

Chapter 3

Videoconferencing in Medicine

One of the most widely used telemedicine tools is videoconferencing allowing interactive real-time two- or multiway information exchange. Modern videoconferences are based on hardware and software solutions as well as special interface protocols (H.32x, SIP, etc.). Development of such technology resulted from adaptation of modern telecommunication means for medical purposes.

Television expanded the range of telemedicine tools and resulted in the formation of a new trend – medical videoconferencing. As many other technologies, television was not an exclusive invention of one person or a group of people. Many scientists all over the world (Boris Rozing, Willoughby Smith, Boris Grabovskiy, I. Belyanskiy, Philo T. Farnsworth, Manfred von Ardenne, Herbert E. Ives, etc.) had been gradually developing more and more efficient means of audio and video information communication. However, two specialists, Semyon Katayev (Russia, USSR) and Vladimir Zvorykin (Russia, USA) (Fig.3.1-3.2), are globally recognized.



Fig. 3.1. Semyon Katayev

In 1931, within an interval of one and a half month between, the USSR and the USA, respectively, both scientists patented an electronic television technology that became the main one for decades (Vladimirskiy A., 2008).

It should be pointed out, that it was professor Zvorykin that played an important role in the development of medical videoconferences. He was not only an inventor but an active promoter of television, cooperating with American doctors and medical associations on the issues of introducing television technologies in healthcare. In March 1959, he became one of the co-founders of the first non-governmental organization in the area of telemedicine, Health Sciences Communications Association (HeSCA) (former Council on Medical Television). Professor Zvorykin was also Director of the Centre for Medical Electronics at the Rockefeller Institute, President and Founder of the



Fig. 3.2. Vladimir Zvorykin

International Federation for Medical Electronics and Biological Engineering. Another significant medical and biological invention of professor Zworykin is the electronic microscope (Vladzimirskiy A., 2008; Zworykin V., 1957; Zworykin V., Hatke F., 1957).

3.1. Early Period of Development: Medical Television

Television was first used for medical purposes in 1939 in the USA. A black and white TV broadcasting system was installed in Israel Zinon Hospital (New York) to broadcast operative treatments. It is known that the use of medical television attracted certain attention though the outcome of the experiment remained unknown (Fig. 3.3) (Television Lets Students Watch Operation, 1939).

The first most significant experience using medical videoconferencing took place at the School of Medicine, Creighton University (Omaha City,

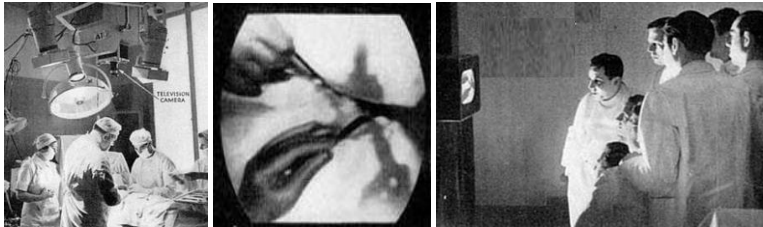


Fig. 3.3. Medical black and white video conferences in Israel Zion Hospital (New York, USA), 1939

Nebraska State). In May 1947, the black and white TV technology was first used for distance learning. The employees of WOW-TV participated in the project together with the surgeons of St. Joseph's Hospital: John W. Gatewood, Arthur C. Johnson, Harry H. McCarthy, Louis D. McGuire, etc. The key person and the initiator of the videoconferencing technologies development at Creighton University in the end of 1940s was a priest, scientist and teacher, Rosewell C. Williams (Boro C., Mead B., 1991) (Fig.3.4).



Fig. 3.4. Rosewell C. Williams

The method was first used for transmission of stomach carcinomaectomy to a remote lecture hall in the school of nurses at the university. The quality of the broadcasted video stream at that time was quite bad; moreover, a lot of operations at Creighton University were made using the method of abdominoscopy (there were no endocavitary cameras). All this prevented wide application of videoconferences (Fig. 3.5-3.6) (Boro C., Mead B., 1991). Nevertheless, educational films were made and in September 1947 an interactive videoconference on alimentary canal surgery was held between the medical centers in Omaha (Creighton University, Qwest Hospital) with the participation of over 100 doctors.

Two cameras were installed in the operating theatre (one on the ceiling and one on the side). The microphones were installed above and around the operative field. Each stage of the surgical intervention was followed by comments and answers to questions.



Fig. 3.7. Telesurgery at School of Medicine, Creighton University, USA, 1947

provided his comments. After the operation, a plan of post-surgical treatment was discussed (Fig. 3.7) (ibid).



Fig. 3.5. R.C. Williams operates the TV camera



Fig. 3.6. Videoconferencing in dentistry (Omaha, Nebraska, USA, 1947). Photo from Creighton University archive <http://cdm16272.contentdm.oclc.org/cdm/singleitem/collection/p4044coll6/id/692/rec/17>

Anaesthesiologists provided data about the patient's condition and were telling about their manipulations. After the localization of the tumor the surgeons discussed further actions plan and different types of resections. The oncotomy process was followed by cytology diagnostics and a pathohistologist also participated in the videoconference and



Fig. 3.8. Alfred Blalock (1899-1964) made > 1 000 operations of Fallot's tetrad, photograph Yousuf Karsh



Fig. 2.9. Helen B. Taussig (1898-1986), photograph Yousuf Karsh



Fig. 2.10. Vivien T. Thomas (1910-1985), portrait made by Bob Gee

There is an interesting fact: a professional cameraman was invited to work in the operating theatre at Creighton University Hospital. The moderators' concern was that the cameraman might faint when he sees blood or medical manipulations. A nurse was assigned to the TV company employee with liquid ammonia and other "anti-fainting tools".

The experience of medical videoconferences was thoroughly analyzed. The ways to improve distance teaching techniques, information protection, sterility, etc. were established, thus ensuring the methodological basis for further interactive distance learning in surgery (ibid).

One more interesting episode occurred in 1947. Three years before it, a unique method of surgical treatment of children with severe congenital heart disease, Fallot's tetrad, was developed at the John Hopkins Hospital (Baltimore, USA). The authors of the method were the surgeon Alfred Blalock, child's cardiologist Helen B. Taussig and the Head of Surgical Laboratory Vivien T. Thomas (Fig.3.8-3.10) (The Blue Baby Operation, 2015).

On February 27, 1947 Dr A. Blalock demonstrated the surgeon's show case for several hundreds of doctors that gathered

at the Conference held by the Association of Surgeons, by using the closed television cable system. At that time, over 200 children were treated, with



Fig. 3.11. Operation of Fallot's tetrad under the supervision of Dr. A. Blalock. The TV camera for remote transmission is visible

the help of this method. The demonstration of this surgical intervention resulted in its wide recognition and rolling-out (Fig. 3.11) (Operation “blue” baby television, 1947; The Blue Baby Operation, 2015; Trimble I., Reese F., 1947).

In 1947, the television system for medical conferences was also used in the city of Cleveland (Ohio) for post-graduate distance learning (Hague J., Crosby E., 1948; Ruedemann A., 1947). In September of the same year, black and white medical videoconferences were held during the Congress of the American College of Surgeons in New York. The following year, medical videoconferences were held during the annual conference of the American Medical Association (multipoint videoconference between the Passavant Memorial Hospital and several lecture halls in Chicago). In October 1948, medical videoconferences were held between the university hospital in Pennsylvania and a lecture hall for the annual conference of doctors in the same State (Carroll W., 1949).

Indisputably, a black and white video image significantly limited the possibilities of videoconferencing for medical applications. Yet, the situation evolved shortly after that.

In the 1940s, the PhD in physics Peter Carl Goldmark (Fig. 3.12) developed the technology of color television that was further used in the Zenith television equipment (Fig. 3.13). P. Goldmark presented his invention to Joseph DuBarry, President of Smith, Kline and French Laboratories Company (currently, GlaxoSmithKline), as well as to a group of surgeons under the supervision of doctor Isador S. Ravdin from the University of Pennsylvania (Genova T., 2015; Mackenzie J., 2015).



Fig. 3.12. Peter Carl Goldmark

A medical dummy was used for the tele demonstration. The inventor suggested remote transmission for educational purposes. The accuracy of the image and the technological



Fig. 3.13. Zenith color television unit (USA, 1948)

possibilities impressed the doctors so much that a set of equipment (remote camera on a high tripod and a receiving station with a 12 inch screen) was immediately ordered for the university hospital (Cooper B., 2004; Genova T., 2015; Mackenzie J., 2015).

The first color television broadcasting of a surgical operation was held on 31 may 1949 between from John Hopkins Hospital (Baltimore) and the lecture hall of the American Medical Association in Washington (Fig. 3.14-3.15) (Genova T., 2015; Elsom K., Roll G., 1951).



Fig. 3.14. The first in the world color broadcasting of surgical operation in Pennsylvania, May 31, 1949



Fig. 3.15. The "Television studio" in the operating theatre of John Hopkins Hospital from where the broadcasting was carried out

According to witnesses, the definition of the images was so high that a lot of viewers (even doctors) were about to faint (Genova T., 2015; Mackenzie J., 2015). The facilitator and the moderator of the videoconference was the professor's assistant, Dr. Kendall A. Elsom (University of Pennsylvania) (Fig. 3.16).

On December 6-9 a similar, event took place in Atlantic City allowing 15 000 doctors, members of the American Medical Association, to distantly watch different surgical operations (caesarean section, osteoplasty, appendectomy). Twelve Zenith television units were used.



Fig. 3.16. Kendall A. Elsom, <http://ihm.nlm.nih.gov/images/B06>



Fig. 3.19. Medical videoconferences during the AMA congress in San Francisco, June, 1950

In 1955-1958, Smith, Kline and French Laboratories and a non-governmental organization, the Council on Medical Television (later HeSCA), implemented a large-scale program on the use of medical television. John K. Mackenzie, secretary of the society and television director of the company, was actively working on that project (Fig. 3.20) (Mackenzie J., 2015).

Over 300 clinical and educational videoconferences were held for 25 medical institutions (ibid). With the help of a telebridge, Michael DeBakey, Professor and outstanding cardiac surgeon, for the first time ever in the



Fig. 3.20. Show-case medical videoconference hosted by John K. Mackenzie

world, remotely demonstrated endarterectomy and Dr Owen Wangenstein did the same on gastrectomy (ibid). Distance learning courses were also held by Dr Robert Warner) (Castle C., 1963; Mackenzie J.,

2015).

On 6 December 1951, the first transcontinental surgical videoconference was held via the cable communication channel between Los Angeles and New York (Fig. 3.21) (Mackenzie J., 2015). The videoconference was held by cable and wireless (microwave) data communication. Up to twenty color Zenith television sets were simultaneously used in large lecture halls (one television set per 50 people) (Fig. 3.21-3.23) (Castle C., 1963; Elsom K., Roll G., 1951; Genova T., 2015; Mackenzie J., 2015).

In 1950, the television video-conferencing system was used in Argentina and in 1951 in France (Elsom K., Roll G., 1951). In 1952, medical



Fig. 3.21. Medical television in Harper Hospital (Detroit, USA, 1950s), Surgeon H. B.Fenech (left), cameramen A. Mattison and R. Sigrist

television was used for broadcasting of operative treatment during the International Congress of Surgeons in Madrid, Spain (Surgeons of the International Congress of Madrid follow

operations on color television, 1952).

