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TELEMEDICINE; AN EXPANDING NEW SCIENCE ON LAND & SEA

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ABSTRACT.

Several medical and technical men in San Diego County have long been concerned with the need in many rural communities for a 24-hour day, 7-days a week access to adequate medical care. People isolated from urban areas by travel-times of 40-minutes tend to delay seeking early and effective medical care. The authors have been able to assemble quality technology, within a reasonable budget, which permits narrow-band video-pictures, better known in the 'CB' trade as 'ROBOT' slow-scan television (SSTV), to be transmitted over telephone lines, by micro-wave, through satellite-bounce, or by 'HF' radio. These 'ROBOT' pictures can be accompanied with explanatory 'audio' communication and with diagnostic signals from electronic instruments.

Remarkable progress is being made in San Diego County by physicians, remote clinics, fishing fleets, and deep-sea drilling crews in using 'Audio/Video' and 'SSTV'/ROBOT technology of medical diagnosis and treatment of critically-ill patients many miles away from the medical center. Earlier programs for extending health care have been promising and somewhat effective, but to date they have been much more complicated and costly than the present San Diego trials of 'ROBOT' Telemedicine on land (over telephone lines) and sea (via 'HF' radio).

INTRODUCTION.

'Telemedicine' is the art of applying communication technology through nurse-practitioners, paramedics, corpsmen with special training, or even less-trained personnel, in areas of human habitation remote from physicians and hospitals, to provide primary health care, under a physician's guidance, to patients through audio/video communication, for the diagnosis

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and management of health problems.

Although recent data from the American Medical Ass'n (AMA) indicate that an increasing number of new physicians are choosing to specialize in 'general' and 'family-practice', at the present rates of population growth, the assurance of access to quality health care at reasonable cost in rural areas is a problem which will be with us into the next century. Meanwhile, the communication technologies that are being built in to space probes will permit physicians direct aural and video contact with isolated 'physician-extendors' and patients in medically-deprived areas on land and sea, so as to make satisfactory discriminations between serious medical conditions requiring extensive technology and those which do not, and to direct the local treatment of the latter. A wide range of capabilities of the 'physician-extendor' in the new art of 'telemedicine' can be tolerated in isolated communities on land or in the crews of ships at sea.

The authors of this first of several reports to the scientific and medical press, on the applications and advancements of 'Telemedicine,' are conscious that the startling technologies that have been developed for the 'Mariner' and 'Apollo' and other space probes can be applied, with negligible changes, to extend physician services into rural areas. In addition to these programs referenced or discussed in the text, the authors wish to acknowledge that C.V.I. Systems of Boulder, Colorado markets equipment which is similar in function to that which we have in operation. This paper is intended to show what had been done locally rather than be a product endorsement.

RECENT AUDIO/VIDEO 'BREAK*THROUGHS' IN HEALTH CARE.

'Telemedicine', although a relatively new art, combining the best efforts of the physician, the engineer, and the scientist, has been quietly practiced over the last four-years in San Diego County by radio(audio-HF) transmissions between a local physician and the working crews of the 'Tuna Fleet' operating around the world, through 'Marine Medical Service, Inc.', a San Diego firm dedicated to providing medical services for fishermen at sea.

To the successful 'audio', or verbal instructions by radio(HF) from the physician, it is now possible and practical to add the benefits of 'Slow-scan' pictures (SSTV) of the sick or injured patient. This continuing program, sometimes referred to locally as 'ROBOT 1' after the local manufacturer-- ROBOT Research Inc.,

augments the 'HF' radio instructions in that the physician in his San Diego office or hospital can more accurately diagnose the health problem or critical emergency by 'seeing' the patient, 'look' at the wound, and even 'view' the X-ray film of the injured part before taking action.

Simultaneous with the 'Audio/Video' provision of health-care to fishing fleet crews, there is a program underway in San Diego County whereby small health outposts in rural communities, medically deprived since they are too few in population to support a full-time doctor, can by the 'ROBOT'-method maintain better rural health conditions. Thus these two programs; one on oceans around the world, and the other in 'outpost' clinics in the outer San Diego County areas, can augment each other and learn from each other's problems, successes and failures.

