronic blood-pressure system, basically similar to conventional ausculatory sphygmomanometers, employing a standard occluding cuff, a gas-pressure source, and a gas-pressure regulator and valve. An electrical output transducer senses cuff pressure, and a microphone positioned on the brachial artery under the occluding cuff monitors the Korotkoff sounds from this artery. The output signals present the conventional systolic and diastolic indices in a clear, graphical display. The complete system also includes an electronic timer and cycle-control circuit.

How it's done: The output of the microphone is fed through a solid-state amplifier and a 35-cps filter into the mixing circuitry where it is superimposed on the signal from the pressure transducer. The output of the mixing circuitry is fed to a continuous chart recorder which gives a plot of cuff pressure versus time. The first signal pulse appearing on the graph as the cuff pressure is slowly reduced indicates the systolic pressure and the last pulse corresponds to the diastolic pressure.

(continued overleaf)

Notes:

1. The occluding cuff must be of a minimum width in order to ensure correlation of the measured systolic and diastolic values with the accepted indices. A narrow cuff is highly desirable for comfort and mobility of the subject.
2. Over 2,000 blood pressure measurements have been taken using this system on various individuals, and many of the readings have been compared with those taken with a conventional sphygmomanometer and stethoscope. In only a few instances were the readings off by more than a few millimeters of mercury.
3. A small amount of additional development would be required to make the system completely automatic. Such a system should be of considerable value for monitoring the blood pressure of hospitalized patients and as a clinical diagnostic aid.
4. Inquiries concerning this invention may be directed to:

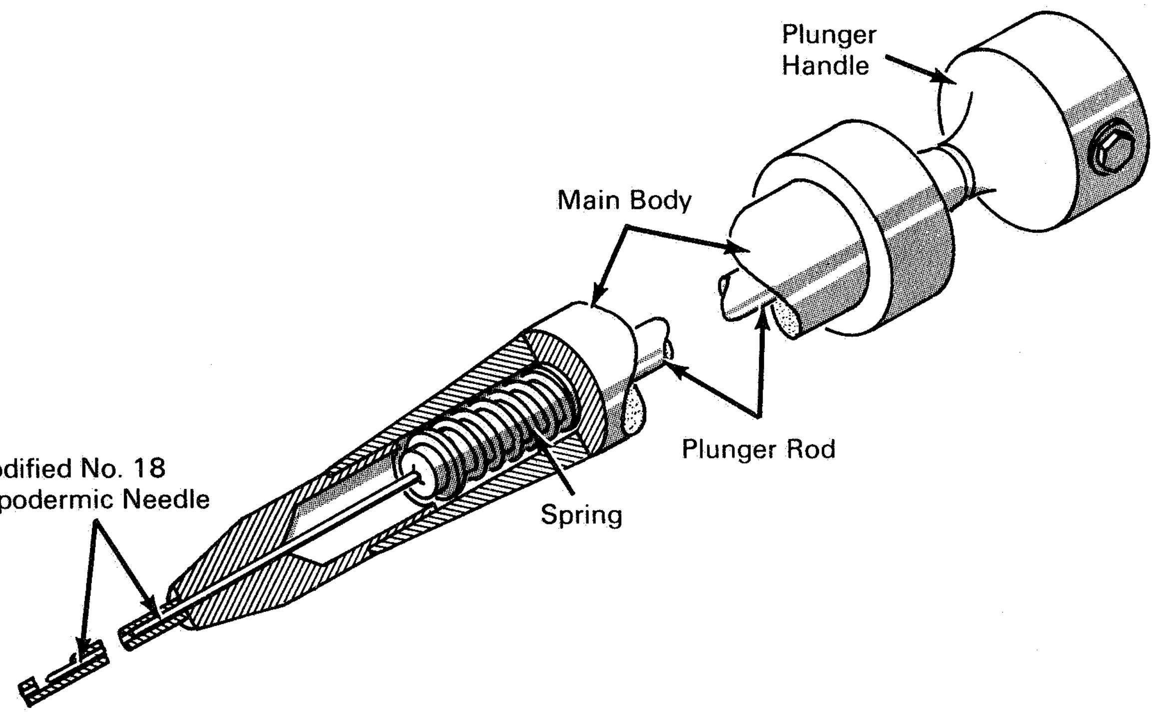
   Technology Utilization Officer
   Manned Spacecraft Center
   P. O. Box 1537
   Houston, Texas, 77001
   Reference: B65-10365

Patent status: NASA encourages the immediate commercial use of this invention. It is owned by NASA and inquiries about obtaining royalty-free rights for its commercial use may be made to NASA, Code AGP, Washington, D.C., 20546.

Source: The Garrett Corporation under contract to Manned Spacecraft Center
(MSC-191)

NASA TECH BRIEF

Micromanipulation Tool Is Easily Adapted to Many Uses



The problem:

A micromanipulation tool is needed that can be easily adapted to a number of work operations, such as cutting, precision clamping and spot welding of microscopic filaments or other parts.

The solution:

A special tool equipped with a plunger mounted in a small tube and designed so that the tip of the tube can be varied to accommodate a variety of work operations.

How it's done:

The main body of this tool is made so that a plunger handle can be inserted at one end and a modified No. 18 hypodermic needle can be mounted at the other end. A cylindrical hollow inside the main body permits a spring to be placed around the plunger. By moving the spring from one side of a stop (a washer soldered in place) to the other, the plunger rod can be forced to move down the tube and act as a clamp or to be held in an open position. For greater ease of handling, a flexible cable release may be used instead of a plunger.

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Several tips should be made using a thin tube or a modified hypodermic needle. For cutting actions, a slot is cut at the tip of the tube and the end of the plunger rod is ground to a diagonal cutting edge. To use as a clamp, the end of the tube is plugged with a soft metal and the end of the plunger rod ground flat. Small jaws can also be fixed to the tube and the plunger rod.

Notes:

1. Where extreme steadiness at high magnification is required, this tool is particularly useful. It would also be of value where the work area is inaccessible to bulkier tools, such as jewelers forceps.
2. Repair and assembly of instruments which have fine watchlike parts would be another application of the micromanipulation tool. Specific tips and plunger rods could be designed for particular operations.
3. Inquiries concerning this innovation may be directed to:

   Technology Utilization Officer
   Jet Propulsion Laboratory
   4800 Oak Grove Drive
   Pasadena, California 91103
   Reference: B67-10004

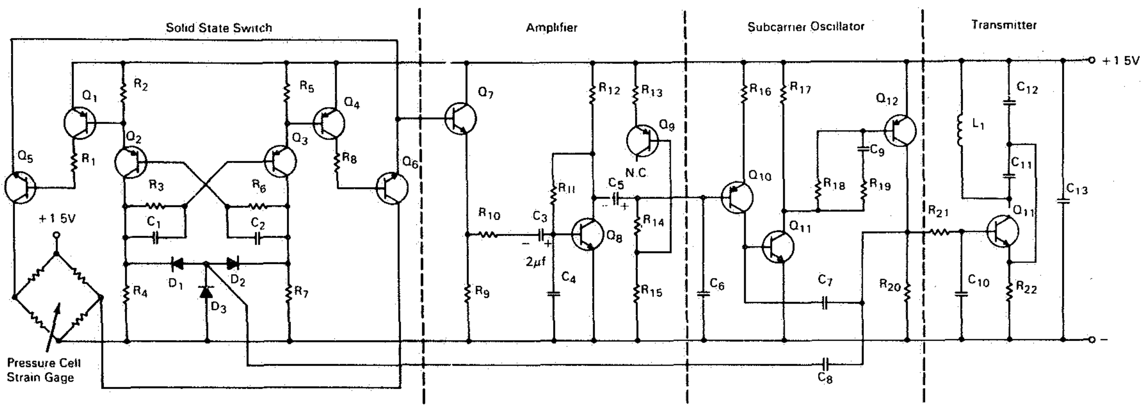
Patent status:

No patent action is contemplated by NASA.

Source: Paul J. Shlichta
Jet Propulsion Laboratory
(JPL-129)

NASA TECH BRIEF

Miniature Telemetry System Accurately Measures Pressure



The problem:

To design a telemetry system to accurately measure pressure with a small implantable pressure cell and transmitter. The system must operate with low power consumption.

The solution:

A miniature, low power, telemetry system that can be used with any of a number of commercially available strain gage pressure transducers. A small, solid state, strain gage pressure cell, designed for implanted physiological applications, is used with the new circuitry to provide a complete, implantable pressure transducing system.