At the same time, a lot of companies started manufacturing special television sets for medical videoconferences (Fig. 3.24).

In 1949, the Government of Kansas took a decision to financing innovative medical education by introducing “medical television”. Performance of this task was entrusted to the surgical department of the Medical School at Kansas University and Professor Paul William Schafer. After analysis of the available technical solutions, a black and white television system by Remington Rand Inc. and Wilmot Castle Co. was selected. On 19 September 1949, the first camera was installed in the operating theatre (Fig. 3.25-3.26) (Schafer P., 1953 a), b)).



Fig. 3.22. Postcards with the information on distance learning with the help of medical television sent to doctors in 1957 by a pharmaceutical company



Fig. 3.23. Medical television in surgery



Fig. 3.24. Color television system for hospitals manufactured by Wilmot-Castle (USA, 1953)



Fig. 3.25. Paul William Schafer
<http://ihm.nlm.nih.gov/images/B23289>

Videoconferences and broadcasting were included in the surgery course as an essential element for practical skills learning. The innovations were introduced in the regular teaching process.

In November 1951, a color system was installed instead of the monochrome one. This allowed to significantly improving the quality of medical videoconferences that were held daily from 8:00 to 12:00. In his publications, professor Schafer thoroughly described methodological and educational aspects of “medical television” (ibid).



Fig. 3.26. Monochrome television unit installed above the operating table. The employees are working at the system's control display, Kansas University, USA, 1949



Fig. 3.27. Application of telehelmet in ENT treatment: patient's examination and surgical operation (USA, 1959)

In 1959, Dr Paul Moore and Dr Hans von Leden developed a special helmet equipped with a light television camera, a system of lenses and lighting tools. With the help of this helmet it was possible to carry out remote broadcasting of otorhinolaryngology examination or treatment for

educational and clinical purposes (Fig. 3.27) (Moore P., von Leden H., 1959).

Similar telediagnostic tools were proposed for cytology diagnosis (L. E. Flory) and for ophthalmology (A. M. Potts and M. C. Brown) (Potts R., 1974; Flory L., 1951).

In March 1959, in the USA, the Institute for Medical Communications Development and the Academy of General Physicians held a conference on Television and Postgraduate Medical Training. This event resulted in the creation of a public organization, the Council on Medical Television (CMT). Five years later, the organization became independent and in 1971 it changed its name to Health Sciences Communications Association (HeSCA) under which it carries out its activities till today (Fig. 3.28). The organization's main goal is to develop medical education, practice and science by applying different educational technologies (HeSCA.Health Sciences Communications Association, 2016; Hesca Feedback, 2000). For decades the organization conducted significant work on promotion, enhancement and introduction of television technologies in practical healthcare and professional education.



Fig. 3.28. V. Zvorykin speaking the VIIth CMT conference (USA, 1965)



Fig. 3.29. Dr Lewitt holds a teleconsultation on hand functioning (USA, 1969)



Fig. 3.30. Television camera in the operating theatre (USA, 1960s)

At the end of 1950s a lot of articles on the topic of application of television in medical education were published. News was also published on the use of teletypes for connection of hospitals to the network, exchange of pharmacological and scientific information, solving of emergency care

issues, automation of medications record keeping, etc. (Fig. 3.29-3.30) (Beales E., 1953; Jang R., Barker K., 1965; Reese E., 1957).

At the end of 1950s and the early 1960s, the idea of the use of television technologies for organization of medical videoconferences became widely spread. In the USA, color medical videoconferences based on television (cable) technologies were used in stomatology (Ellman I., Ellman I., 1951), pediatrics (Gersonde J., 1958) and surgery (Klein M., Ruhe D., 1957).

However, it should be pointed out that educational aspects prevailed. In most cases, medical videoconferencing served exclusively as a tool for distance learning and continuous medical education (Bloom R., 1958; Babcock B., 1951; 1953; Galdston I., 1954; Gorby A., 1956; Holleb A., Buch F., 1954; Moses C., Wolfe R., 1964; Muller C. et al. 1977; Shimberg B., Aird E., 1955; 1 Warner R. 1954; Warner R., Bowers J. 1954), especially in surgery (Erikson C. Jr, Brown R., 1949; Ladika O., 1957; Rousselot L. 1954; Vanderwarker R., 1948; Viguers R., Shea M., 1950).

It should be underlined that medical television was developing not only in the USA. Clinical educational opportunities of videoconferencing were also being explored in France (Bird K., 1971; Delcros G., 1951; Fourestier M. et al. 1956), in particular, in surgery and otolaryngology (Ennuyer A., Guenot J., 1956; Gosse L., 1954).

Special attention in European countries was paid to distance teaching to surgeons. Such works were carried out in Spain (Ottolenghi C., 1950), Great Britain (Television an aid to teaching surgery, 1949), Germany (Meisner R., 1957) and Italy (Biancheria A., 1950) (including in obstetrics and gynecology Terzi I., 1955).

“Medical television” was actively developing in the USSR too, however, there was no remote broadcasting as such. Interactive videoconferences were held within one medical establishment at a physical distance between the transmitting and receiving equipment of about 100 meters. There were also experiments with black and white broadcasting of surgical operation and significant achievements in color educational telesurgery (Voronov A., Bykov P., 1959).

In 1957, a model of a typical color television surgical unit was being developed under the supervision of Professor P. Kupriyanov (Fig. 3.31) and with the active participation of Candidate of Medical Sciences B. Aksyonov and engineer B. Kuzmin. This was done at Kirov Military Medical Academy (St. Petersburg) with the purpose of further mass manufacturing (Aksyiniy B., Kuzmin B., 1959). Research thoroughly focused on the issues of the quality of transmitted images. The values of allowed color distortion, the minimum visual resolution, the optimum dimensions of the recorded operative field and the scale of the displayed image were determined.



Fig. 3.31. P. Kupriyanov, Academician and Vice-President of the Academy of Medical Science of the USSR

The issues of asepsis and “medical television” were also studied. The proprietary design was, in its essence, a sequential system of color television with a bidirectional telephone communication between the transmission and reception centers (Fig. 3.32) (ibid).

The system itself had three main units:

- A camera (based on typical KT-7 model), connected to a group of lamps suspended above the operative field;
- The operating panel;
- A group of viewing units (Raduga type receivers).

Clinical testing of the installation started on 18.04.1958 and continued for at least two months. The authors considered further opportunities in determining the role and place of a new technology in the educational process (ibid).

In December 1957, single channel color television equipment, adapted to broadcasting of operative

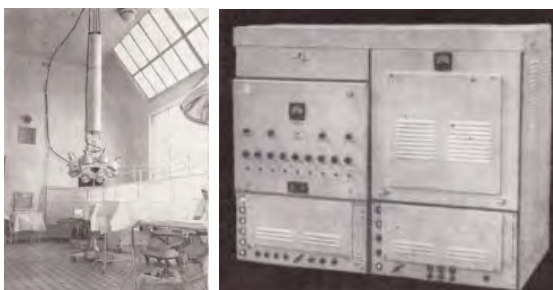


Fig. 3.32. Transmission camera of color television system in the hospital of Kirov Military Medical Laboratory - left; right - the installation operating panel (St. Petersburg, USSR, 1958)

treatments, was installed in the surgical clinic of the Pavlov First Saint Petersburg State Medical University. The work was mainly performed by Assistant A. Voronov and engineer R. Bykov. Later on Dr A. Voronov (1920-1995) became a professor and Chairman of the Phthysiopulmonology and Thoracic Surgery Department in the North-Western State Medical University named after I. I. Mechnikov and one of the pioneers in open heart surgery and single-stage operations on alimentary tract cancer. The system included the following components: transmission camera with amplifiers, synchronizing generator, control oscillograph, control unit of the transmission camera, power units, 6 receivers and 1 video monitor, additional lighting, bilateral loudspeaker



Fig. 3.33. Television camera in the operating theatre of the Pavlov First Saint Petersburg State Medical University (USSR, 1957)

communication. The camera was installed horizontally at a 3 meters distance from the operating table. The actual shooting was from a mirror installed at an angle of 45° above the operating field. Live broadcasting of the work of anesthesiologist, blood transmission, etc. was carried out (Fig. 3.33-3.35) (Voronov A., Bykov P., 1959). The first broadcasting took place on 30 December 1957 and the audience highly appreciated the image quality.



Fig. 3.34. Surgery - operative field reflected in the mirror



Fig. 3.35. Lecture hall with receivers

The authors immediately pointed out the areas for further improvement: to facilitate maintenance, ensure prompt change of scales, zoom the image

on the receiver by developing a projector receiver. They also suggested the innovative idea of television microscopes (including multispectral), connected to a computer and allowing to not only display but to automatically analyze the microimage. According to the authors, color television in surgery provided increased efficiency and visualization for education (ibid).

In about 1961, professor A. Karavanov (born on 18.08.1907) and the Candidate of Medical Science V. Revis used “medical television” at the hospital of departmental surgery of Kalininskiy Medical Institute (in Kalinin / Tver), USSR). An industrial television camera unit “PTU-3” was selected for technical implementation. It included a fixed transmission

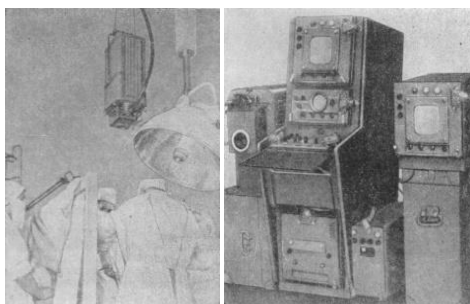


Fig. 3.36. “Medical television” in Kalinin Medical Institute; the control unit is “PTU-3” (USSR, 1961)

camera, the operating panel with remote video monitoring device and two television receivers “Rubin” (Fig. 3.36) (Karavanov A., Revis V., 1961). The camera was installed vertically on the ceiling in the operating theatre in front of the shadow less lamp at a distance of 135 cm from the operative field.

Additionally, two microphones and speakers were installed for two-way communication. The maintenance of this user-friendly system did not require specific supporting personnel (ibid).

In 1961, “medical television” was also introduced in the First Moscow Medical Institute. The work was supervised by Candidate of Medical Science S. Gorshkov. Standard television equipment with additional two-

way audio communication was used. The video and photo cameras were installed in the shadowless lamp; the control panel and video monitor were installed in a separate room (Fig. 3.37) (ibid). Several receivers were installed in the lecture hall and a separate screen was installed in the office

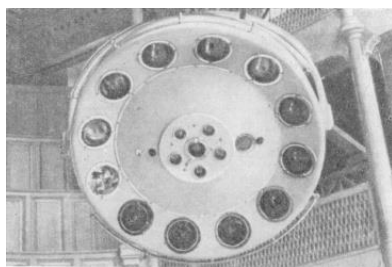


Fig. 3.37. TV camera, shadowless lamp and a video with a viewing screen in the First Moscow Medical Institute (Moscow, USSR, 1961)

of the Head of the hospital thus expanding the system's opportunities, i.e. it became possible to ensure telemedicine during operations and monitor the work of medical personnel (Gorshkov S., 1961).

“Medical television” was also an important distance learning tool in the USA (Fig. 3.38).