A 'ROBOT' LIFELINE TO BETTER MEDICAL CARE.

The objective of the sea and land 'ROBOT' projects in Southern California is to provide the technology, 'hardware', and the 'software' to permit adequate 'Audio/Video' communication between the physicians, on a 24hours/day, seven-days/week basis, and their individually-trained nurse-practioners or 'physician's-assistants at the rural 'outpost' or on board ship, each of whom are normally a medically-deprived group of people. To these isolated communities can now be added the 30 to 70 men operators on 'off-shore' oil-drilling platforms, or on deep-sea mineral-mining ships operating on rerote assignments for long periods of time, in many instances located in distant ocean areas out-of-range of helicopters and CoastGuard airplanes.

The emphasis, within the last several years, of the U.S. Government in extending the NASA/Space technologies, developed in the 1960s and 1970s, to small businesses and industry, gave these authors the hope that, with the typical dynamism of American Industry, someone would put this 'Audio/Video' medical technology together and market an efficient, low-cost health plan for isolated areas. To date this has not happened to any satisfactory degree. True, there have been several Federal-grants given for primary health and emergency care in isolated communities, but little use has been made of the cheapest and most-dependable method of signal transmission;- the telephone system on land, and 'HF'-radio at sea. More exotic and expensive methods, such as Interactive Television communication have been developed for extension into rural areas with the use of Federal funds, involving micro-wave, satellite

bounce, laser, picture-phone, etc., but little use has been made of the less expensive and generally more dependable method of communicating over long distances which telephone-lines provide in these United States.

'ROBOT-1' will be concerned, first, with the expanded use of telephone lines into 'out-back' rural communities, and from sea 'HF'-stations to physicians' offices and hospitals. Future emphasis, possibly in 'ROBOT-2', on alternate transmission methods of medical information from isolated areas without adequate telephone services, after statistics on costs, practicality, maintainability, and the ease of use have been collected and studied.

Many 'isolated-area' test programs have been, or are now being tried through 'Telemedical' methods into rural areas in the United States. Some examples are the 'STARPACH/ NASA', Indian Health Services on the Papago Reservation, Arizona (by micro-wave); 'NASA'-Simulated Telemedicine Systems, Houston, Texas; 'Apache'; 'NASA'/ Canada CTS, San Antonio, Texas, (Satellite), etc. These projects, where applicable in results to the present San Diego 'remote-health' efforts, will be briefly reviewed in a future paper, to form a background against which these authors can evaluate the San Diego County 'ROBOT' program. This medical evaluation will be made using prototype 'SSTV' Audio/Video equipment for pilot-runs in Southern California rural clinics, in medically-deprived urban areas, on ocean-going San Diego fishing ships, and on isolated 'deep-sea mining' ships and 'oil-drilling rigs' in the Pacific Ocean.

'ROBOT-1' Software and Hardware.

Today's technologies will permit physicians, clinics, and urban hospitals to work effectively with direct 'SSTV'-communication, transmission of photo-electric cardiograms, accurate heart and lung sounds, pictures of eye-grounds, photo-micrographic pictures of laboratory specimens, transmission of photo-fluorograms of fair resolution, pictures of the fundus, lesions, and readings of temperature, blood pressure, and blood flow.

The authors have found in the past few months that all necessary 'hardware' is available locally in San Diego, as 'shelf-items', to combine the necessary 'Audio/Video' phases of 'ROBOT-1' for the benefit of patients in medically-deprived areas on land or sea, that 'SSTV'-Video transmission of radiograms from conventional X-Rays on a 'light-box' over telephone lines or by 'HF'-radio is not only practical(Ref.#3)

but easily diagnosed through a white/black reversal process on both 'ROBOT'-Models #400 and #530 transceivers, and that only minor modifications of 'software' in techniques of camera focussing remains to be 'proofed' with actual longdistance telecommunication 'pilot-runs' to remote clinics or to ships at sea. It is firmly believed by the biomedical consultant member of 'MMS', San Diego, that a new breakthrough in Telemedicine will take place in the next six months by remote patient medical diagnosis from a local San Diego physician's clinic, by combining the proven methods used during the past four-years on 'tuna-seiner' ship-crews medical programs by 'Marine Medical Service Inc.', in San Diego, with the medical needs and selfsupporting potential of doctor-deprived small communities 'out-back'(as we say in Australia.)