How it's done:

The electronic circuit uses a pulse code modulation similar to ones previously used for temperature and biopotential monitoring. The subcarrier modulation technique allows accurate transmission of the low output level of the pressure cell from an implanted location to a remote radio receiver. The small strain gage signal (approx. 15 mv for 250 mm of Hg) is chopped by means of a solid-state switch (Q_1, Q_2, Q_3, Q_4, Q_5, Q_6) and amplified by an ac amplifier Q_7 and Q_8 (gain approximately 5). After amplification the signal controls the period of an astable multivibrator (Q_9, Q_{10}, Q_{11}, Q_{12}) operating at approximately 1 kHz. The pulse derived from the astable multivibrator is applied through C_8 to obtain synchronous operation of the solid-state switch, thereby causing the period of the multivibrator to be controlled alternately by the voltage derived from Q_5 and Q_6. The difference between successive periods then is proportional to the bridge unbalance signal and hence the pressure. The interval between pulses at bridge balance would be identical, but in order to avoid ambiguity the bridge is initially unbalanced in such a manner that one period remains smaller than the other over the

(continued overleaf)

entire operating pressure range. A typical modulation of ±20 percent of the mean period is obtained for a pressure change of 250 mm of Hg.

The short pulse developed by the astable multivibrator (approx. 20 microsecond long) is used to turn on the rf oscillator, Q_{13}. L_1 is used both as a tank circuit inductor and as a transmitting antenna. Since the information is derived from the time period between rf pulses, amplitude and frequency changes in the rf link do not affect the accuracy. After the pulses are received on a commercial FM receiver (88–108 MHz) a suitable demodulator is used to obtain an analog signal.

The telemetry system is shown with a protective coating of elasticized silicone rubber applied. In this condition, the system is ready for implantation.

Notes:

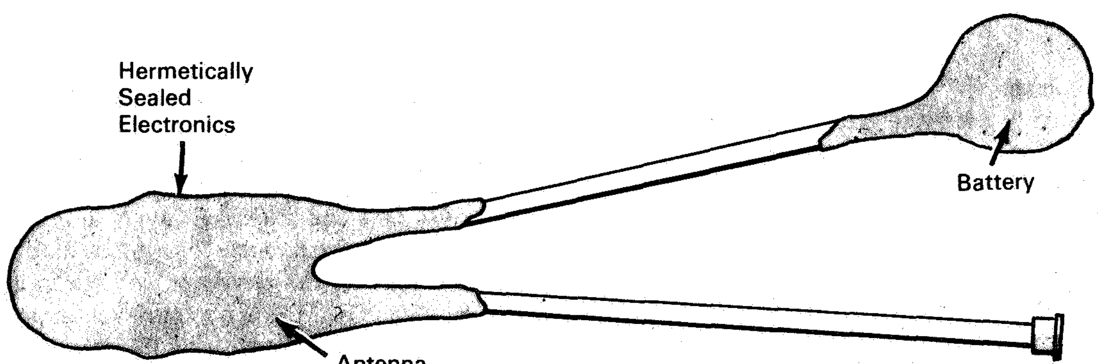
1. The system has been used to date only with pressure transducers, but the circuit is equally applicable to any measurement using a strain gage sensor. The pressure transducer is commercially available.
2. The transducer used is 6.5 mm in diameter and 1 mm thick. The lead-in wires terminate on the back of the transducer in a package that is 3.5 mm in diameter by 4.5 mm long.
3. The compensated temperature range of the transducer is from 77°F to 113°F. The telemetering electronics are suitable for temperatures to 150°F.
4. The battery lifetime of 500 hours is associated with a transmission distance of 3 to 5 feet. Increased transmission distance will be accompanied by increased power consumption with a reduced battery life. It is estimated that the battery life would be reduced to 125 hours for a transmission distance of about 100 feet.
5. Similar applications are described in Tech Brief 64-10171 for biopotential monitoring and Tech Brief 66-10057 for temperature monitoring.
6. Inquiries concerning this invention may be directed to:

   Technology Utilization Officer
   Ames Research Center
   Moffett Field, California 94035
   Reference: B66-10624

Patent status:

Inquiries about obtaining rights for the commercial use of this invention may be made to NASA, Code GP, Washington, D.C. 20546.

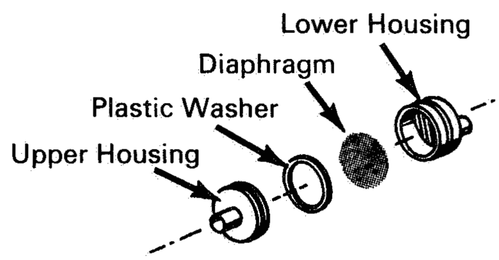
Source: T. B. Fryer
(ARC-74)



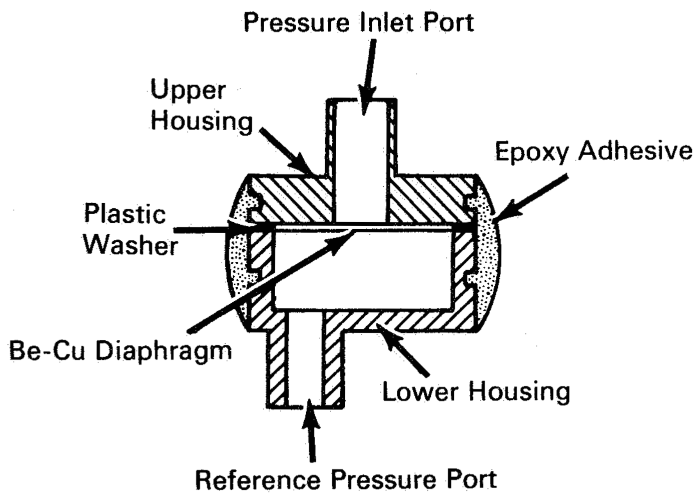
Miniature Telemetry System Ready for Implantation

NASA TECH BRIEF

Miniature Capacitor Functions as Pressure Sensor



ACTUAL SIZE



The problem:

To devise a miniature capacitor that will operate reliably as a differential-pressure telemetry sensor over wide ranges of pressure, temperature, and acceleration encountered during free flight of an instrumented test model in a hypersonic continuous-flow wind tunnel.

The solution:

A capacitor incorporating a beryllium copper diaphragm that produces a variation in capacitance as a function of the pressure applied to one face of the diaphragm relative to a reference pressure applied to the opposite face.

How it's done:

The actual size of the unit (exploded view) and the construction details (sectional view) are shown in the illustrations. The diaphragm is secured to the rim of the lower housing by means of a low-melting solder in a specially designed fixture. This subassembly and electrically insulating washer are then fitted to the upper housing and aligned in another specially designed fixture. An epoxy adhesive is used to hold the assembly together and provide a pressure seal at the seam.

When the respective pressures are applied to the inlet and reference ports, the diaphragm moves slightly and correspondingly changes the capacitance of the unit in response to the pressure difference. The capacitance is measured between the upper and lower housings connected to the tank circuit of a telemetry oscillator.

Notes:

1. The capacitor is capable of withstanding an overpressure of 50 psi and is insensitive to the accelerations and temperatures encountered in a hypersonic wind tunnel. It may also be used as an absolute pressure sensor by sealing the reference port.

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2. The units can be easily produced within close capacitance tolerances using the specially designed assembly fixtures.
3. Capacitors of this design can be used for remote measurement of rapid as well as slow changes in pressure in a variety of applications.
4. Inquiries concerning this invention may be directed to:

   Technology Utilization Officer
   Jet Propulsion Laboratory
   4800 Oak Grove Drive
   Pasadena, California 91103
   Reference: B67-10020