Fig. 3.38. Vaccination (poliomyelitis) broadcasted during educational videoconference. Dr J. E. Salk provided instructions, University of Michigan (USA, 1955), <http://ihm.nlm.nih.gov/images/B22439>



Fig. 3.39. “Medical television” for distance learning in ophthalmology, USA, 1958; cover of Radio&TV News magazine

In 1958, color medical videoconferences were applied on conferences for distance learning in ophthalmology at Hampstead General Hospital (Long Island, New York, USA). However, the black and white communication was still used as a low-cost alternative for hospitals with limited financing (Fig. 3.39) (An eye for an eye, 1958).

In 1965, on the campus of the University of Iowa Medical Centre, a telemedicine communication based on videoconferencing (cable television) was rolled out to 8-9 hospitals. The main priority of the network was distance learning in a system of postgraduate education. Interactive educational events (lectures, show case operations) were held and recorded for the purpose of further video sales. This project was implemented on the initiative and under the supervision of the Deputy Dean, Dr Robert E. Carter (Fig. 3.40) (Medical TV network will start operating Monday, 1965).



Fig. 3.40. Telemedicine network in the University of Iowa (USA, 1965)

“Medical television” was widely used for distance learning in the US Army Medical Service. In summer-autumn 1967, the largest network was set up, composed of 300 colors TV receivers installed in 100 geographically spread lecture halls. It was used to train 15 000 students annually. Such vast implementation was preceded by successful experience of educational videoconferences held between Fort Sam Huston and the School of Aviation Medicine (Fig. 3.41-42) (Medical TV Net Launched, 1967).



Fig. 3.41. Distance learning at the University of Missouri (USA, 1968)



Fig. 3.42. Network for distance learning for military medics based on color videoconferences (USA, 1967)

In 1965, “medical television” was introduced at Glasgow University (Scotland) for postgraduate professional development training (Dr. Bernard Lennox, Producer David Johnstone) (Fig. 3.43) (Lennox B., 1965).

The main disadvantage of “medical television” was “no possible interactivity”. The lectures and the practical presentations were recorded as typical TV programs and then broadcasted at certain times on commercial channels avoiding prime time. Up to 15 programs were broadcasted per month. Soon discussions started about the possibility of creating a separate educational channel (Johnstone D., 1965; Lennox B., 1965). Such medical programs, directed specifically to doctors, were broadcasted in the USA. For instance, in California, they were broadcasted in 70 hospitals and in Utah for some 700 doctors and 4 hospitals (Kalba K., 1971; Warner R., 1954; Warner R., Bowers J., 1954).

In the late 1960s - early 1970s the so-called “television networks” of medical institutions were established in several cities (San-Francisco, Indianapolis, Milwaukee, Detroit, Huston). In-house two-way television systems were used for videoconferencing and broadcasting of educational materials (including previously recorded videotapes).

Several examples of such networks focusing on distance learning are provided below. In Louisiana, in 1967, under the supervision of Director L. Stanley and Dr R. Sanchez, several tertiary referral hospital, a psychiatry institute, and two medical schools were connected to one network. In Georgia, the network centre was located at the Grady Memorial Hospital, Atlanta. The network included 24 medical establishments (hospitals, medical school, the state department for healthcare services) (Kalba K., 1971).



Fig. 3.43. Preparation for television program for postgraduate trainings for doctors, Glasgow, Great Britain, 1965

In 1967, in Vermont, Professor John P. Tampas, Dr A. Bradley Soule and Professor Wilfred Roth (24.07.1922-06.04.2004) from the Electrical Engineering Department (Engineering College) organized a telemedicine network based on videoconferencing between the geographically spread branches

of the University of Vermont Medical Centre (Fig. 3.44-3.45) (Tampas J., Soule A., 1968).



Fig. 3.44. John P. Tampas



Fig. 3.45. A. Bradley Soule



Fig. 3.46. Telemedicine workstation, University of Vermont Medical College (USA, 1968)

Telemedicine consultations were held on a regular basis (interactive videoconferences), including transmission of photofluoroscopy, ECG, EEG data and microimages. According to the authors themselves, the diagnostic value of the microimages was questionable using black and white television systems. Lectures and operations were also broadcasted. It should be noted, that somewhat later technical upgrade was made and color television equipment was installed (Fig. 3.46) (ibid).

Special radiographic equipment with an option of image intensification was used to broadcast X-ray pictures. A separate branch of telemedicine in this network focused on distance control of radiotherapy – telemonitoring of the process of radioterapy, patient's position and functioning of the equipment. As soon as uninterrupted and efficient work was ensured, the network expanded by introducing microwave data communication and connection between rural hospitals in the towns of Middlebury and Morrisville, and the medical centre in the town of Burlington.

The team of engineers under the supervision of Professor Wilfred Roth conducted significant work to improve the television equipment for medical videoconferences and broadcasting of radiological images. According to the authors, the development of medical videoconferences was hindered by high cost of equipment and frequent technical problems and breakdowns. There was also a need to improve the teleradiology methodology itself by means of videoconferencing (ibid).

Talking about medical videoconferencing in 1960-1970s, we should mention the device developed by Bell. The so called Picturephone was most probably the first videotelephone in the world (Fig. 3.47).



Fig. 3.47. Bell Picturephone®

The development of this technology started back in mid-1960s. Promotion of Bell Picturephone was aggressive, but it failed. Nevertheless, it was applied in medicine at some occasions (Bell working on picture phone uses,

1973; Stockbridge C., 1972; 1974). In 1970, at Mercy Hospital (Pittsburgh, Pennsylvania) video telephony was applied for intra-hospital organization and personnel administration.

In 1971, Professor Jacob Gershon-Cohen demonstrated the possibilities of teleconsultations on X-ray pictures with the help of the Bell Picturephone. More details are provided in chapter “Teleradiology”.

In 1972, C. D. Stockbridge, an employee of Bell Telephone Laboratories, published an article on the possibilities of the Picturephone application in medicine, demonstrating broadcasting of ECG, X-ray images

and microscopic slides. Special lenses and filters were developed allowing broadcasting medical data at the required level of diagnostic quality.

In 1973, at Cook County Hospital (Chicago, Illinois) video telephony was used at an intra-hospital level for teleradiology and examination of patients in the wards (urology department). The network moderator was Dr. Irving M. Bush. In other words, the doctors were able to conduct daily rounds without leaving their offices

In Chicago, Bell Picturephone was also installed at the branches of Tetani Brethren Garfield Park Community Hospital (a total of eight points) for management and distance learning. The network moderator was Vernon Showalter. A separate network was organized between the State of Illinois Psychiatry Institute and six medical establishments. It was used for teleconsultations between paramedics, providing medical aid to specialized patients and the specialists. In this case the network moderator was William H. Lewis.

In 1974, clinical tests using the Bell Picturephone were carried out in Chicago hospitals servicing western districts of the city.

3.2. Clinical Medical Videoconferences

In 1959, a two-way cable television system for teleconsultations (mainly in psychiatrics) and distance teaching of doctors (Fig. 3.48-3.50) was developed under the supervision of professor and honorary chancellor Cecil L. Wittson and Director for Biomedical Communications, Professor Reba Ann Benschoter, with the assistance of the Head of the Nebraska Psychiatric University Dr Frank J. Menolascino in University of Nebraska Medical Center (Omaha, Nebraska, the USA) (Benschoter R. et al. 1965; Benschoter R., 1967; Benschoter R. et al. 1967; Wittson C. et al. 1961; Wittson C., Benschoter R., 1972; Wittson C., 1965).



Fig. 3.48. Cecil L. Wittson



Fig. 3.49. Reba Ann Benschoter



Fig. 3.50. Frank J. Menolascino

In 1959, a distance demonstration of patients with neurological pathologies was organized for medical students. In 1961, significant scientific research on efficiency and possibilities of cable television systems in intra-group and individual psychological therapy was carried out. It was

determined that the application of telesystems did not affect the treatment results, i.e. the results were the same for all compared groups. However, a positive economic and logistic effect was obvious; consequently, the possibility of application of videoconferences in psychiatry with a respective level of quality was accepted (Wittson C. et al. 1961; Wittson C., Benschoter R., 1972; Wittson C., 1965).

In 1964, a telemedicine network between the Nebraska Psychiatric University (Omaha) and Norfolk Psychiatric Hospital, Virginia was built. The telepsychiatric system allowed solving personnel and organizational issues in this remote hospital. It significantly improved the quality of treatment, enhanced distance learning, supported holding teleconferences and special sessions for nurses, etc. It should be noted, that for the first time ever the teleconsultations were held 24-hours a day and separately from videoconferences. Faxes were used to dispatch text information (medical reports, educational books, etc.).

Distance maintenance of the hospital by the specialist doctor was also implemented for the first time. The neuropathologist consultant from the Nebraska Psychiatric University supervised the patients of the Norfolk Psychiatric Hospital on a regular basis; videoconferences and transtelephone transmission of electroencephalogram were used for teleconsultations (Fig. 3.51-3.53) (Chipps J. et al. 2012; UNMC Archives, 2015).



Fig. 3.51. Dr C. L. Wittson and Dr R. A. Benschoter at the University telemedicine centre



Fig. 3.52. Dr Menolascino holds a telemedicine consultation (1966)

Sometime later, reduction of available doctors in the city of Norfolk additionally stimulated development of telepsychiatry. For instance, in January 1965, regular 30 minutes teleconsultations were held on treatment and provision of medical aid to patients in closed departments. Three doctors from the psychiatry institute remotely supervised 10 wards in Norfolk Hospital (Fig. 3.54-3.56; UNMC Archives, 2015).



Fig. 3.53. Distance learning in psychiatry (1957)



Fig. 3.54. Omaha-Norfolk telemedicine consultation (~1964, Dr L. Strough in the photo)

Cecil L. Wittson and Reba A. Benschoter considered reduction of outpatients sent to the Institute (from over 900 in 1965 to 476 in 1968) as an efficiency indicator. In other words, telepsychiatry ensured quality treatment instead of primary reference.

By 1968, cable television system connected the University of Nebraska Medical Centre and three hospitals for veterans (in Omaha, Lincoln and Grand Island). The network operation was quite efficient and in 1970, 1 267 hours of telemedicine procedures were held. In 68% of the cases the telemedicine system was used for educational purposes, in 25% - for



Fig. 3.55. Nebraska telemedicine network (in about 1960.): distance learning and group telepsychiatry

clinical and only in 7% - for organizational issues. The encountered problems included technical difficulties and human factor (Wittson C. et al.

1961; Wittson C., Benschoter R., 1972; Wittson C., 1965).

It should be noted, that within this period, R. Leiser, D. S. Kornfeld and R. B. Lewis with colleagues from telepsychiatry were working on the basis of videoconferencing (Leiser R., 1952).

3.3. Telemedicine Network of Massachusetts General Hospital (MGH), Boston, Massachusetts

In Massachusetts General Hospital (MGH) (Boston, Massachusetts, USA) Dr Kenneth T. Bird, Dr Milton Henry

Clifford, physical scientist W. Scott Andrus, Dr Jack R. Dreyfuss, Dr Farooq Jaffer, Charles Hatch Hunter, Raymond L. H., Murphy et al. initiated the establishment of a telemedicine network (Andrus W., Bird K., 1972 a), b); Andrus W. et al. 1975; Bird K., 1971; 1972; Dwyer T. 1973; Murphy R., Bird K., 1974; Murphy R. et al., 1970; 1973).