There is no doubt that a single institution, such as UCSD in Southern California, with sufficient financial support, could work with aerospace systems technologists and develop the attendant technology. On the other hand, more is necessary than that approach, since now maritime agencies are involved, such as the application of 'ROBOT-1' to deep-sea drilling rigs and mining ships. All 'AUDIO/Video' equipment must be assembled, tested, calibrated, and built into the community structure in a substantial number of areas on land and sea, before it becomes a sensible and accepted form of remote health care.

The authors believe that health care in rural land areas can be much more effective if 'licensed clinics; manned by 'lay' local medical personnel, can be managed and serviced by professional medical agencies and physicians in urban communities. Such 'Rural Clinics' can be licensed as a satellite of the physicians' home offices. The physician in each case is totally responsible for the 'emergency' training and effective use of the 'satellite clinic'(or 'Outpost') lay personnel.

Medical Simplification Needed At 'Outposts'.

In practical rural health care the need at this moment is a quantum jump backward in our technological approach. Most rural communities have electricity and telephone lines. Our health care needs in isolated communities can be 85 to 90% satisfied by something less than full-color 'video' transmissions between rural clinics and urban or suburban medical centers. Black/white 'Video-transmissions of radio-grams have proved very successful.(Ref.#3)

More important than a mobile clinic, microwave relay station, etc., for the primary care in rural areas may be an 'emergency' installation, like 'ROBOT-1', which is always available at a center-village agency; perhaps at a Fire Station, Health Station, or at a Park Ranger Headquarters for 24-hours each day. Here local 'trained' townspeople can attend the sick or injured, with professional medical advice available through the 'Audio/Video'-link to a distant physician for diagnosis and followup instructions. This 'remote-instruction' system may be of more lasting value to the patient than a mobile medical unit which pulls into town once a week for 'sick-call'

In developing countries around the world, and in some isolated parts in the United States, where the telephone services are absent or undependable in outlying communities, the writers propose to use a modification of 'ROBOT-1' in which some other transmission method, such as 'microwave' or 'satellite-bounce' will be evaluated for economy and then proofed.

Alternates To 'ROBOT-1' System.

As many of our readers probably know, Lockheed Missile and Space Division, at Sunnyvale, California, has a telemedicine-system, called 'STARPAHC', working in the Papajo Indian villages in Southwest Arizona. This project serves over 10,000. people, in 75 villages, in an area of nearly 17,000. square kilometers. This system uses relatively high-level technology, with large capital expenditures. (Ref.#1) Radio Corporation of America, too, has developed equipment modules now being used by the U.S.Navy in several installations to achieve similar communication objectives.(Ref.#5) Too often it appears that whenever NASA technologies are brought to bear on health problems, in urban or rural areas, an attempt is made to apply 'Goldstone technology' and complexities without first considering the capacity of our Nation to meet such expenditures and to provide for such advanced technology support.

'ROBOT'-SSTV differs from more than thirty telemedicine projects outlined by Dr. Sur Wah Chan and Mr. James R. Messick of 'OMERL D', Michigan State University, East Lansing, Michigan. (Ref.#2) in 1975, in that 'Audio/Video' communication is used over telephone lines in the current program in San Diego. The two-way 'hear & see' capability is being applied simultaneously to rural mountain areas and to wide ranging ships. Not one of the Federal Grant programs reviewed in Reference#2 used telephone lines for communication.

Possible 'ROBOT-1' Health Funding.

With today's technologies, the full-range of 'tele-medicine' supportive communication in the USA, from rural areas to urban health centers, would require capital expenditures comparable to those involved in building our modern highway systems. Although it is possible that the value of such an investment for 'physician extenders' might be argued successfully, the authors question whether this Nation is prepared, this year or for a few years to come, to undertake an investment of this magnitude in rural health services.