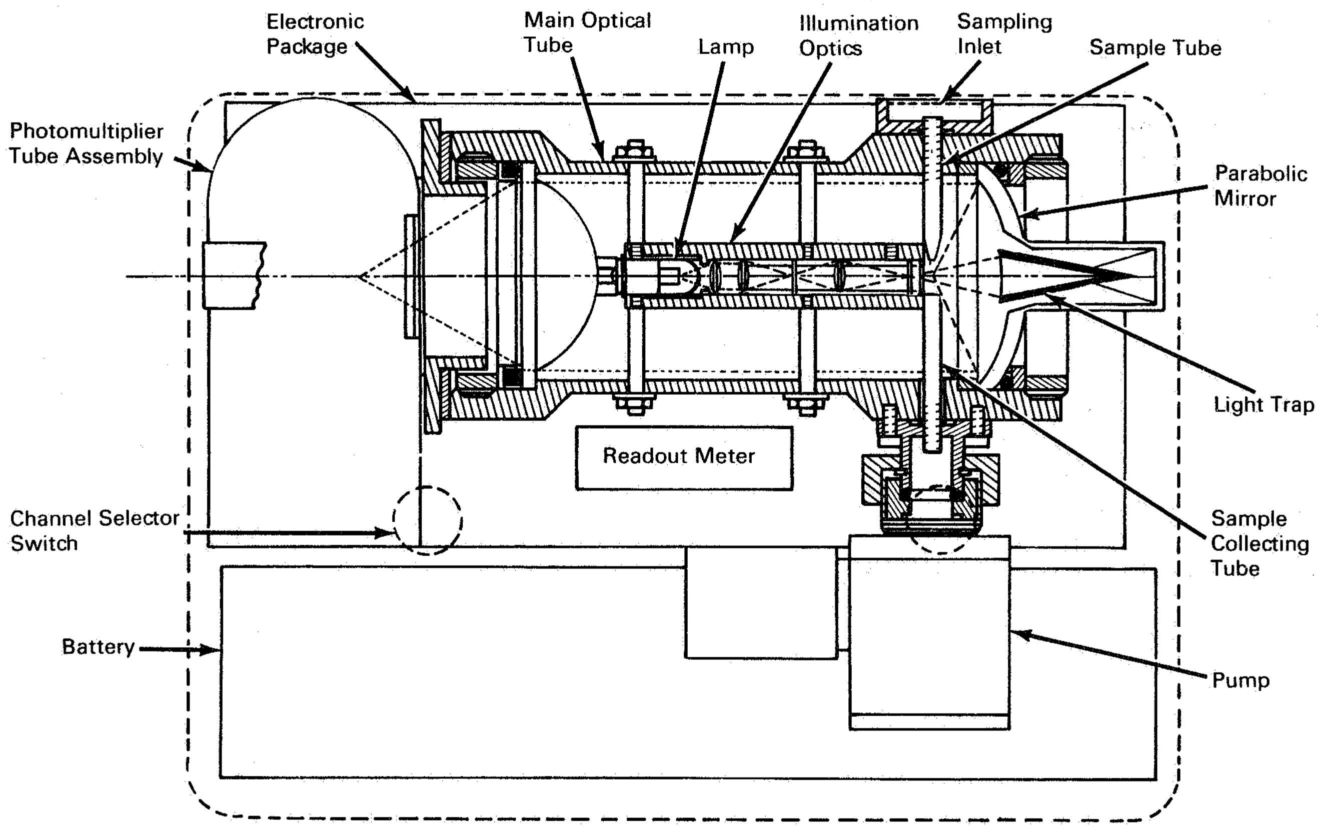
Patent status:

Inquiries about obtaining rights for the commercial use of this invention may be made to NASA, Code GP, Washington, D.C. 20546.

Source: R. G. Harrison
(JPL-903)

NASA TECH BRIEF

Improved Atmospheric Particle Analyzer



The problem:
To design an instrument that will measure aerosol particle concentrations in the range of 500 to 500,000 particles per cubic foot and size distributions in the range of 0.5 to 10 microns. The sampling rate of the instrument must be high enough to provide accurate readings within a reasonable time.

The solution:
An electro-optical instrument (nephelometer) that measures the light scattered from the aerosol particles at a controlled sampling rate to ensure laminar flow through the sample tube, and thereby eliminate the need for sheath air. This instrument employs a concentric configuration, wherein the scattering angle is

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concentric with, but outside the illuminating beam. An evaluation of conventional particle-size analyzers based on optical scattering phenomena indicates that the concentric configuration is preferable for measuring small aerosol particles of unknown refractive index.

How it's done:

Air to be sampled is drawn through the sampling inlet, located at the top of the instrument. This air passes through the sample volume, which has a diameter of 1 millimeter and a length that does not exceed 5 times this dimension. The air then passes through the collecting tube from where it is exhausted through the pump, which is driven by a permanent magnet motor. The velocity of the flow is 10 meters per second, which is equivalent to 0.465 liter per minute, or 1 cubic foot per hour. Reduced pressure (or an oxygen environment) will not have an appreciable effect on this rate, as long as the pressure remains significantly higher than the loss (approximately 15 inches of water) in the sample tube.

Nearly uniform illumination is provided by a type 328 lamp focused on a square slit. The slit is then reimaged on the sample volume through a solid angle of ±12 degrees, particular care being taken to avoid stray light from the lenses or tube walls. The main illuminating beam diverges into a light trap. Should a particle be present in the air sample, it will scatter light from the illuminating beam. The light scattered in a forward direction between 30 and 53 degrees from the axis of the main beam is intercepted by a parabolic mirror and focused on a photomultiplier. A pulse of 100-microsecond duration appears at the output of the multiplier, whenever a particle passes across the slit. The amplitude of this pulse increases with particle size. By detecting only those pulses above a certain amplitude, a count of the number of particles above a given size is obtained. The detection is accomplished by simultaneously counting pulses in 5 discriminators, each set at a different amplitude. The output of each discriminator is integrated, using an integration time constant of 8 seconds, and the number of particles per second is then available as a dc voltage. This voltage is measured at the end of the sampling time by connecting the output meter sequentially to each of the output channels by means of the channel selector switch.

Power for the lamp, motor, and electronic circuitry is obtained from a 6.2-volt regulator, which is supplied from a 7.2-volt, 750-milliampere-hour nickel-cadmium battery.

Notes:

1. The output from this instrument is suitable for either analog or digital pulse processing.
2. This instrument should be useful in air pollution measurements, dust control in clean rooms, abrasive particle monitoring, and control of mine ventilation systems.
3. Inquiries concerning this invention may be directed to:

   Technology Utilization Officer
   Electronic Research Center
   575 Technology Square
   Cambridge, Massachusetts 02139
   Reference: B67-10231

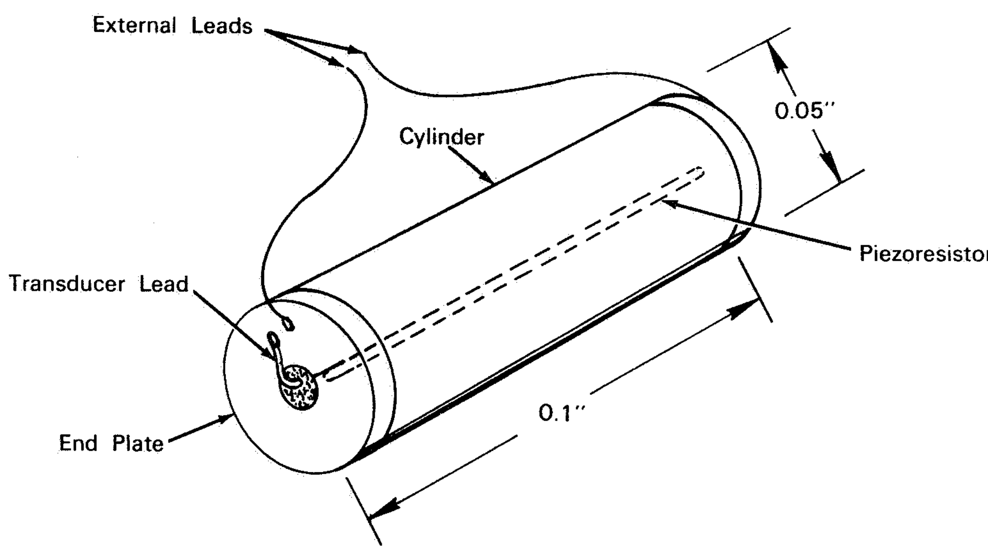
Patent status:

Inquiries about obtaining rights for the commercial use of this invention may be made to NASA, Code GP, Washington, D.C. 20546.

Source: Block Engineering, Inc.
under contract to
Electronics Research Center
(ERC-33)

NASA TECH BRIEF

Miniature Stress Transducer Has Directional Capability



The problem: The measurement of stresses internal to a mass and, especially, along the direction in which they are oriented.

The solution: A miniature stress transducer that employs a semiconductive piezoresistive element that is stress sensitive along a specific axis only.

How it's done: A semiconductive transducer is fashioned from a p-type silicon splinter embedded in a centerless ground, high-density, polyethylene cylinder. The silicon splinter is a piezoresistor grown in a selected crystallographic orientation to possess piezoresistive characteristics along a selected axis. Brass end plates, drilled for the transducer leads, are fastened to the transducer cylinder ends using an epoxy adhesive. The assembly is held in a fixture while epoxy adhesive is injected into the cylinder to embed the silicon splinter permanently. The transducer leads are resistance welded to the brass end plates that include external leads for connection to instrumentation.

The mechanism of measurement is based on the compressive deformation of the transducer. Loading of the transducer cylinder along the piezoresistor's sensitive axis changes resistance of the silicon splinter in direct relation to the amount of stress applied. Various deformation sensitivities are possible by using cylinders of differing Young's modulus.

Notes:

1. Other cylinder materials which exhibit the characteristics of homogeneous structure, low modulus, nonconductivity, ease of machining, and good bonding to the semiconductor crystal have been found to be suitable, e.g., etched teflon.