The innovation was supported by the Director of MGH, Professor John H. Knowles (Fig. 3.57-3.63). Telemedicine centers were created in cooperation with an engineer from Boston Educational Television Studio, Richard Olkham. Soon, a psychiatrist, Thomas F. Dwyer, joined the team. When he heard about the videoconferences, he doubted about their efficiency for such a specific area of patients' treatment as psychiatry. However, after some telepsychiatry consultations in 1968, Dr Dwyer became the supporter of the new technology and in 1971, he coordinated a two-month scientific project in that field. Nevertheless, his colleagues called him "doubting Thomas". Thomas F. Dwyer wrote: "With the help of television interviews I can do the same as what I do in my office, except for the handshake... Probably for many patients, such form of communication with a psychiatrist is a lot more convenient" (Dwyer T., 1973).

In 1968, a telemedicine network was established between the MGH and a medical unit at Logan Airport (Fig. 3.64-3.66) (Andrus W., Bird K., 1972 b), Slavin P. 2015).

In 1970, a telemedicine network was established between the MGH and the Veterans Hospital in Bedford (Massachusetts). As another mean of communication, the so-called two-way television was used (Andrus W., Bird K., 1972 b). It is important to point out that not only cable but also wireless (microwave) means of communication were applied. Initially, black and white television was used; however, due to its functional deficiency, color technologies for image transmission were soon introduced.



Fig. 3.56. Dr D. Affleck is testing video equipment before telemedicine session (1961)

The telemedicine network at MGH was equipped with not only videoconferencing, but also with other tools for distance data exchange, including electronic stethoscopes. That was a key moment in defining the role and place of videoconferencing for telemedicine assistance. In 1972, Kenneth T. Bird wrote: “When interactive television is supplied with tools for diagnostics and monitoring, this is where a telemedicine network is established” (Bird K., 1972).



Fig. 3.57. John H. Knowles



Fig. 3.58. Kenneth T. Bird



Fig. 3.59. W. Scott Andrus



Fig. 3.60. Charles Hatch Hunter



Fig. 3.61. Raymond L.H. Murphy



Fig. 3.62. Jack R. Dreyfuss



Fig. 3.63. Farooq Jaffer

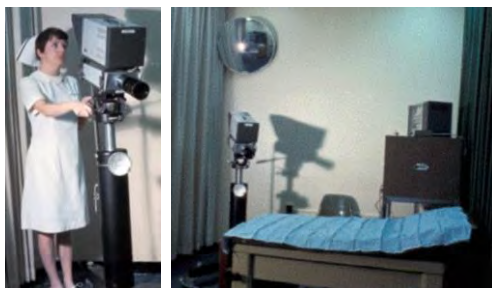


Fig. 3.64. A nurse operating a camera of the television system, telemedicine unit in Logan Airport (1960-1970s)



Fig. 3.65. Telemedicine consultation – medical unit in Boston Airport Dr K. T. Bird on the screen (1960-1970s)

A special room was arranged for teleconsultations in each institution, equipped with television facilities and screens (Fig. 3.67). Notably, technologies in those times already allowed remote control of the camera; an expert

doctor could freely choose an angle, projection, zoom and other image characteristics. Respective coordinators (mainly nurses) were appointed in each institution: Elizabeth E. Quinn (who died in 2006) at MGH, Gertrude B. Nolin (1916-2009) in Bedford; medical specialists Alice Kaknes, Barbara Pratt, William Twining also worked at telemedicine centres.

Both networks were designed for medical consultations in psychiatrics (neurotic and psychotic disorders), internal diseases, traumatology and radiology

(Bird K., 1971). From April 1968 to November 1970, 1 400 patients were examined via the MGH-Logan line. In 1974 – there were more than 550 patients, not taking into account preventive examination.

The MGH-Bedford the line was used even more frequently. Not only teleconsultations for doctors were held, but also for nurses and distance consultations of social workers, clinical psychologist, nutritional specialists. Telerehabilitation sessions in audiology were held daily; also rehabilitation treatment of patients after amputation took place. The dermatologists from Boston remotely controlled specialized patients on a daily basis adjusting their drug therapy. Distance learning was also held. In 1971, not less than 6 hours of telemedicine procedures were held daily. Distance preventive examinations of school children were carried out by psychiatrists via the

MGH-Logan line; that is, not only teleconsultations were active but also a telemedicine center. It is so that telemedicine procedures were preceded by a written consent of the patients (Fig. 3.68-3.74).

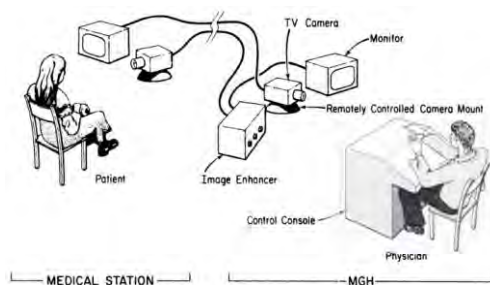


Fig. 3.66. Telemedicine system between the MGH and Logan Airport: a cable television system is used; both cameras are operated by a medical adviser



Fig. 3.67. Plan of telemedicine centre, Bedford (USA, 1971)



Fig. 3.68. Telepsychiatry consultation (MGH-Logan line), Dr T. F. Dwyer on the screen

When discussing this intense telemedicine activity, Dr T. F. Dwyer stated that telemedicine shows “how two separate medical establishments, each having reached significant achievements in specific spheres, can complement each other”. According to Dr K. T. Bird, telemedicine “expands a doctor’s usefulness”. Possibly, T. F. Dwyer was the one that introduced the term “telepsychiatry” (Dwyer T., 1973). A distinctive feature of the MGH telemedicine network was a systematic scientific assessment of telemedicine efficiency and a justified development of the methodology for clinical telemedicine use.

In 1972, the opportunities and quality of dermatological diagnostics with the help of telemedicine systems based on television communication were evaluated.



Fig. 3.69. Telepsychiatry, MGH-Logan line; K.T. Bird (left) and T. F. Dwyer (right)



Fig. 3.70. Hospital for Veterans in Bedford: nurse E. E. Quinn operates the camera



Fig. 3.71. Teleconsultation: Dr R. Baginsky represents the patient (USA, 1971)

In 1973, the findings of the studies on diagnostic value of distance heart auscultation with the help of an electronic stethoscope were presented. The data of direct and distance cardiophonography were compared. Tele-ECG was also discussed and the term teleauscultation was

probably introduced for the first time. The clinical and diagnostic efficiency of telecardiology was convincingly proved (Murphy R. et al. 1970; 1973).



Fig. 3.72. Distance training for nurses: M. Clifford is trained under the supervision of the Massachusetts General Hospital Supervisor A. Kaknes and the coordinator of teleconsultations G. Nolin (USA, 1971)



Fig. 3.73. Dr M. Clifford holds a teleradiology consultation (left) and a teleconsultation with the help of electronic stethoscope (right) (USA, 1971)



Fig. 3.74. Preventive telepsychiatry in the Massachusetts General Hospital (pilot programme of psychological teleassistance to teenagers via MGH-Logan line), 1971. On the screen is the hospital employee, social worker M. Schwartz

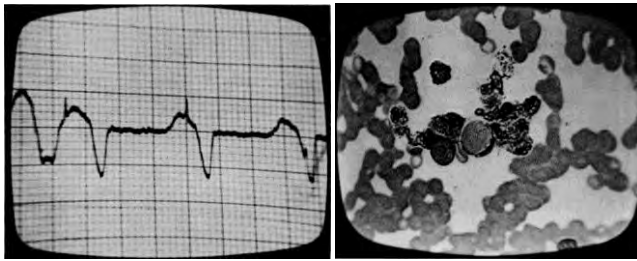
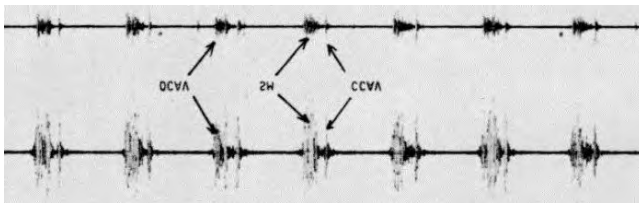


Fig. 3.75. Telemedicine network of the Massachusetts General Hospital - transmission of cardiophonogram, electrocardiography, microimage with LE-cells

In 1975, the study of diagnostic value of teleradiology was conducted under the supervision of the physical scientist W. Scott Andrus. At MGH-Bedford 100 radiographic appearances were performed: 33 of chest, 32 of abdominal cavity and 35 of locomotorium. The analysis of response curves showed the diagnostic value of teleradiology. Later, the technical aspects of teleradiology were thoroughly studied and published (Fig. 3.75) (ibid).

Dr Kenneth T. Bird is considered as the scientific leader of the

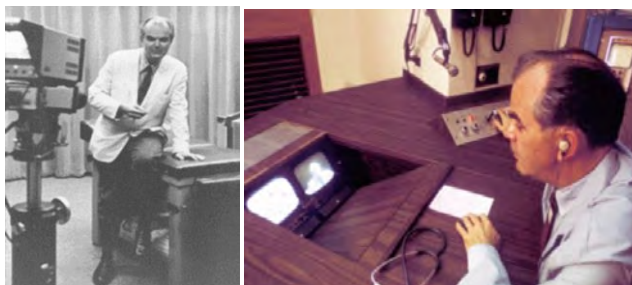


Fig. 3.76. Dr K. T. Bird holds telemedicine consultations (1968-1975)

Massachusetts Telemedicine Network. In autumn 1970, he presented a concept of national telemedicine network based on videoconferencing, i.e. the work stations in rural areas and towns had to be serviced by nurses, paramedics and only sometimes by doctors. The centers of expertise should be specialized medical centers and university hospitals (Fig. 3.76). The implementation plan included the following stages:

1. Establishing a federal telemedicine agency;
2. Installing at least one videoconferencing system in each state (50 systems at a price of USD 200 000 each with annual maintenance costs of USD 10 000);
3. Gradual increase of the number of systems to 50 in each state (a total of 2 500 in the country);
4. Compulsory connection of all medical educational establishments to the network.

In 1972, Dr K. T. Bird gave an academic definition of telemedicine as “a medical practice by means of interactive audio/video communications. Telemedicine does not replace the physician or delegate him to a less important role. Telemedicine depends on a physician and his special abilities and it offers him a new way to practice medicine. Through an interactive telemedicine system, the fundamental doctor-patient relationship not only can be preserved, but potentially augmented, enhanced and more critically focused”.

K. T. Bird, was one of the first who start using the term “telemedicine center” widely (Bird K., 1972) (Fig. 3. 76).

It should be noted that academic studies on telemedicine based on videoconferencing were also conducted by other scientists in 1970s. For instance, D. W. Conrath et al. (1977) conducted comparative analysis of engineering solutions for telemedicine, and C. Muller et al. studied economic feasibility of its application (1977).

Telemedicine systems based on cable television were used in Walter Reed General Hospital (Washington, USA); however, the diagnostic value and impact on the treatment process by such systems were negatively evaluated due to low image quality and technical problems (Vladimirskiy A., 2008).

In 1974, a manual by R. Potts on creation of medical television centers in educational establishments was published (Potts R.1974).

It was the team of Dr Kenneth T. Bird that justified and developed fundamental principles for the application of videoconference communication as telemedicine tool and provided proof of its efficiency.