Our colleagues at the University of New Mexico were demonstrating over four years ago that physician to 'physician-extender' liaison into isolated and medically-deprived areas can be effectively carried out on a communication level far below that suggested in the preceding paragraph. Given sufficient interest, technical dedication, and a small capital investment, it will be possible within a year to develop and assemble 'low-cost equipment' packages for permanent placement in rural communities, sometimes referred to as medical 'Outposts', in the 'outback' to Australians. These village 'Clinics' will be attended by two or more local inhabitants who have been thoroughly trained by the 'referral physician' in an acute-care hospital or doctor's office, also equipped with similar 'Audio/Video' medical equipment, better known as the 'Medical-Center'. Note-- The foregoing paragraph was drafted three-months prior to this final typing for the 1977 NASA Space Symposium and the prediction of 'one-year' has taken place in a few months by discovering in San Diego a small company, ROBOT Research Inc., which has developed a 'Slow-Scan Television' (SSTV) system for the amateur 'Ham-Radio' market. This fortunate find locally has resulted in the tests of ROBOT-Model#400. (Figures 1 and 2). Plans are now being made to evaluate the new ROBOT-Model#530, a simplified version for use in rural clinics and on tuna-seiner ships.

There is high potential in the use of 'ROBOT-1' programs in present medically-deprived rural areas and for the application of direct service pre-payment financing methods, with formal organizational linkages between such rural primary-care physicians and teaching hospitals. This proposed 'ROBOT-1' system between primary-care physicians and the 'outback' rural towns is immediately suggestive of new forms of successful 'HMOs' for the 1980s.



Figure#1. Typical Setup of 'ROBOT-1' System
in a Physician's Office. (Model#400.)

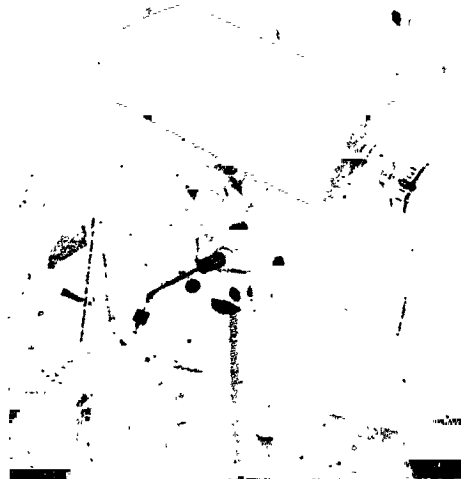
Recent Evaluations Of 'ROBOT' Model#400 Systems.

Three-months ago, when the first draft of this paper was prepared on the initial uses of the 'Audio/Video' communication concept to aid rural health situations, few photographs of test results were available, since this 'Lifeline' concept of telemedicine was so new in San Diego County.

The financing of such medical systems in the next few years on the basis of small Federal 'grants' is a short-term solution for a long-term problem. This rural health deprivation problem will not go away without our long-range planning and financial help. The public needs to build financial mechanisms which will support the continued existence of medical-aid systems similar to 'ROBOT-1' across this Nation, and in many medically-deprived developing countries.

A 'consortium' of funding might be desirable. 'HMO' funding for service to the medically-underserved comes readily to mind. Department of Defence funding might be possible inasmuch as the clinical types of equipment likely to be specified in these projects would be of immense utility to the military in battlefield and shipboard applications.

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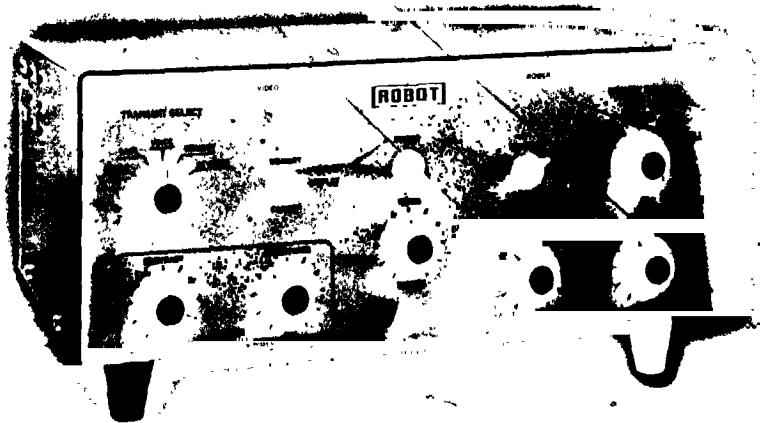
Figure#2. RCA-1000 'SSTV'-Camera, Mounted
On A Tripod, And Equipped With A Special
25mm. Lens.