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2. Materials having poor bonding qualities, e.g., nylon, were found to be unsatisfactory.
3. A number of transducers may be readily mounted about a point region in a structural member, each aligned with a direction of interest, thereby obtaining multiaxial stress analysis of the point region.
4. This transducer would be useful for constant monitoring of stress in structural members of buildings, dams, etc.
5. Inquiries concerning this invention may be directed to:

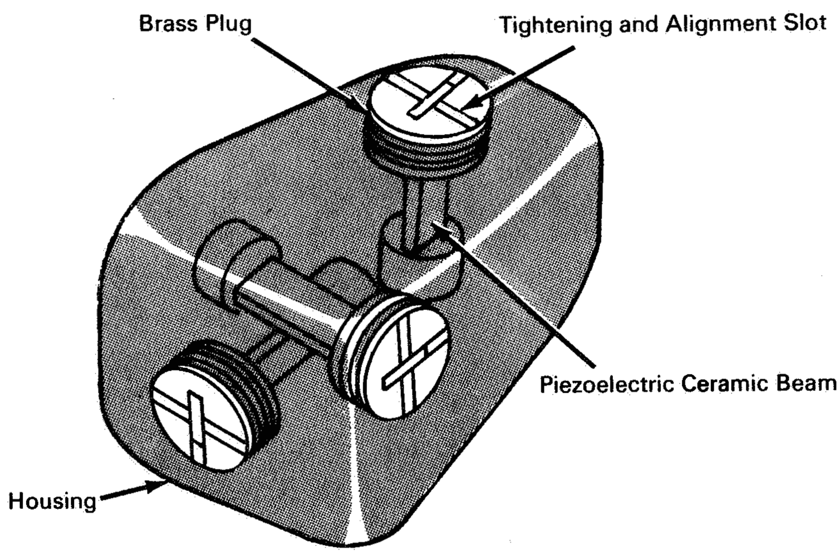
   Technology Utilization Officer
   Jet Propulsion Laboratory
   4800 Oak Grove Drive
   Pasadena, California, 91103
   Reference: B65-10023

Patent status: NASA encourages the immediate commercial use of this invention. Inquiries about obtaining rights for its commercial use may be made to NASA, Code AGP, Washington, D.C., 20546.

Source: Anthony San Miguel and
Robert H. Silver
(JPL-591)

NASA TECH BRIEF

Miniature Piezoelectric Triaxial Accelerometer Measures Cranial Accelerations



The problem:

To design and build a triaxial accelerometer to measure human cranial accelerations when a subject is exposed to a centrifuge or other simulators of g environments. The size and shape must be suitable for attachment to the teeth without discomfort.

The solution:

A tiny triaxial accelerometer whose sensing elements are piezoelectric ceramic beams. The accelerometer physical shape is compatible to a human mouth and may be attached to the teeth by an appropriate bridge and located behind the upper teeth in the roof of the mouth. The sensitivity is about 20 millivolts (rms) per g and the frequency response is essentially flat over the range tested (5 to 500 cps).

How it's done:

The accelerometer consists of three orthogonal cantilever beams of piezoelectric ceramic material mounted in an aluminum case having external dimensions approximating those of a human molar. The beams are 0.2-inch in length and each has a gold weight bonded to the free end. The beams are located in a slot cut in a brass threaded plug and bonded in place with a nonconductive epoxy cement.

All three elements are made identical as far as possible. A slot on the brass plug face provides an alignment reference. Insulated soft copper wires are soldered to the top and bottom electrodes of each beam and passed through the open slot of the plug along the beam side. The elements are then inserted

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into the housing and potted in place with epoxy cement.

Notes:

1. In testing, the linearity for all components proved to be excellent. Sensitivity was of the order of 20 millivolts (rms)/g. The repeatability was excellent and the response was essentially flat over the entire range tested (5 to 500 cps). The cross axis sensitivity did not exceed 5.5 percent.
2. A related innovation is described in NASA Tech Brief B64-10004, "Ultrasensitive Transducer Advances Micromeasurement Range," May 1964. A method of testing piezoelectric transducers is described in NASA Tech Brief B66-10533, "Method Permits Mechanical and Electrical Checkout of Piezoelectric Transducers While Installed in a System," November 1966.
3. This device could be considered for application in dental, medical, and automotive safety research.
4. Inquiries concerning this innovation may be directed to:

   Technology Utilization Officer
   Ames Research Center
   Moffett Field, California 94035
   Reference: B66-10534

Patent status:

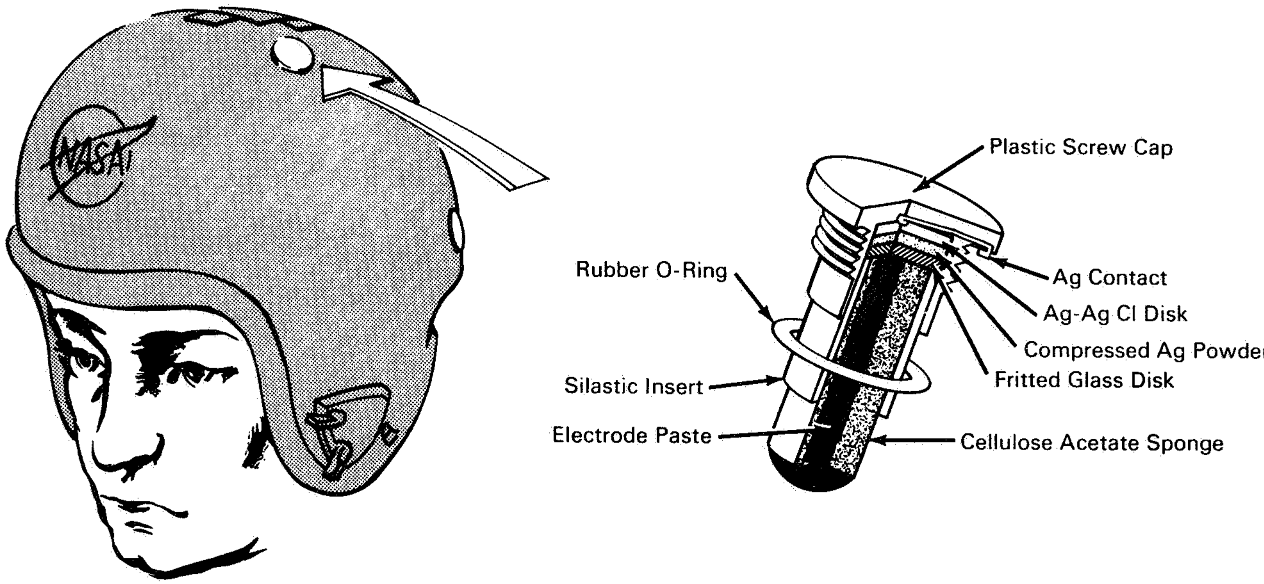
No patent action is contemplated by NASA.

Source: V. L. Rogallo and G. J. Deboo
(ARC-71)

November 1966 Brief 66-10536

NASA TECH BRIEF

Helmet System Broadcasts Electroencephalograms of Wearer



The problem:

To develop an improved system for obtaining electroencephalograms (EEG's) of pilots and astronauts performing tasks under stress. In the past, electrodes were cemented to the scalp and were uncomfortable, irritated the scalp, and took as long as an hour to attach. Furthermore, the wires to the readout equipment restricted the subject's motions.

The solution:

An EEG monitoring system consisting of non-irritating sponge-type electrodes, amplifiers, and a battery-powered wireless transmitter, all mounted in the subject's helmet. No preparation of the scalp is required. After a quick initial fitting, the helmet can be removed and replaced without further adjustment. There are no external wires.

How it's done:

A flight helmet is modified to contain the EEG electrodes and the electronic components. The elements of the system fit conveniently in the helmet and do not impair its usefulness as a protective device.

The key element in this system is the EEG electrode, which consists of a flexible portion that rests against the scalp and a rigid portion that fits securely in the helmet and is connected to the amplifier. The flexible portion consists of a hollow-core cellulose acetate sponge impregnated with an electrode paste. The rigid portion consists of the following: a disk of fritted glass wetted with a saline solution; a disk of compressed silver powder; a disk of Ag–AgCl; and a solid silver contact which connects with the amplifier.

Fitted to the subject, the sponge portion containing the electrode paste contacts the scalp with a light

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steady pressure. This member can accommodate a certain amount of relative motion between the scalp and the helmet without altering the electrical properties of the connection or distorting the signal.

The remaining elements of the system are a pair of miniature biomedical amplifiers, a pair of commercially available FM subcarrier oscillators, a miniature PM transmitter operating at 108 MHz, and standard miniature mercury cells that provide 90 hours of continuous operation.