3.4. Telemedicine Projects Based on Videoconferencing in 1970-1980

In 1970s closed-circuit videoconferences were used for a medical purposes (including psychotherapy and nursing) in Sweden, Great Britain and other countries (Sanborn C. et al., 1974; Sundin K., Wengraf U., 1974). During the same period a special television system was offered for disabled people, as a means of communications. For example, O. J. Downing and J. E. Tully (1979) developed a unique teleconference-system «Telecad» for children with cerebral palsy.

In the early 1970s, a significant telemedicine project was implemented in Cleveland (Ohio, USA). Doctors and engineers from several local institutions were involved in it (Fig. 3.77-3.80) (Gravenstein J. et al., 1974; Grundy B. et al., 1977; 1982; Grundy B., 1976):

- The Technology Department of Case Western Reserve University (CWRU): Professor Arnold Reisman, Professor Joachim Stefan Gravenstein, Professor Paul K. Jones, Professor Yoh-Han Pao, Dr of Science T. Ott, Masters and Bachelors of Science May Lou Kiley, T. George, P. Chou;
- The University hospital: Dr E. A. Ernst (supervised at least the preparation of the project devoted to justification of telemedicine application), Professor Betty (Elizabeth) Lou Grundy, Dr Edward L. Wilkerson (1942 - 2005);

- Forest City Hospital: Dr C. Berry, Dr D. Brittenum, Nurses Pauline Crawford, W. Callaham, R. Fields, Administration officer D. Snyder.

The employees of the local veterans' hospital also participated in the implementation of the initial stage of the project.



Fig. 3.77. Betty (Elizabeth) L. Grundy



Fig. 3.78. Paul K. Jones



Fig. 3.79. Arnold Reisman



Fig. 3.80. Joachim Stefan Gravenstein

The idea of the project came up in 1972, based on the need of continuous consulting assistance regarding anaesthesiology issues between the University Hospital and the small Forest City Hospital. A distinctive feature of the project was its scientific justification. Before proceeding with the development of technical means and infrastructure, a thorough analysis of infrastructure, performance indicators and production processes

of the involved medical institutions was conducted. The patients' routes were developed and analysed, as well as organisational and hierarchy diagrams. A questionnaire survey was held for the personnel. Based on the obtained data, a substantiated algorithm for telemedicine implementation and its integration in healthcare process was suggested in order to optimize and improve the quality of medical assistance. The principles of continuous telemedicine supervision were also developed and introduced. That way of the project management is still relevant today (ibid).

Based on the scientific findings, development of a set of equipment for videoconferencing was started up. A two-way audio and video system was foreseen. The pilot testing took place in 1973 between the CWRU and a Hospital for Veterans. The equipment adjustment took a lot of time and during 1974 the preparatory works and development of the respective infrastructure was carried out at Forest City Hospital. Data were constantly accumulated for further efficiency analysis.

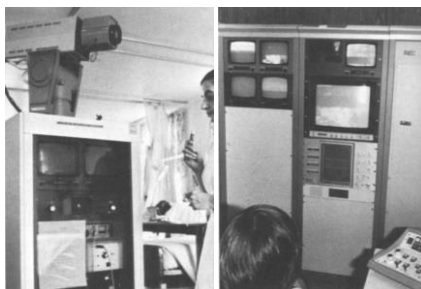


Fig. 3.81. Mobile work station equipped with a color video camera and a monochrome screen. The work station of the expert is equipped with a color screen and a camera

Finally, in March 1975, the first ever telemedicine consultations on anaesthesiology were held. In the following months, neonatology and intensive care units were connected to the network. Starting from 16 October 1975, the use of telemedicine in Cleveland became regular (Fig. 3.81) (ibid).

After 175 days of active work, the first conclusions were drawn. 540 consultations were held on 128 patients. An average session lasted for 30-60 minutes. From the technical point of view, initially the system's fault rate was 20%; however, thorough improvement and through the introduction of microwave data transmission, the fault rate was decrease.

The satisfaction of patients and of the medical personnel (doctors and nurses from different units) was studied too. The reasons for patients' refusals to participate in videoconferences were analysed.

The relevance of teleconsultations was also analysed. According to the authors, in the first 3 months 35% of recommendations were applied, and 46% in the following period. The significance of the educational component of telemedicine was acknowledged by 70% of respondents (ibid).

In 1981-1982, 1 548 teleconsultations on 395 patients of the intensive care unit were held. The authors claimed that notwithstanding the significant positive impact of telemedicine on clinical and educational aspects, further thorough scientific study and justification was required for future implementation, as the possibilities of interactive television in

intensive care were not fully used (ibid). We would take it upon us to say that the videoconferencing systems in the medical institutions in Cleveland had to be additionally equipped with medical data transmission tools (biotelemetry, teleauscultation, etc.), taking into account the successful experiences in the USA in this area at that time.

In any case, based on the obtained data and findings, the authors came to conclusions that became the postulates of telemedicine:

- "Continuous consultation in intensive care can be held via videoconferences;
- The technology model is appropriate but costly;
- Telemedicine consultations are acceptable for the users and suppliers of medical services;
- Telemedicine can be used as an important educational tool;
- Telemedicine can have an impact on the process of medical aid provision and result in clinical outcomes;
- Videoconferencing is preferable to telephone communication in intensive care units;
- Telemedicine ensures important connection between the large medical centers and small hospitals thus significantly improving the performance of intensive care units of the latter" (ibid).

In 1973-1979, telemedicine was implemented in Florida correction facilities. Consultations for Dade County Jail, the Women's Detention Center and the Men's Stockade were provided by the University of Miami and Jackson Memorial Hospital (Dr. Jay Sanders and Dr. Louis Sasmor). Nurses worked in prisons with telemedicine equipment. The telemedical wireless network «Interact» infrastructure was developed by Westinghouse Electric Corporation. Facsimile and voice communication, biotelemetry and black and white low scanning television systems were used. Thanks to telemedicine, over 86% of the doctors' visits to correction facilities were substituted by teleconsultations. Based on the network performance, the company concluded contracts for installation of similar systems in Iraq and South Korea. This was the first telemedicine network for correctional facilities that widely involved nurses for telecare purposes (Telemedicine is latest closed circuit service, 1976; Interact-a microwave medical network, 1979).

In Great Britain, medical videoconferencing was developed under the supervision of Dr Dennis Walter Hill. For foreign distance monitoring and consultations on anaesthesiology during surgical treatments, a Viewphone television system and computing diagnostics means were applied. The Viewdata system (a service for information receipt via common communication channels and its display) was used for work with remote

computers and databases. Testing of such telemedicine technology was made between the Middlesex Hospital in London and computer centers in Cambridge. The Viewdata service was based on simultaneous use of remote databases; simple television receivers and digital keypads were used (Fig. 3.82).



Fig. 3.82. Terminal for Viewdata service operation

As an interesting addition we want to report the following fact. During our work on historical materials we received a letter from our colleague, Dr Gisele Ricur from Argentina. She wrote: «I wanted to let you know that regarding surgical films and telemonitoring, the 1st documentary film in medicine was shot in Buenos Aires in 1898 by Dr. Alejandro Posadas (“Padre de la cirugía moderna en Argentina”), just only 2 years after cinematography was developed by the Lumiere brothers. It showed a surgery performed on a lung hydatid cyst that was filmed next to a window. Both the film libraries of Paris and Belgium have acknowledged it as the first documentary film in medicine. Here is a link to the clip that was rescued in 1971 during the demolition of the original building of the Hospital de Clínicas of the city of Buenos Aires (founded in 1877)». This information may not have a direct bearing on telemedicine, but we decided nevertheless to mention this historical fact related to medical visualization (Fig. 3.84).

In the late 1970s – early 1980s, that tool was applied in clinical pharmaceutical tests. It was considered as the foundation for development of geographically distributed information systems for hospitals (Fedida S., Roach M., 1979; Waldron H., Cookson R., 1984).



Fig. 3.83. The color television camera in operating room of Walter Reed Army Hospital, equipped with a number of lenses and looks at the surface of a mirror that is suspended at an angle above the operation. Date of picturing November 14, 1957.

Source: National Archives and Records Administration, SC 521403



Fig. 3.84. Screenshots from first in the world filmed surgery made by professor Alejandro Posadas in 1897. <https://www.youtube.com/watch?v=nEIZJEmdhe0>, user Javier Barreiro

In conclusion: The development of videoconferencing as a telemedicine tool started in 1939. The television technologies were used as technological basis for interactive videoconferences in the 20th century. Initially, it was black and white television, although it did not have any significant value. It only demonstrated the possibility of application of new telecommunication equipment in medical institutions, including operating theatres.

The development of the color television in the late 1940s completely changed the opportunities and significance of medical videoconferencing making it an effective telemedicine instrument. Television communication itself was not always used at considerable distances. At the beginning this was a connection between separate buildings. In number of countries, as part of certain projects, interactive videoconferences were performed within one building. However, large networks for distance learning and consultation were soon in use. From the point of view of functional load, medical videoconferences in the 20th century were mainly applied as a distance learning tool. Nevertheless, they were also quite efficient in clinical medicine. In the middle of the century, a separate application, telepsychiatry, was developed, based on videoconferencing technologies. Being an important telemedicine tool, videoconferencing developed significantly allowing to determine its role and place in healthcare service.

References

- [1] Aksyinin B. N., Kuzmin B. A. [Experience in the use of color television for the transmission of images of surgical operations], *Vestnik hirurgii im. I.I. Grekova*, 1959, 82, 4, pp. 3-10 (in Russian), Аксенов Б. Н., Кузьмин Б. А. Опыт применения цветного телевидения для передачи изображений хирургических операций, *Вестник хирургии им. И. И. Грекова*, 1959, 82, 4, с. 3-10
- [2] An eye for an eye, *Radio & TV News*, May, 1958, p. 37