Today, however, with three 'ROBOT' Model#400 systems in use; in the Campo Indian Reservation Clinic (80-mi. South-East of Downtown San Diego), at Dr. Anthony Rippo's medical office in San Diego, and at K.R. Jackman's residence in La Jolle (10-mi. North of San Diego), frequent 'SSTV' tests have been made over telephone-lines, and recorded with a Minolta Pocket Autopak#270 camera as shown in Figures#1 to #12. Note that the 'ROBOT' Model#400 Scan-Converter has a switch whereby an X-Ray photo might be changed from 'positive' to 'negative' for easier interpretation, as shown in Figures #6 and #7. More engineering specifications on the 'ROBOT' Scan-Converters or Transceivers (on Model 530), shown in Figures #4 and #5, are available for the reader if requests are directed to the authors.

With four more months elapsing before the Los Angeles presentation on April 26, 1977 by the authors, a color-slide presentation will illustrate the up-to-date test results of newer 'ROBOT' systems, beyond the scope of this paper. 'ROBOT' Model #530 should have been evaluated by that date, both on land and sea.



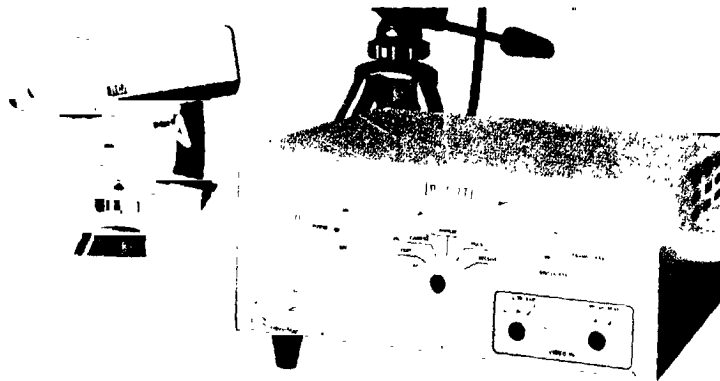
Figure#3. 'SSTV'-Transmission Is Possible
Over Telephone Lines Adapted With A Patch
Plug. (May be installed on all telephones.)



Figure#4. 'ROBOT'-Model#400 Scan-Converter
Is Now In Use In San Diego Rural Areas.

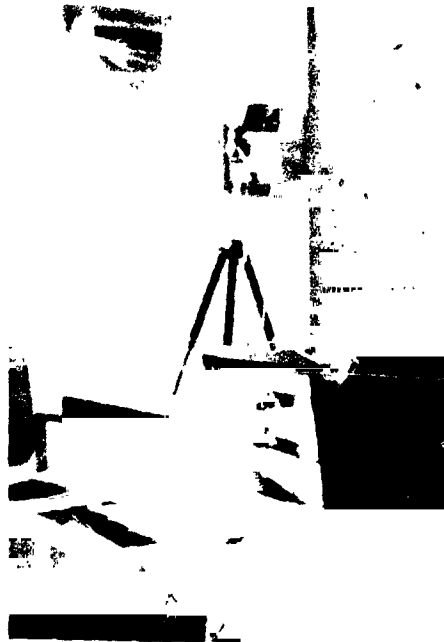
Probable 'Futures' For The 'ROBOT-1' Concept.

Looking into the future, say five-years hence, the writers believe that the prestige and backing of academic/medical centers will be necessary in introducing and operating the 'ROBOT-1' system, or a comparable remote area medical program, on a continuing basis.



Figure#5. 'ROBOT' Transceiver Model#530
Is Simple To Operate And Will Soon Be
Evaluated With Model#400.