Notes:

1. The helmet shell comes in three basic sizes, and by selection of liner size and length of replaceable sponge, the helmet can be adapted to any subject. Initial fitting requires only about five minutes.
2. Experiments with a variety of subjects (some with thick hair, with and without hairoil, and some bald) have been made in the laboratory, in flights of a T-33 airplane, and in centrifuge runs. The data obtained have been consistent with EEG records obtained with carefully applied metallic electrodes.
3. A related innovation is described in NASA Tech Brief B65-10203, July 1965.
4. Inquiries may also be directed to:

   Technology Utilization Officer
   Ames Research Center
   Moffett Field, California 94035
   Reference: B66-10536

Patent status:

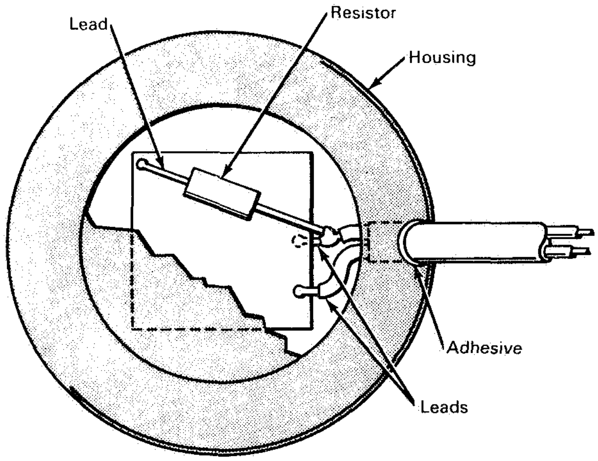
Inquiries about obtaining rights for the commercial use of this invention may be made to NASA, Code GP, Washington, D.C. 20546.

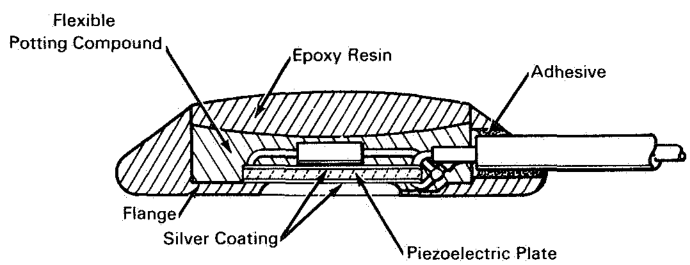
Source: Richard M. Westbrook and
Joseph J. Zuccaro
(ARC-70)

NASA TECH BRIEF

NASA Tech Briefs are issued to summarize specific innovations derived from the U. S. space program and to encourage their commercial application. Copies are available to the public from the Clearinghouse for Federal Scientific and Technical Information, Springfield, Virginia 22151.

Phonocardiograph Microphone Is Rugged and Moistureproof





The problem:

To design a microphone to be used as a phonocardiograph transducer under conditions such as experienced by an astronaut. The microphone must be capable of monitoring small amplitude audio signals in the presence of large shock loads, accelerations of up to 40g, temperatures from 30° to 200° F, and high humidity.

The solution:

A microphone incorporating a lead zirconate–lead titanate piezoelectric plate encapsulated in a flexible polyurethane resin contained in a sealed nylon case having a diameter of less than 1 inch.

How it's done:

A square plate (approximately 0.4 inch on a side) of the piezoelectric ceramic with a silver coating on opposite faces, to permit soldering of lead wires to the plate, is supported at diagonally opposite corners on a flange at the bottom of the nylon case. The lead wires are soldered to the plate surfaces as shown in the illustration. A 470 Kohm (0.1 watt) carbon resistor, soldered in parallel with the terminals of the piezoelectric plate, serves to provide the required low frequency response of the transducer. The plate is secured to the support points on the flange by means of a suitable adhesive coating. This adhesive material is also used to seal the joints between the case and the cable.

The space directly above the plate is partially filled with a polyurethane resin, which, when cured, remains sufficiently flexible so as not to interfere with the piezoelectric characteristics of the plate. The polyurethane resin also holds the resistor in fixed relation to the plate and effectively seals the internal circuit against moisture in the atmosphere and from perspiration from the body to which the transducer is attached. The remainder of the cavity is filled with an epoxy resin, which, when cured, serves as an

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electrical and thermal insulator and exhibits high resistance to mechanical shock. This epoxy resin is also applied as a seal to the interface junction between the piezoelectric plate and the opening at the base of the transducer.

Notes:

1. In use, the base of the microphone is secured to the skin over the area to be monitored with a piece of double-backed surgical tape.
2. Inquiries concerning this invention may be directed to:

   Technology Utilization Officer
   Manned Spacecraft Center
   Houston, Texas 77058
   Reference: B66-10314

Patent status:

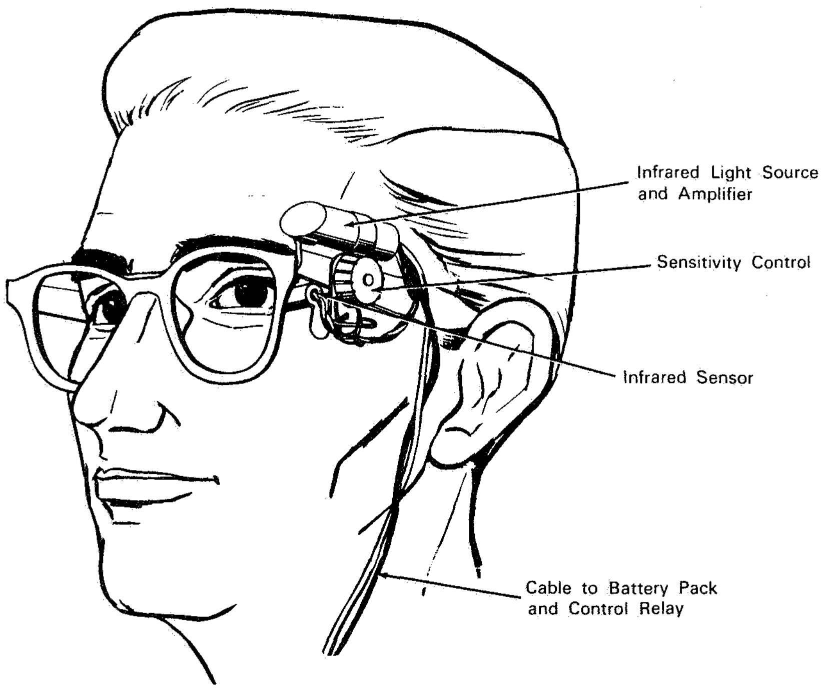
Inquiries about obtaining rights for the commercial use of this invention may be made to NASA, Code GP, Washington, D.C. 20546.

Source: William J. Young
(MSC-212)

March 1965 ASTRA Brief 65-10079

NASA TECH BRIEF

Photoelectric Sensor Output Controlled By Eyeball Movements



The problem: NASA research in the areas of bioscience and biotechnology has included a number of studies to devise methods of utilizing certain voluntary physiological functions (extracted output) for communicating or for controlling external operations. One of these studies has been directed to devising a means of extracting useful signals from the self-controlled movements of the human eye.

The solution: A small device combining an infrared (IR) source and sensor that can be attached to eyeglass frames or a headband. Operation of the device depends on the difference in IR absorption between the iris, which is a relatively good absorber, and the surrounding area of the eyeball, which reflects a relatively high percentage of the incident IR energy.

How it's done: The device incorporates an IR source, consisting of a battery-powered 6-volt or 10-volt lamp and high pass infrared filter (to filter out visible light from the lamp), and a cadmium selenide IR sensor. A filter is also placed in front of the IR sensor to exclude all ambient visible light. The IR source and sensor are mounted relative to one another so that when the eye is looking straight ahead all of the IR radiation from the source is incident on the

(continued overleaf)

area of the eyeball lying on one side of the iris and the radiation on this area is reflected to the sensor. This is the normal or off condition of the device. When the iris is voluntarily turned toward the IR source, a high percentage of the radiation is absorbed by the iris, and the external control relay connected to the sensor is actuated. An amplifier is used to amplify the current generated by the IR sensor. A sensitivity control connected to the amplifier permits adjustment of the threshold value for proper switching action under different ambient lighting conditions.