- [3] Andrus W. S., Bird K. T. Teleradiology - evolution through bias to reality (Editorial), *Chest*, 1972, 62, pp. 655-657, b)
- [4] Andrus W. S., Bird K. T. Teleradiology: Remote interpretation of roentgenograms. *Photographic Science and Engineering in Medicine, Proceedings of a tutorial seminar sponsored by the Society of Photographic Engineers and Scientists*, 1972, a)
- [5] Andrus W. S., Dreyfuss J. R., Jaffer F., Bird K. T. Interpretation of roentgenograms via interactive television. *Radiology*, 1975, Jul 116, 1, pp. 25-31
- [6] Andrus W. S., Hunter C. H., Bird K. T. Remote interpretation of chest roentgenograms, *Chest*, 1975, 67, 4, pp. 463-468
- [7] Babcock B. Colour television; a dramatic teaching medium, *Can Hosp*, 1953, Feb 30, 2), pp. 42-45
- [8] Babcock B. Telecasts offer hospitals a mass teaching medium, *Hospitals*, 1951 Feb, 25, 2, pp. 55-56
- [9] Beales E. Sisters of St. Joseph of Wichita score national first: Teletype system links nine hospitals, *Hosp Prog*, 1953 Dec, 34, 12, pp. 46-49
- [10] Bell working on picture phone uses, *The Pittsburgh Press*, 1973 Sep 23, p. B-11
- [11] Benschoter R. A. V. Television. Multi-purpose television, *Ann NY Acad Sci*, 1967 Mar 31, 142, 2, pp. 471-478
- [12] Benschoter R. A., Garetz C., Smith P. The use of closed-circuit TV and videotape in the training of social group workers, *Social Work Education Reporter*, 1967 July 15, pp. 18-19
- [13] Benschoter R. A., Wittson C. L., Ingham C. G. Teaching and consultation by television. I. Closed-circuit collaboration, *Ment Hosp*, Mar 1965, 16, pp. 99-100
- [14] Biancheria A. Television and surgery, *Minerva Med*, 1950 Jul 28, 41, 38, pp. 244-246
- [15] Bird K. T. Cardiopulmonary Frontiers: Quality Health Care via Interactive Television, *Chest*, 1972, 3, 61, pp. 204-205
- [16] Bird K. T. Teleconsultation: A New Health Information Exchange System, *Massachusetts General Hospital*, 1971, p. 58
- [17] Bloom R. R. Pioneering in color television education, *US Armed Forces Med J.*, 1958 Feb, 9, 2, pp. 180-186
- [18] Boro C. J., Mead B. T. A Century of Teaching and Healing, *The First One Hundred Years of the Creighton University School of Medicine*, Publisher: Creighton University School of Medicine, USA, 1991
- [19] Carroll W. W. Medical television, *Q Bull Northwest Univ Med Sch*, 1949, 23, 2, pp. 207-214
- [20] Castle C. H. Open-circuit television in postgraduate medical education, *J Med Educ.*, 1963 Apr, 38, pp. 254-260
- [21] Chipps J., Ramlall S., Mars M. A telepsychiatry model to support psychiatric outreach in the public sector in South Africa, *Afr J Psychiatry (Johannesbg)*, 2012 Jul, 15, 4, pp. 264-270
- [22] Conrath D. W., Dunn E. V., Bloor W. G., Tranquada B. A clinical evaluation of four alternative telemedicine systems, *Behav Sci*, 1977 Jan, 22, 1, pp. 12-21
- [23] Cooper B. Television: The Technology That Changed Our Lives, 2004, www.earlytelevision.org
- [24] Delcros G. Limits and possibilities of television in the education of physicians and medical students, *Concours Med*, 1951 Sep 22, 73, 38, pp. 3157-3160
- [25] Downing O. J., Tully J. E. Telecad-a television communication aid for the disabled, *Med Biol Eng Comput*, 1979 Jul, 17, 4, pp. 476-480
- [26] Dwyer T. F. Telepsychiatry: Psychiatric Consultation by Interactive Television, *Am J Psychiatry*, 1973, 130, pp. 865-869
- [27] Ellman I. W., Ellman I. A Television in the dental operating room, *NY State Dent J*, 1951 May, 17, 5, pp. 220-221

- [28] Elsom K. A., Roll G. F. Color television as a new medical-teaching aid; report of two and one-half years' experience, *J Am Med Assoc*, 1951 Dec 15, 147, 16, pp. 1550-1554
- [29] Ennuyer A., Guenot J. Contribution of television to teaching otorhinolaryngology, *Presse Med*, 1956 Jan 21, 64, 6, pp. 121-122
- [30] Erikson C. A. Jr, Brown R. F. Exit, the surgical amphitheater; enter, television, *Mod Hosp*, 1949 Dec, 73, 6, pp. 48-51
- [31] Fedida S., Roach M. E. Viewdata and Its Application to Medical Informatics, *Lecture Notes in Medical Informatics*, 1979, 5, pp. 781-788
- [32] Flory L. E. The television microscope, *Cold Spring Harb Symp Quant Biol*, 1951, 16, pp. 505-509
- [33] Fourestier M., Dubois D. E., Montreynaud J. M. The future of television in hospital and postgraduate medicine, *Presse Med*, 1956 Jul 7, 64, 54, pp. 1285-1286
- [34] Galdston I. What have radio and television to contribute to continuation medical education? *J Med Educ*, 1954 Apr, 29, 4, pp. 28-30
- [35] Genova T. Television history – the first 75 years, www.tvhistory.tv - Last visit Dec 2015
- [36] Gersonde J. R. Pediatric care improved with closed circuit TV, *Hosp Manage*, 1958 May, 85, 5, pp. 62-63
- [37] Gorby A. L. Color television in medical education, *Med Bull US Army Eur*, 1956 Jul, 13, 7, pp. 152-157
- [38] Gorshkov S. Z. [Recent advances in television in the surgical clinic], *Hirurgiya*, 1961, 37, 12, pp. 119-121 (in Russian), Горшков С. З. Современные достижения телевидения в хирургической клинике, *Хирургия*, 1961, 37, 12, с. 119-121
- [39] Gosse L. Surgical education and television, *Presse Med.*, 1954 Sep 11, 62, 59, p. 1221
- [40] Gravenstein J. S., Berzina-Moettus L., Regan A., Pao Y. H. Laser mediated telemedicine in anesthesia. *Anesth Analg*. 1974 Jul-Aug, 53, 4, pp. 605-609
- [41] Grundy B. L., Crawford P., Jones P. K., Kiley M. L., Reisman A., Pao Y. H., Wilkerson E. L., Gravenstein J. S. Telemedicine in critical care: an experiment in health care delivery. *JACEP*, 1977 Oct, 6, 10, pp. 439-444
- [42] Grundy B. L. Telemedicine in critical care. A preliminary report, *Critical Care Medicine*, 1976, 4, 2, p. 104
- [43] Grundy B. L., Jones P., Lovitt A. Telemedicine in critical care: Problems in design, implementation and assessment. *Crit Care Med*. 1982 Jul, 10, 7, pp. 471-475
- [44] Hague J. E., Crosby E. L. Television, Newest Aid in Teaching Surgery. *Mod Hosp*. 1948 Apr, 70, 4, pp. 65-67
- [45] HeSCA Feedback, 27, 2, 2000
- [46] HeSCA. Health Sciences Communications Association, www.hesca.org – Last visit June 2015
- [47] Holleb A. I., Buch F. B. Color television in medical education: A report on "telecolor clinics". *J Am Med Assoc*, 1954 Sep 25, 156, 4, pp. 298-302
- [48] Interact-a microwave medical network. *Educ Ind Telev*, 1979 Apr, 11, 4, pp. 62-66
- [49] Jang R., Barker K. Punch cards, teletype help to automate drug system. *Mod Hosp*. 1965 Apr, 104, 124-126
- [50] Johnstone D. The Glasgow Postgraduate Medical Television Programme. *Postgrad Med J*. Apr 1965, 41, 474, p. 220
- [51] Kalba K. K. *Communicable Medicine: Cable Television and Health Services*, New York: Alfred P. Sloan Foundation, 1971, p. 57
- [52] Karavanov A. G., Revis V. A. [Application of industrial television installations (PTU-3) for the television from operating theater], *Hirurgiya*, 1961, 37, 1, pp. 128-130 (in Russian), Караванов А. Г., Ревис В. А. Применение промышленной телевизионной установки (ПТУ-3) для телепередач из операционной, *Хирургия*, 1961, 37, 1, с. 128-130

- [53] Klein M. R, Ruhe D. S. Television of operative surgery. *Med Biol Illus.* 1957 Jan, 7, 1, pp. 33-38
- [54] Ladika O. A. Telecast of operation. *Hosp Prog.* 1957 Nov, 38, 11, p. 98
- [55] Leiser R. Television helps patients in mental hospitals. *Hosp Manage.* 1952 Jan, 73, 1, p. 40
- [56] Lennox B. The Glasgow postgraduate medical television series: production problems on the medical side. *Postgrad Med J.* 1965, 41, pp. 220-222
- [57] Mackenzie J. K. The Smith, Kline & French (Mobile) Medical Color TV Unit. CBS Field-Sequential Color TV System, www.thewritingworks.com/nostalgia.html - Last visist Febr 2016
- [58] Medical TV Net Launched, *San Antonio Express* (San Antonio, Texas), Sun, Aug 13, 1967, p. 113
- [59] Medical TV network will start operating Monday, *The Mason City Globe-Gazette*, Mason City, Iowa, Wed, Feb 17, 1965, p. 7.
- [60] Meisner R. The use of television for transmission of operations and for demonstrations. *Munch Med Wochenschr.* 1957 Sep 27, 99, 39, pp. 1429-1431
- [61] Moore P., vonLeden H. Television in otolaryngology and other specialities; a new teaching device. *J Am Med Assoc.*, 1959 Apr 25, 169, 17, pp. 1976-1980
- [62] Moses C., Wolfe R. Grand rounds via television: an experiment in continuing education. *Pa Med J.*, 1964 Aug, 67, pp. 23-28
- [63] Muller C., Marshall C. L., Krasner M. et al. Cost factors in urban telemedicine. *Med Care*, 1977 Mar, 15, 3, pp. 251-259
- [64] Murphy R. L. H., Barber D., Bird K. T. et al. Microwave transmission of chest roentgenograms. *Am Rev Resp Dis*, 1970, 102, pp. 771-777
- [65] Murphy R. L. Jr., Bird K. T. Telediagnosis: a new community health resource. Observations on the feasibility of telediagnosis based on 1000 patient transactions. *Am J Public Health*, 1974 Feb, 64, 2, pp. 113-119
- [66] Murphy R. L., Block P., Bird K. T., Yurchak P. Accuracy of cardiac auscultation by microwave. *Chest*, 1973 Apr, 63, 4, pp. 578-581
- [67] Operation "blue" baby television, *Cumberland Evening Times*, Cumberland, Maryland, Fri Feb 28, 1947, p. 2
- [68] Ottolenghi C. E. Television, sound and color, in the teaching of surgery. *Dia Med.*, 1950 Apr 17, 22, 16, pp. 625-627
- [69] Potts A. M., Brown M. C. A color television ophthalmoscope. *Trans Am Acad Ophthalmol Otolaryngol.*, 1958 Jan-Feb, 62, 1, pp. 136-137
- [70] Potts R. E. A medical television center: a guide to organizing a large television center in health science educational institutions, Atlanta, Ga.: National Medical Audiovisual Center, 1974
- [71] Reese E. A. Teletype equipment can save time and lives. *Hospitals*, 1957 Nov 16, 31, 22, p. 59
- [72] Rousselot L. M. TV in surgical teaching. *Hosp Prog.*, 1954 Oct, 35, 10, p. 55
- [73] Ruedemann A. D. Use of Television in Medicine. *Cleve Clin Q.*, 1947 Jul, 14, 3, p. 145
- [74] Sanborn C. J., Seibert D. J., Sanborn D. E. 3rd, Pyke H. F., Ferland S. F., Welsh G. W. Speech therapy by interactive television. *Community Health* (Bristol), 1974 Nov-Dec, 6, 3, pp. 134-137
- [75] Schafer P. W. Television at the University of Kansas medical center. *JAMA*, 1953, 152, 1, pp. 78-82, b)
- [76] Schafer P. W. The Kansas television experiment. *J Am Med Assoc*, 1953 Jun 6, 152, 6, pp. 554-557, a)
- [77] Slavin P. Connected Health: Empowering Care through Communication Technologies. Keynote Address, www.connected-health.org - Last visist Jan 2015