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Figure#6. 'ROBOT'-#400 System Used To
Transmit Bone X-Rays. As A Negative,
Between Rooms In A Doctor's Office.

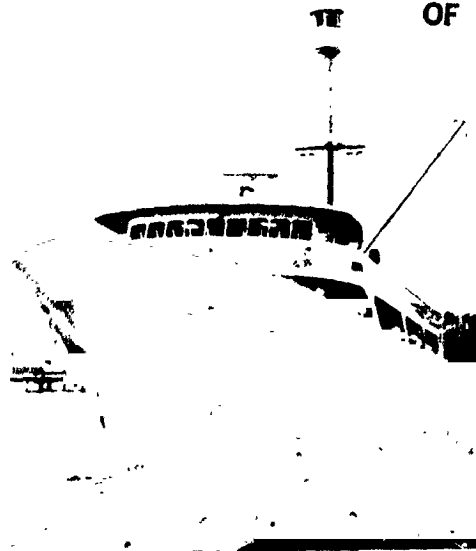
In fact, a 'consortium' of such academic centers in Southern California, with their joint expertise and resources, when combined with independent 'non-profit' research institutions, and with one or more firms with aerospace technology capabilities would add impact and national prestige to this home-grown San Diego 'Audio/Video' project.



(Positive) (Negative.)
Figure#7. Broken Femur Leg-Bone Displayed
On 'CRT'-Monitor. P or N By Switching.

A recent book --"Telemedicine", released in 1975 by eighteen authors, and edited by Dr. Rashid I. Bashshur, PhD, et al.(Ref.#7) defines 'Telemedicine' as the remote practice of medicine via 'interactive communication links'. This book, one of the very few dealing with this new and novel medical approach to better rural health, gives as its ultimate purpose --"to provide an objective analysis of the potential benefits and pitfalls of 'Telemedicine' as an alternate solution to today's pressing problems of health services delivery and as an inevitable trend for the future." With this statement of health experts in mind, would it not be exercising good judgment here in San Diego County where 'ROBOT' SSTV-video is designed and built, to apply this low-cost and effective method of 'physician extender' to medically-deprived areas?

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Figure#8. The First Successful 'HF'-Radio
Transmissions On 'ROBOT'-Model#400 Were
Made On Only 5-Watts, In November 1976,
From This Tuna-Seiner In San Diego Harbor.

CONCLUSIONS.

This preliminary introduction to the present and probable extended use of 'Telemedicine' in rural areas of San Diego County, on commercial fishing ships and pleasure yachts around the World, and on deep-sea

drilling rigs and mining ships at remote parts of the Pacific Ocean may be of only passing interest to many readers. However, it will be of vital, life-saving impact to physicians interested in serving patients in many medically-deprived and remote portions of the United States and in most 'developing countries', as well as in medical clinics that must serve large populations, in wide geographical areas.



Figure#9. Radio-Room On A Typical Tuna-Seiner During 'SSTV'-Video Tests On 'ROBOT'#400 To A San Diego Shore Station.



Figure#10. Co-Author Anthony Rippe, MD, Using 'ROBOT' Model #400 At San Diego Base-Station During 'HF'-Video Reception From A Tuna-Seiner At The 'Embarkadero', San Diego.

As indicated at the start of this paper, the term 'Tel-
medicine is so new and unfamiliar, and its applicat-
ion is so untried on today's medical problems, that it
is quite possible that several other economical solu-
tions, than the 'ROBOT-1' approach herein proposed, may
eventually prove effective in this age of doctor short-
ages. However, this 'SSTV' equipment, using telephone
lines and 'HF' radio, appears to be the most economical
and easiest to install and use.



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Figure#11. Monitor Picture Of Clinic
Receptionist Transmitted To San Diego
Over Telephone-lines From The Campo
Indian Reservation Clinic, 80-Miles East.

Figure#12. First 'CRT-Monitor Picture
Of An Injured Child-Patient Transmitted
Over Telephone-lines From Campo Clinic
To San Diego.