Note:

1. Inquiries concerning this innovation may be directed to:

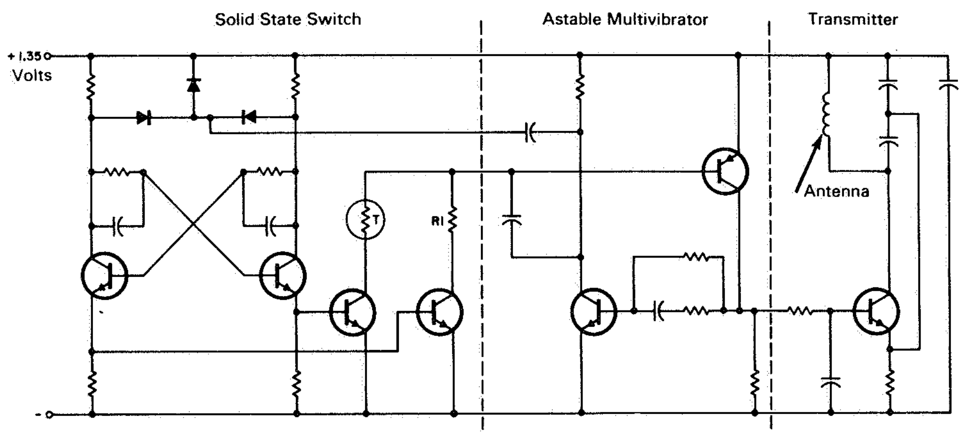
   Technology Utilization Officer
   Marshall Space Flight Center
   Huntsville, Alabama, 35812
   Reference: B65-10079

Patent status: NASA encourages the immediate commercial use of this invention. Inquiries about obtaining rights for its commercial use may be made to NASA, Code AGP, Washington, D.C., 20546.

Source: Spaco, Inc., under contract to
Marshall Space Flight Center
(M-FS-274)

NASA TECH BRIEF

Miniature Bioelectronic Device Accurately Measures and Telemeters Temperature



The problem:

To design a microminiature implantable instrument that will continuously and accurately measure and telemeter the body temperature of laboratory animals over periods up to two years. The implanted instrument must be impervious to attack by body fluids and have a negligible effect on the physical activity of the animal.

The solution:

A miniature micropower solid-state circuit employing a thermistor as a temperature sensing element (with a compensating resistor) and a FM transmitter. The circuit is designed to be very stable for a long period and to be accurate to within 0.1°C. The instrument may be constructed from conventional discrete components or integrated circuits. A special feature of the instrument with integrated circuitry is that the electronic components are sealed in a metal can, separate from the battery, so that seal rupture due to battery out-gassing is not a problem.

How it's done:

The circuit operates in the FM broadcast band and may be used with a commercial FM receiver. It transmits 15-microsecond pulses spaced 8 to 20 milliseconds apart, depending on the temperature being monitored (45° to 30°C). The average current drain of the circuit is approximately 7.4 microamperes at 1.35 volts.

A bistable multivibrator alternately switches the temperature sensor (a thermistor and a standard resistor, R1) into the frequency determining circuit of the astable multivibrator. The demodulator produces an output proportional to the ratio of the pulses obtained from the thermistor and the standard resistor.

(continued overleaf)

This ratio is used to compensate for variations in battery voltage and component values.

The integrated circuit employs a ferrite-core antenna to concentrate the rf field and prevent induction effects in the battery. The ferrite core also serves as a holder for the battery, and both components, mounted outside of the circuitry container, are sealed in wax.

Notes:

1. Although designed primarily for measuring and telemetering body temperature, the circuit can be easily modified to allow differential monitoring of other variables. The system can be extended to measurement of several variables (voltages) by replacing the bistable multivibrator with a ring counter.
2. A related invention is described in NASA Tech Brief B64-10171, October 1964. Inquiries may also be directed to:

   Technology Utilization Officer
   Ames Research Center
   Moffett Field, California, 94035
   Reference: B66-10057

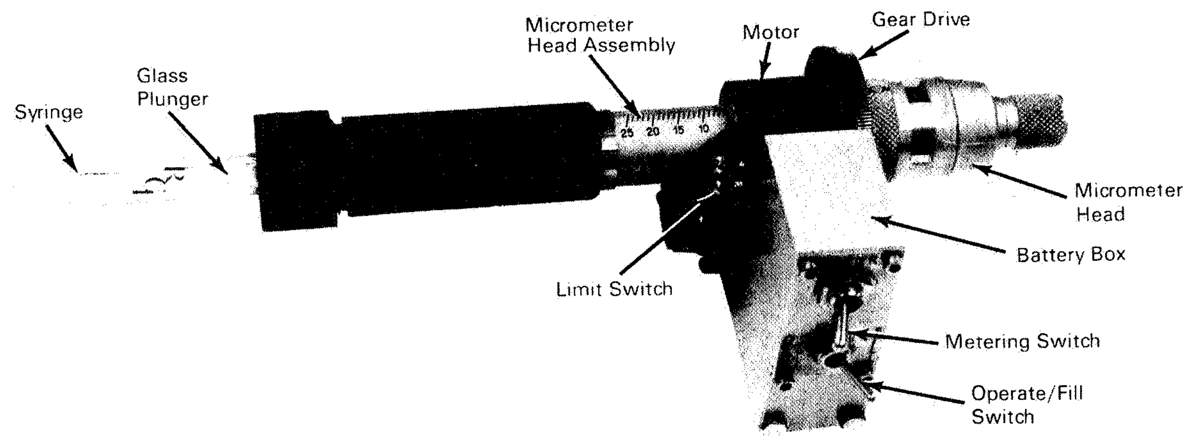
Patent status:

Inquiries about obtaining rights for the commercial use of this invention may be made to NASA, Code AGP, Washington, D.C., 20546.

Source: Thomas B. Fryer
(ARC-52)

NASA TECH BRIEF

Automated Microsyringe Is Highly Accurate and Reliable



The problem:

To develop a device that will meter small (microliter) volumes of fluid. In performing chemical analysis with extremely small volumes of fluids (microchemistry) a simple, reliable and convenient metering device was needed.

The solution:

A standard syringe body and plunger that has been adapted to fit with a motor driven micrometer.

How it's done:

A miniature electric motor and self-contained battery drive the micrometer. The contents of the syringe can be metered very precisely since there is a proportional relationship between the amount of fluid drawn into or expelled from the syringe and the relative reading of the micrometer. The micrometer is a standard depth-type micrometer that has been mechanized by the addition of gears and a motor drive.

To meter one sample of solution, the metering switch is toggled from the normally open position, and the motor is energized. The cycle proceeds automatically until one unit volume of fluid has been metered out of the syringe. At the end of the cycle, the motor drives the stop cam and, in turn, the stop switch to its normally closed position. This process may be repeated as many times as there are samples of fluid within the syringe. On the last delivery sample, the limit switch will move to the opposite position to prevent any further fluid from being delivered by the syringe through manipulation of the metering switch.

One feature of the normally closed position of the stop switch is to provide dynamic braking on the motor when the cam lifts the stop switch and deenergizes the motor. This makes a short circuit across the motor, thus providing dynamic braking which permits accurate metering of fluids.

(continued overleaf)

Notes:

1. This syringe can be used in automated wet chemical instrumentation. It is a highly adaptable device which can be used in a variety of applications where manually operated syringes are now used.
2. Commercial use of this instrument in automatic and semiautomatic chemical apparatus could be extensive. It may also find application in biomedical areas such as pathology laboratories in hospitals, or where extremely small and exact quantities of drugs or chemicals must be extracted or dispensed.
3. Simple packaging modifications would permit timed and metered medication dosage, while allowing the patient to have ambulatory freedom or outpatient status.
4. Other possibilities for this instrument are:
   (a) it can be operated by electrical signals;
   (b) it may be used in a chemical or electromechanical servo loop as a feedback element;
   (c) optical or electrical readout is possible.
5. Inquiries concerning this invention may be directed to:

   Technology Utilization Officer
   NASA Pasadena Office
   4800 Oak Grove Drive
   Pasadena, California 91103
   Reference: B67-10203

Patent status:

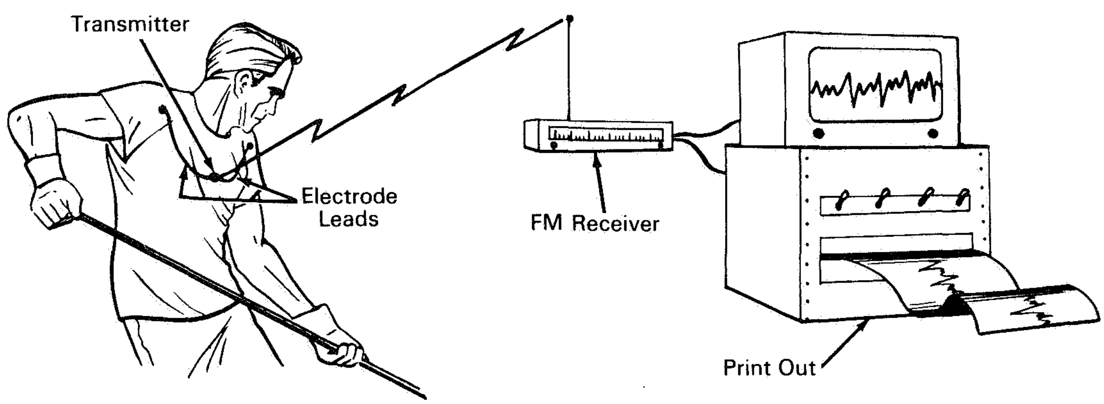
Inquiries about obtaining rights for the commercial use of this invention may be made to NASA, Code GP, Washington, D.C. 20546.