- [78] Stockbridge C. D. Experience of Picturephone System Usage in Hospitals. Proc. SPIE 0043, Application of Optical Instrumentation in Medicine II, 179, May 1, 1974, doi:10.1117/12.953910
- [79] Stockbridge C. D. The Performance of Picturephone Systems in Transmitting Medical Data. Proc. SPIE 0035, Application of Optical Instrumentation in Medicine I, 9 (June 1, 1972, <http://proceedings.spiedigitallibrary.org/proceeding.aspx?articleid=1224508>, doi:10.1117/12.953655
- [80] Sundin K., Wengraf U. Closed-circuit television in health services and nursing care. Tidskr Sjukvardspedagog, 1974, 21, 4, pp. 87-90
- [81] Surgeons of the International Congress of Madrid follow operations on color television. Union Med Can, 1952 Jul, 81, 7, p. 886
- [82] Tampas J. P., Soule A. B. Experiences with Two-Way Television in a Teaching Hospital Complex. JAMA, 1968, 204, 13, pp. 1173-1175
- [83] Telemedicine is latest closed circuit service, Lebanon Daily News, Pennsylvania, Mon Apr 5, 1976, p. 19
- [84] Television an aid to teaching surgery. Hosp (London), 1949 Jun, 5, 6, pp. 331-334
- [85] Television Lets Students Watch Operation, Popular Science, 1939, 135, 1, pp. 94- 95
- [86] Terzi I. Didactic television in obstetrical and gynecological clinics. Minerva Ginecol, 1955 Jan 15, 7, 1, pp. 1-4 (in Italian)
- [87] The Blue Baby Operation, <http://www.medicalarchives.jhmi.edu/page1.htm> - Last visit Dec 2015
- [88] Trimble I. R., Reese F. M. The Use of Television in Surgical Operations. Bull Johns Hopkins Hosp., 1947 Sep, 81, 3, pp. 186-191
- [89] UNMC Archives, Special Collections Department, McGoogan Library of Medicine, University of Nebraska Medical Center, Omaha, <http://www.unmc.edu> - Last visit Dec 2015
- [90] Vanderwarker R. D. Operation television, the next step for teaching hospitals. Mod Hosp. 1948 Oct, 71, 4, pp. 54-56
- [91] Viguers R. T., Shea M. L. Televised clinics are as useful for teaching medicine as they are for teaching surgery. Mod Hosp, 1950 Jul, 75, 1, pp. 71-73
- [92] Vladzimirskiy A. V. [The history of telemedicine, people, facts, technology], Donetsk: ООО 'Tsifrovaya tipografiya', 2008, p. 82 (in Russian), Владимирский А. В. История телемедицины: люди, факты, технологии, Донецк: ООО «Цифровая типография», 2008, с. 82
- [93] Voronov A. A., Bykov P. E. [Using a color television to demonstrate surgeries], Vestnik hirurgii im. I. I. Grekova, 1959, 82, 4, pp. 11-16 (in Russian), Воронов А. А., Быков Р. Е. Использование цветного телевидения для демонстрации хирургических операций, Вестник хирургии им. И. И. Грекова, 1959, 82, 4, с.11-16
- [94] Waldron H. A., Cookson R. F. Use of a viewdata system to collect data from a multicentre clinical trial in anaesthesia, Br Med J, Clin Res Ed, 1984 Oct 20, 289, 6451, pp. 1059-1061
- [95] Warner R. S. New audio-visual methods in postgraduate medical education. J Biol Photogr Assoc., 1954 Nov, 22, 4, pp. 150-160
- [96] Warner R. S., Bowers J. Z. The use of open-channel television in postgraduate medical education. J Med Educ, 1954 Oct, 29, 10, pp. 27-33
- [97] Wittson C. L. Nebraska initiates cross-country TV psychiatry. Educational Screen and Audiovisual Guide, 1965, 44, pp. 22-23, 39, 45
- [98] Wittson C. L., Affleck D. C., Johnson V. Two-way television in group therapy. Mental Hospitals, 1961, 2, pp. 22-23
- [99] Wittson C. L., Benschoter R. Two-way television: helping the Medical Center reach out. Am J Psychiatry, 1972 Nov, 129, 5, pp. 624-627

- [100] Zworykin V. K. Television techniques in biology and medicine. *Adv Biol Med Phys*, 1957, 5, pp. 243-283
- [101] Zworykin V. K., Hatke F. L. Ultraviolet television color-translating microscope, *Science*, 1957 Oct 25, 126, 3278, pp. 805-810

Chapter 4

Biotelemetry

New facts require new ideas.
V. V. Rosenblatt, 1967

The development of physiology and related disciplines in the 20th century led to new specific tasks for biomedical engineering - the development and implementation of systems, which allowed performing distant recording and transmission of physiological data of motor activity. Special attention was dedicated to records in extreme conditions - underwater, underground and in microgravity. The "Dynamic Biotelemetry" concept was formed (Fig. 4.1-4.2). The basis for this concept was laid by physiologists in the USSR as early as in 1930-1932. The first to develop a simple telemetry system for the experiments on animals regular activities were A. A. Yushchenko and L. A. Chernavkin. Both were I. P. Pavlov's students. Later P. P. Pakhomov also joined them. All the radio transmitting equipment was fixed to the back of the experimental dogs. Telemetry under the conditions of absolute freedom of animal motion was very useful for settling number of issues related to the physiology of higher nervous system (Yushchenko A., Chernavkin L., 1932 a), b).

In 1938 the following team: K. Zemlyakov, D. Ivanov and T. Fedorov (USSR), suggested a telemetry system - "tele-radio station", enabling to record remotely the cardiac function (Zemlyakov K. et al., 1938). A phonocardiogram of a person placed in an altitude pressure chamber was transmitted over the radio.

Ten years later J. L. Fuller and T. M. Gordon (USA) offered a "radio inductograph for transmission of respiration rate, pulse or other mechanical signals, which were detected with an inductive pickup, connected to transmitting circuit and changing transmitter frequency" (publication in "Science", No. 108, 1948, p. 287 (Parin V., 1971).

The period 1960s and the early 1970s can be called "the Golden Age" of bioradiotelemetry. In many countries around the world (USSR, USA, Norway, Great Britain, Germany, Poland, the Czech Republic, Japan, etc.) various devices and systems were developed and successfully applied, which enabled to record remotely physiological parameters of sportsmen, pilots, military officers, divers, miners etc., and also, of patients suffering from various diseases.

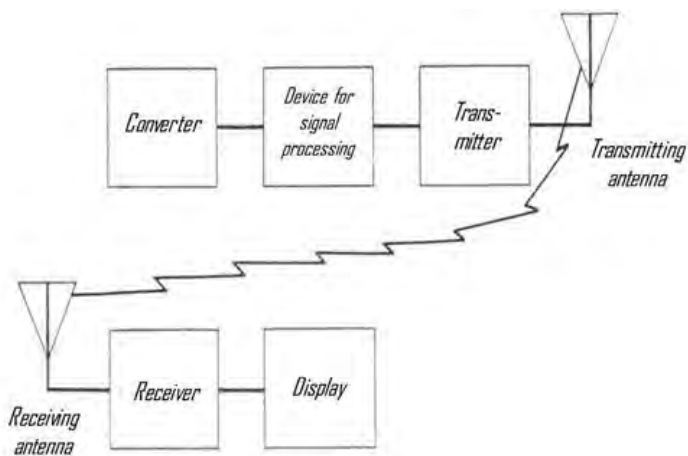


Fig. 4.1. Schematic diagram of a classical biotelemetry system according to (Cromwell et.al., 1981)

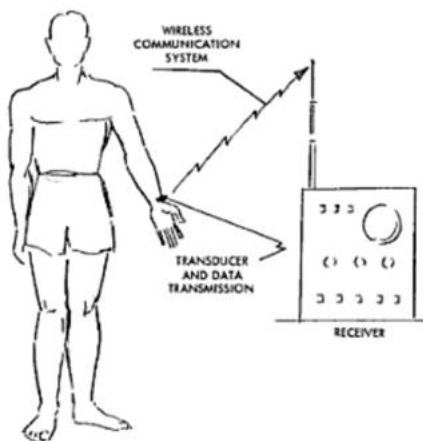


Fig. 4.2. Overall, "idealised" schematic diagram of biotelemetry system according to D. R. Hitchcock from 1965

The famous scientist V. V. Rosenblatt proved this as follows: "Between 1948-1965, several dozens of laboratories and design-engineering departments both in the USSR and abroad (USA, England, Bulgaria, Czech Republic, France, German Democratic Republic, Federal Republic of Germany, The Netherlands, Hungary and others) published information about the first developments of miniature devices for radio-telemetry of physiological information from unrestrained human or animal subjects" (Parin V., 1971).

General methodical issues of biotelemetry were illustrated in the works by Allen R. T. et al. (1964), Tolles (1963) (incl. in the physiology field), Rubenstein (1962), Pessar et al. (1962) (in occupational medicine), Parker C. et al. (1953).

Description of various telemetering gears and devices as well as the technical aspects were published by Kashin et al. (1974), Shafer W. (1967), Degre S. et al. (1966), Stattelman A. et al. (1965), Ax A. F. et al. (1964), Barry W. (1964), Bell D. et al. (1971), Morgenstern J. et al. (1978), Byford G. (1965), Girson T. et al. (1962), McPetrie J. et al. (1963), Kitamura K. (1963), Kitamura K. et al. (1963), Rothfeld E. et al. (1965), Kobayashi T. et al. (1963), Slater L. E. (1965), Davis D. (1964), Davis D. et al. (1961), Roach C. J. et al. (1962). They all worked on the issues of clinical telemetry. New aspects, connected with individualization of the telemedical procedure and its usage at the outpatient treatment stage, were studied by Fascenelli F. (1965), Bergey G. et al. (1965), Parker C. S. et al. (1953). Table 4.1 provides information about publications, related to telemetry of some physiological parameters.

It is impossible to describe every project or device developed in that period. Onwards we will cite in detail only the most remarkable achievements in the sphere of biotelemetry in the middle of the 20th century.

Table 4.1. Summarized information about research in the field of Biotelemetry (the 1960s - early 1970s)

Physiological index	Author(s)
Arterial tension	Bradfute G. et al. (1968)
Intra-oral tension	Kydd W. L. et al. (1963)
Pedometry	Herron R. E. et al. (1967)
Photoplethysmogram	Jones J. W. et al. (1989)
Pulse	Seliger V. et al. (1965), Pircher L. (during workload and sport load, 1964), Bauer H. et al.

	(1977, in nursing officers during physical stress connected with work activities)
Rheogram	Bolshov V. M. et al. (1974)
Temperature	Morhardt J. E. (1972)
Respiratory function and criteria	Lewillie L. et al. (1968), Lota M. J. (1967)
Electrocardiogram	Czaplicki S. (1967), Tejerina Raygana M. (1967, in miners, working at a depth of 4 160-4 800 metres), Nagasaka T. et al. (1967, under high altitude conditions and in a low pressure chamber), Hill D. W. (1966, paediatrics and neonatology), Müller C. (1965), Ueda H. et al. (1964), Fabris F. et al. (1964, under the conditions of surgery department), Straneo G. et al. (1963), Furman K. et al. (1963), Winsor T. et al. (1961), Tatoyan S. Kh. (1971)
Electromyography	Moore M. L. et al. (1963), Kuck A. et al. (1963), George R. et al. (1967, of uterine muscles); Simmons K. (1965), Murooka H. et al. (1966)

4.1. Aerospace Biotelemetry

This day was worth living the whole life.
V. V. Parin, 12.04.1961

On-board biotelemetry became a special scientific field in the middle of the 20th century. It was characterized by the location of a subject and a transmitter on board of some object (aircraft, spaceship), moving at a great speed at a significant distance from a researcher and a receiving device. It is natural that this scientific field found its application, at first, primarily, in space medicine.