The authors plan to release several subsequent papers during the next year on the statistical results of the land and sea tests at San Diego, and to review alternate aspects of 'Telemedicine' aid to the patients 'outback' or afloat. It is requested of our readers that any other successful trials in 'physician's extenders' or in the use of Audio/Video means of medical diagnosis and treatment of remote patients, on land or at sea, be brought to the attention of the authors.

Biographical References.

Ref.#1. --"Remote Area Health Care Systems," by Lockheed Missile and Space Company Inc., Sunnyvale, California. (1973)

Ref.#2. --"33 Telecommunication Projects in Medical Education and Health Care," by Suiwah Chan, PhD, and James R. Messick, MA, Michigan State University, East Lansing, Michigan. (1975)

Ref.#3. --"Image Communication By Telephone," by Milo M. Webber and Howard F. Corbus, -- Printed in the "Journal of Nuclear Medicine", June 1972. P379-81)

Ref.#4. --"Does Your Local Hospital Need The Medical Technician, Medical Engineer, and the 'ACTION' Professional Volunteer(VPHC)?" by K. R. Jackman, Biomedical Engineering Consultant, La Jolla, Calif. Paper given December 6, 1974, at the "Fourth Annual 'Cal-Poly' Measurements Science Conference, San Luis Obispo, California. (17 pages)

Ref.#5. --"Navy Remote Medical Diagnosis System," by Dr. John Silva, PhD, Naval Electronics Laboratory Center, Code#3400, 271 Catalina Blvd., San Diego, Ca. 92152. Paper presented at the San Diego Biomedical Symposium, on February 6, 1976, at the Hilton Inn, San Diego, Calif.

Ref.#6. --"Systems Analysis And Computers In Ambulatory Care," by J. Silva, PhD; D.F.Schaller,MD; W.T.Rasmussen,PhD; and W.C.Giagor,PhD. --Paper given at the "Ambulatory Health Care Symposium", on February 11, 1976, at the Hilton Inn, San Diego, Calif.

Ref.#7. --"Telemedicine," by 18 authors, and edited by Dr. Rashid I. Bashshur,PhD; Patricia A. Armstrong,BGS; and Dr. Zakhour I. Youssef,PhD.(1975)

Ref.#8. --"Volunteer Medical Engineers Can Aid Physicians and Hospitals in Telemetry Purchases And Tests," by K.R.Jackman, Biomedical Consultant, La Jolla, Calif. Paper presented on October 15, 1974, at the 'ITC/USA/74' Technical Conference and Exhibit.

Ref.#9. --"Teams Of Medical Engineers And Physicians Will Aid Developing Countries," by Kenneth R. Jackman,ME,AE., Biomedical Engineering Consultant.

Paper presented at 'The Jerusalem Conference On Information Technology!(J.C.I.T.)', Computer Committee, The Jerusalem Economic Conference,--"Computer Impact On Developing Countries", at the Panel--"Computer-Aided Medical Screening For Developing Countries", at the Binyanei Ha'ooma Convention Center, Jerusalem, Israel, on August 18, 1971. (36-pages, with 22-pages 'Comments')

Ref.#10. --"Criteria For The Engineer In The Medical Environment", by Kenneth R. Jackman,ME,AE. Published in the "1973 Proceedings", Of the 19th. Annual Technical Meeting, on April 2, 1973, at the Disneyland Hotel, Anaheim, California. (14-pages.)

Ref.#11. --"Remote Medical Diagnosis System", by Terry Mitchell,PH2, in the "San Diego NAVY DISPATCH".

Ref.#12. --"Telemedicine Systems", pamphlet from Lockheed-'IMSC', 1976(Four pages on the Tuskegee Primary Care Network, Tuskegee Institute, Alabama.)

Ref.#13. --"Bionics And Astronautics", by K.R. Jackman,ME,AE, and Dr. Henning E. von Gierke,PhD. Presented at the 'Symposium On BioEngineering' in a 15-paper seminar--"The Future Of Bio-Engineering In Our Daily Lives", at the '15th Annual Technical Meeting and Equipment Exposition', held at the Anaheim Convention Center, Anaheim, Calif., on April 23, 1969.

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