Source: J. L. Stuart
Jet Propulsion Laboratory
(NPO-10142)

NASA TECH BRIEF

This NASA Tech Brief is issued by the Technology Utilization Division to acquaint industry with the technical content of an innovation derived from the space program.

Subminiature Biotelemetry Unit Permits Remote Physiological Investigations



The problem: The measurement of biopotential response in humans or animals to controlled environmental stimuli has traditionally been impaired by encumbering electrical leads or bulky amplifying and transmitting equipment.

The solution: A subminiature, high-performance, biopotential telemetry transmitter operating in the standard 88- to 108-megacycle FM band.

How it's done: The transmitter was designed using standard, inexpensive, commercially available components and assembly techniques which permit easy and repeatable assembly with no sacrifice of performance or reliability. The transmitter is 0.74 inch in diameter by 0.20-inch thick and weighs two grams. A mercury cell provides power for operation in two modes, selected by the interchange of three components in the basic circuit. In one mode the transmitter has a two-day operating life with a 100-foot range; in the other, the transmitter has a 48-day operating life with a 10-foot range. Conventional biomedical electrodes are used to connect the transmitter to the subject.

Notes:

1. In tests, humans have worn the unit for four or five days without discomfort and have generated useful data while engaged in normal activities.
2. Further information concerning this innovation is described in NASA-TM-X-54068, "A Miniature Biopotential Telemetry System" by Gordon J. Deboo and Thomas B. Fryer, May 1964.
3. A related innovation is described in NASA Tech Brief 64-10025, May 1964.
4. Inquiries may also be directed to:

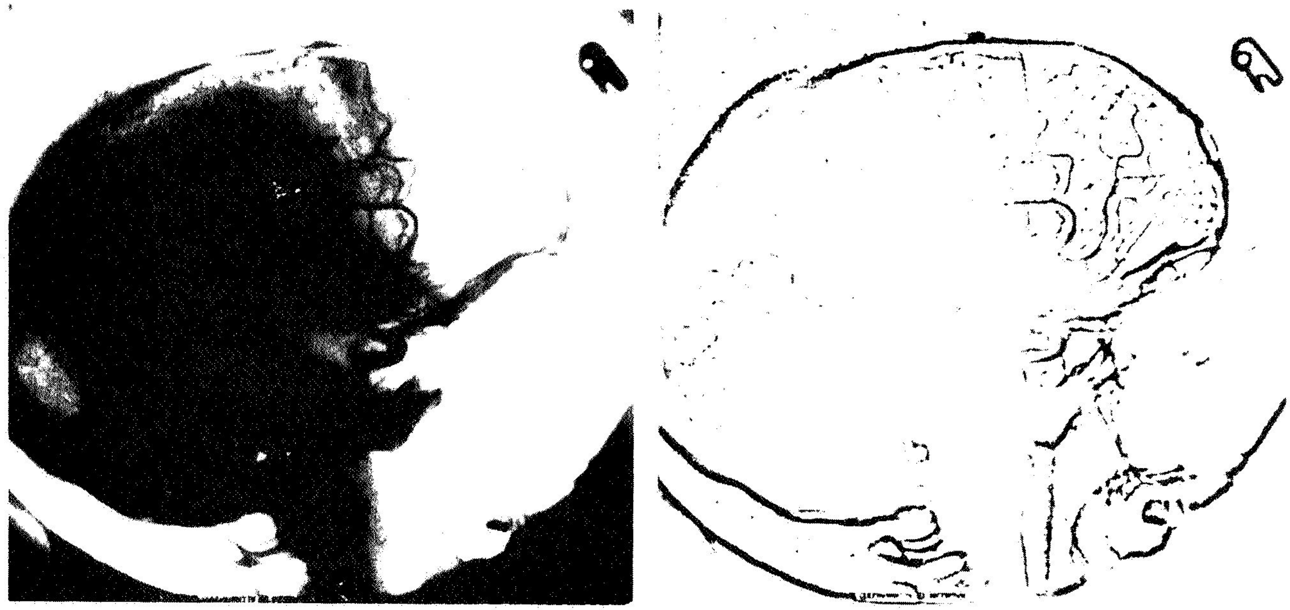
   Technology Utilization Officer
   Ames Research Center
   Moffett Field, California, 94035
   Reference: B64-10171

Patent status: NASA encourages commercial use of this innovation. No patent action is contemplated.

Source: Ames Research Center (ARC-39)

NASA TECH BRIEF

Digital Computer Processing of X-Ray Photos



The problem:

The interpretation of medical and biological pictures such as X-ray photographs could be made easier if selected portions of the image were first enhanced by means of a digital computer.

The solution:

For a number of years, digital computers have been used at Jet Propulsion Laboratory to correct various photometric, geometric, and frequency response distortions in the pictures received from the television cameras of the Ranger, Mariner, and Surveyor spacecraft. These methods have now been applied to the study of medical and biological photographs.

How it's done:

The first step in the process is to convert the picture into a form suitable for input to the computer. This is accomplished by means of a cathode-ray tube device that scans the film with a light beam on a line-by-line basis and converts each point of the picture to a number proportional to the film optical density. Each sample (typically 500,000 samples for a 1-in.-sq. transparency) is recorded on magnetic tape which is subsequently fed into a computer.

One of the principal methods of computer enhancement involves the use of a two-dimensional digital filter to modify the frequency spectrum of the picture.

(continued overleaf)

This filtering, in one case, is used to restore high-frequency losses (loss of fine detail) which result from the use of fluorescent X-ray intensifying screens. In other cases, the filtering is used to deliberately distort the frequency spectrum to bring out specific types of information. The figure on the left shows the sharpening of the image of a skull angiogram, and the figure on the right shows a distortion of the image which brought out the blood vessels in the front of the skull.

Another computer processing method is image subtraction. Two pictures of the same location of the body, perhaps taken at different times are subtracted from one another on a point-by-point basis. The resultant difference picture will tend to emphasize changes such as tumor growth. Subtraction is currently accomplished by optical methods but it is generally not applicable unless the areas photographed are rigid, such as the skull. The computer, however, is not so restricted and can force a match even on chest X-rays by arbitrarily shifting around different parts of the picture.

Preliminary efforts have been made using a pair of chest X-rays separated in time by six months. The rib cage of one picture was shifted by the computer to match the second and then subtracted. The results are sufficiently encouraging, but these results are not yet at a clinically useful stage.

In addition to medical X-ray photographs these methods have been applied to infrared photographs, photomicrograph scintillation, scanner displays, and standard light photographs.

Notes:

1. Further research is being conducted in this area at the Jet Propulsion Laboratory. In particular, emphasis is being placed on enhancement of pictures with specific medical value.
2. This innovation is the subject of Jet Propulsion Laboratory Technical Report No. 32-1028 and 32-877.
3. Inquiries concerning this innovation may be directed to:

   Technology Utilization Officer
   Jet Propulsion Laboratory
   4800 Oak Grove Drive
   Pasadena, California 91103
   Reference: B67-10005

Patent status:

No patent action is contemplated by NASA.

Source: Dr. Robert Nathan and R. H. Selzer (JPL-792)

APPENDIX V

SUGGESTIONS FOR STERILE OPERATING ROOMS

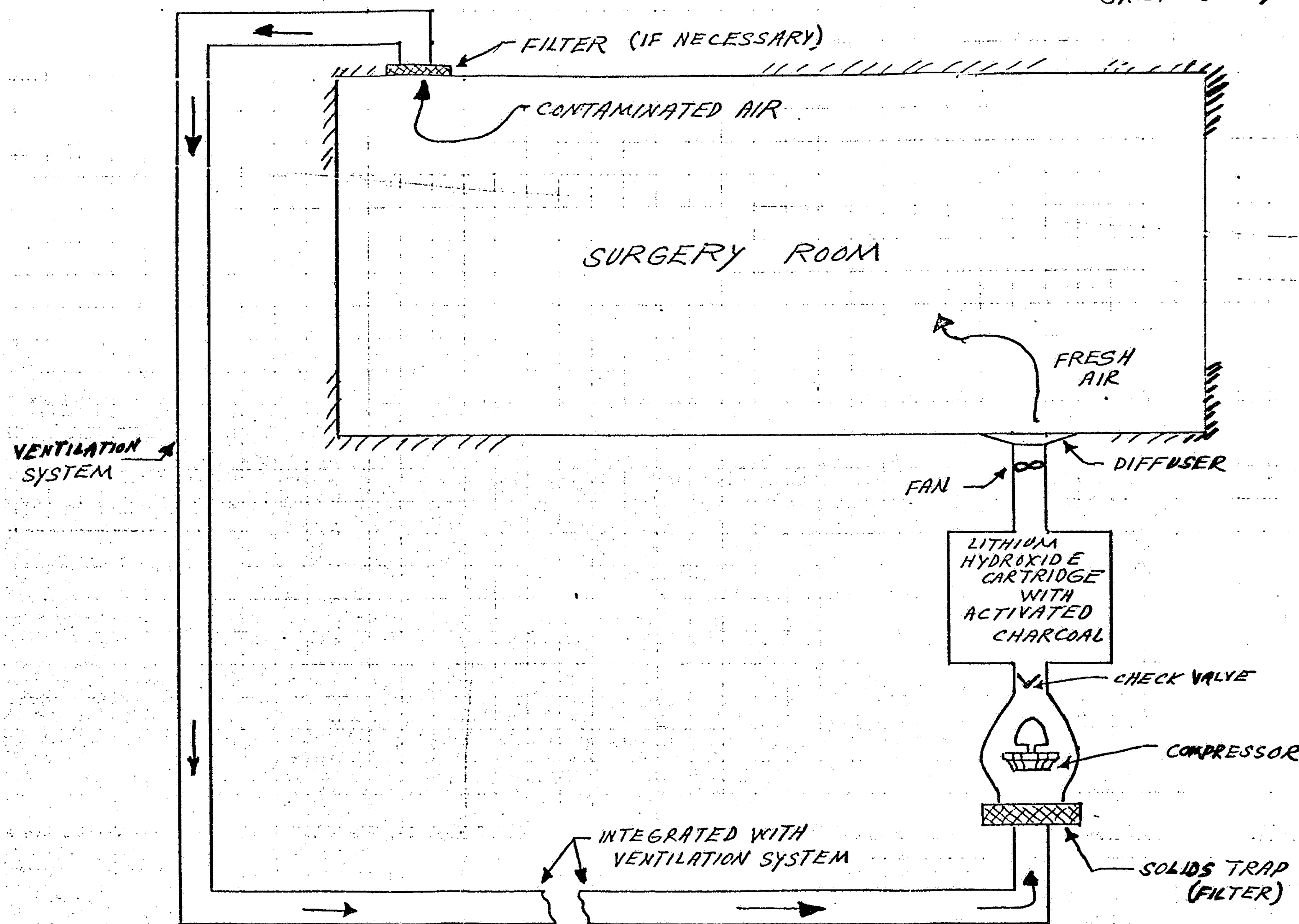
BIOMEDICAL PROBLEM ABSTRACT: UM-1

What is needed: A clean and sterile atmosphere for surgical procedures and post-surgical patient care.

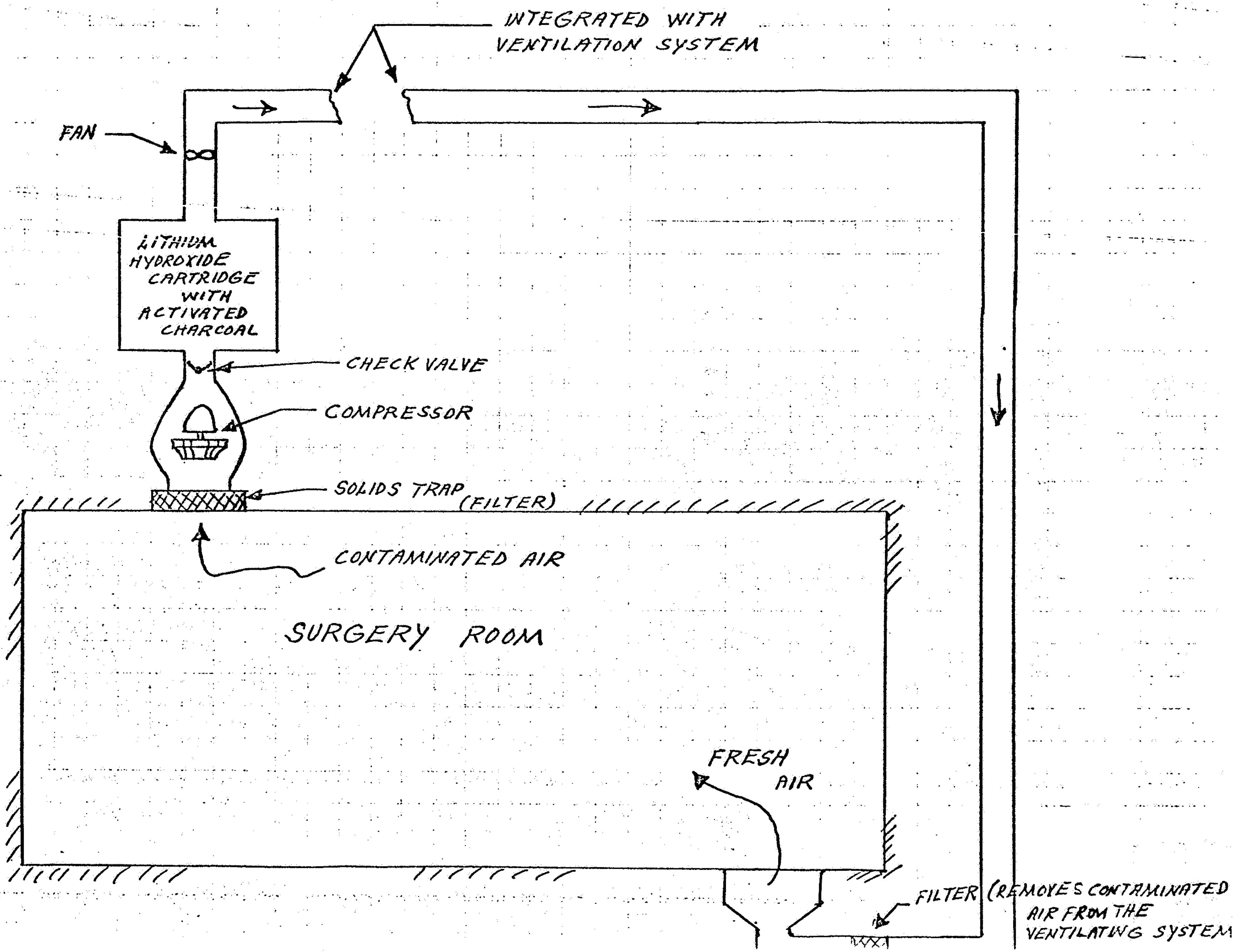
Suggestion: Some of the major components of the suit loop package which provide oxygen regulation, atmospheric purification and temperature control were integrated with the Environmental Control System of the Gemini spacecraft. These components, with possibly some design modifications, may be applicable to the ventilation system required to keep a clean and sterile atmosphere for surgical procedures and post-surgical patient care. A carbon dioxide and odor absorber unit with added components may be possibly integrated with the present ventilation system. (See sketch and component function chart.) Note that the lithium hydroxide cartridge which removes carbon dioxide and odors is replaceable.

Suggested by: Al Ignatonis
R-P&VE-PME
877-3175

SKETCH #1

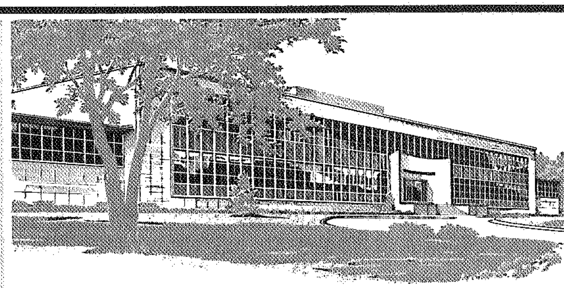

FILTER (IF NECESSARY)
CONTAMINATED AIR
SURGERY ROOM
FRESH AIR
DIFFUSER
FAN
LITHIUM HYDROXIDE CARTRIDGE WITH ACTIVATED CHARCOAL
CHECK VALVE
COMPRESSOR
SOLIDS TRAP (FILTER)
INTEGRATED WITH VENTILATION SYSTEM
VENTILATION SYSTEM

SKETCH #,



INTEGRATED WITH
VENTILATION SYSTEM
FAN
LITHIUM
HYDROXIDE
CARTRIDGE
WITH
ACTIVATED
CHARCOAL
CHECK VALVE
COMPRESSOR
SOLIDS TRAP (FILTER)
CONTAMINATED AIR
SURGERY ROOM
FRESH
AIR
FILTER
(REMOVES CONTAMINATED
AIR FROM THE
VENTILATING SYSTEM

Component	Function
Solids Trap (Replaceable)	Removes airborne debris
Compressor	Provides suction of contaminated air
Check Valve	Prevents recirculation of contaminated air
Lithium Hydroxide Cartridge (Replaceable)	Removes carbon dioxide and odors
Fan	Distributes fresh air to the ventilating system



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