One of the first experiments of a pilot's ECG telemetry, in particular, was performed in Switzerland in 1952 involving G. B. Smith and L. E. Lamb. The year after, in the USA not only heart signals, but also electroencephalograms, respiration rate and body temperature were transmitted from aboard of aircrafts (Parin, 1971). Approximately in 1953 the electrocardiosignal biotelemetry of pilots of the *De Havilland DH.100 Vampire* jet fighter, manufactured in the UK, was performed by R. Glatt. Sensory data were transmitted by means of special device to a land receiving station through a standard airborne radio station. ECG was telemetered in several leads. The system provided qualitative and jam-resistant data transmission. Onwards it was suggested to use the system for cardio-physiological control in airspace medicine (Glatt R., 1953; Glatt R. et al., 1953).

In the 1960s biotelemetry became one of the major diagnostic techniques in airspace medicine. A large number of scientists conducted distant study of physiological parameters on civil (Hoffmann H., 1967; Judica-Cordiglia A. 1967; Litovchenko V. et al. 1981; Nevison T. O. Jr. 1968) and military (Bratt H., Kuramoto M., 1963; Helvey W. et al., 1964) pilots, including haemodynamic (Deangelis A., 1965; Ware R., Kahn A. 1963), respiratory (Bartlett R. G. Jr., 1963), and central nervous system parameters (Simons D., Prather W. 1964; Simons D., 1962).

A series of papers deserve special mentioning. They are dedicated to pilots' electroencephalogram telemetry performed by a team of the National Company "Air France" Medical department headed by Claude J. Blanc (Blank et al., 1966; 1967 a) b).

Physiological parameters of a human body at the time of parachute jumps were studied separately. For instance, P. Gauthier et al. (1977, 1980) conducted telemetry of pulse rate and electroencephalogram on parajumpers before, during and after jumps from the 3 500 m height. Alpha rhythm was recorded separately during a free fall and maintenance phase; deviations from physiological standards were not registered.

Dr Adolf R. Marko contributed decisively to airspace biotelemetry in the USA. He was born in Austria, but moved to USA after graduation from a college in Vienna and headed the department of medical electronics in the Aerospace Medical Research Laboratories for several years. In the period 1961-1969 under his supervision, multiline individual biotelemetry systems were developed, recording remotely pulse and respiratory rate and body temperature. Over a few years the system "grew up" to an eight-channel system, and the range of recorded physiological parameters was enlarged accordingly (Marko A., 1961; Marko et al., 1963; Ration D. et al., 1969).



Fig. 4.3 Norman Lee Barr

In 1956-1961, biotelemetry was successfully applied in the USA in the *Strato Lab* program of stratosphere flights, preceding manned space missions. Captain Norman Lee Barr (Fig. 4.3) developed biotelemetry system to control physiological reactions, heart function and respiration. Initially, it was tested for distant control of physiological parameters during a regular workload (Fig. 4.4) (Research aviation medicine, 1957). During the first *Strato Lab* stratostat flight on August 10, 1956 the physiological data of the pilots Malcolm D. Ross and Morton L. Lewis were recorded. The information was sent to a transmitter located on an escort aircraft (Fig. 4.5-4.10) (Research aviation medicine, 1957; Herman J., 1998).



Fig. 4.4. Barr's biotelemetry system testing: installation of the transmitter, ECG transmission over the radio during workload, distant registration of pulse rate and ECG



Fig. 4.5. "Strato Lab-1" crew M.. Ross and M. Lewis (United Press Telephoto)



Fig. 4.6. Electrode fixing for ECG biotelemetry, August 10, 1956



Fig. 4.7. Indicators on the body of the crew member



Fig. 4.8. Officer P. Gustafson is fixing electrodes on the body of M. Ross



Fig. 4.9. N. Barr and P. Gustafson studying the telemetry results



Fig. 4.10. Technicians are checking the equipment

According to Victor G. Benson and R. D. Squires (1962), on May 4, 1961 during the fifth flight of *Strato Lab* the biotelemetry of the crew members M. D. Ross and V. G. A. Prather was conducted: "The complete biometry system is used in both subjects of the study for the transmission of physiological information to the medical monitoring team... According to the biotelemetry results and voice communication it can be concluded that sufficient qualities of the flight scaphander were demonstrated during the flight...". During the flight the following data were telemetered: EEG, ECG, pulse and respiration rate as well as temperature from different points on the body (Fig. 4.11-4.13) (Bachmann, 2015; Kamp A., Aitink J., 1893).



Fig. 4.11. Strato Lab-5 crew: V. G. Prather and M. Ross (press conference before the flight, Associated Press Photo)



Fig. 4.12. The crew wearing flight scaphanders equipped with biotelemetry system in the stratostat nacelle



Fig. 4.13. Biotelemetry system receiving device installed on board the aircraft

Each crew member had an individual transmitter, sending signals simultaneously to three transmitters. There were six transmitters in total in the system, located "on land, at sea and in the air". So, maximum noise immunity and duplicating of biotelemetry system were achieved. The findings were received from the transmitters by the medical monitoring team consisting of military Dr Captain Carl E. Pruett (Fig. 4.14) and Dr Seymour Stein, located on a naval vessel. *Strato Lab-5* crew set a new



Fig. 4.14 Carl E. Pruett

world record, having reached 34 668 m height. The flight took 9 hours 54 minutes. Unfortunately, the flight ended tragically after a successful water landing, but during the helicopter evacuation V. Prather accidentally died.

In addition, it should be pointed out that the Bio-Science Officer of the medical monitoring team Captain Carl E. Pruett, developed an innovative hospital electronic device for patient's monitoring in 1963 (Pruett et al., 1958). Biotelemetry systems for manned space-flights were designed based on the devices of Dr. Barr which were tested during *Strato Lab* flights.

The important episode in U.S. airspace telemedicine was the use of biotelemetry during the testing of the experimental rocket plane under the X-15 program. For 40 years it was the only piloted hypersonic aircraft, which took to suborbital manned space flights. A pilot officer Burt Rowen (Fig. 4.15) controlled the development of medical and biotelemetry systems of the program. On a real time basis 8 parameters – pulse, respiration rate, temperature, ECG, atmospheric pressure in a helmet and under a one-piece flight-suit, from 4 locations on the pilot's body were transmitted over a radio channel to the Earth observation station. In parallel, the data were recorded by the equipment located on board. Miniature equipment was installed in the pilot's flight suit (Rowen B., 1962; Rowen B. et al., 1959).



Fig. 4.15. Burt Rowen

This biotelemetry system was used for the first time ever during the flight 1-6-11 on May 6, 1960 by pilot Robert Michael White. After a while, the equipment was improved. The Hughes Aircraft Company developed *Bendix TATP-350*, a miniature dynamic FM-FM telemetry system, which enabled to carry out totally wireless transmission of physiological parameters (primarily ECG), pressure differentials and aircraft speed-up indicators.

The system was preliminary tested during parachute jumping. This development was widely used on X-15 aircraft in 1962. With the technological advance, the appearance of new requirements for the size and monitoring characteristics, flight conditions and land testing, the biotelemetry system was altered and improved several times.

No doubt, the milestone stage of telemedicine development in the 20th century was the establishing of space bioradiotelemetry, which considerably influenced medical engineering, physiology, clinical medicine and healthcare system organization. As far back as in the late 1940s, in the USSR and the USA, large-scale studies were held as a part of space programs, which resulted in the appearance of a new scientific and practical field - biotelemetry (bioradiotelemetry).

Academician Vasilii V. Parin, one of the pioneers of space medicine, defined three periods in the history of space bioradiotelemetry (BRTM) development:

1. Application of bioradiotelemetry for the purpose of biological exploration of the outer space (animal experiments);
2. BRTM application for medical supervision in the course of the first manned space-flights;
3. BRTM application for a wide-range study of space-flight factors influencing the human body.

The development and establishment of space bioradiotelemetry is foremost connected with names of Vasilii V. Parin (Parin V., 1971, 2016; Parin et al., 1966), Vladimir I. Yazdovskyy (1966; 2015; Yazdovskyy, Bayevskyy, 1962), Oleg G. Gazenko (Gazenko et al., 1976; Gazenko, Malashekov D., 1996; Volynkin Yu. et al., 1962), Ivan T. Akulinichev (Akulinichev et al., 1964, 1966), Roman M. Baevskyy (2005) (Fig. 4.16-4.20).



Fig. 4.16. Vasilii V. Parin



Fig. 4.17. Vladimir I. Yazdovskyy



Fig. 4.18. Oleg G. Gazenko



Fig. 4.19. Ivan T. Akulinichev



Fig. 4.20. Roman M. Bayevskiy



Fig. 4.21. Oleg G. Gazenko with the first biological space explorer

In the USSR the development, design and application of medical control systems (MCS) for animal flights were performed from 1948 to 1961 under the supervision of Vladimir I. Yazdovskiy (Gurovskiy N., Egorov A., 1981). The recording of animal physiological functions and the information transmission from onboard a spaceship to the Earth were performed, for the first time ever, on November 3, 1957 during the flight of the second artificial satellite with the dog Layka on board. Blood pressure, ECG, pneumogram, blood pressure in femoral artery by the direct method and motor activity were registered. Later on, animal body temperature, EMG, sphygmograms were also telemetered.

The main result in MCS application during orbital flights was the evidence of possible sustainability of animal life in space and the absence of threatening alterations in their functional status (Fig. 4.21-4.22) (Akulinichev et al., 1964, 1966; Bednenko V., 2001; Parin. V., 1971; (Gazenko et al., 1976; Gazenko, Malashekov D., 1996; Volynkin Yu. et al., 1962; Space medicine and biology, 1978; Parin V. 1971; Parin et al. 1966; Preliminary results of the research with the help of the first Soviet artificial earth satellites and rockets, 1958; Ivanov A., 1975; Yazdovskiy V., 1966; 2015; Yazdovskiy, Bayevskiy, 1962).

MCS development for manned space-flight was carried out in the beginning of the 1960s by operative medical supervision laboratory, headed by I. T. Akulinichev, which was a part of space physiology department supervised by O. G. Gazenko. R. V. Bayevskiy, B. G. Buylov, M. D. Venttsel, V. A. Degtyaryov, K. P. Zazykin, A. D. Egorov, M. D. Emelianov, A. M. Zhdanov, A. N. Kozlov, Yu. A. Kukushkin, D. G. Maksimov, V. I. Polyakov, I. I. Popov, V. N. Ragozin, I. S. Shchadrintsev, V. K. Filosofov, N. A. Chekhonadskiy, V. A. Chichkin, K. K. Shcherbakov worked successfully on the solution of this task.

During the first manned space-flights of Yuri A. Gagarin and German S. Titov, dynamic pulse and respiration medical supervision was performed, for which purpose the ECG and pneumogram were transmitted over the telemetry channels. In addition, the mechanical work of the heart was also recorded. For operative medical supervision the acoustic signals, corresponding to pulse rate, were sent out continuously over "Signal" short-wave transmitter (Fig. 4.23-4.25) (ibid).



Fig. 4.22. B. Bundov and A. Prutskey checking on-board physiological equipment



Fig 4.23. Medical examination of Yuri Gagarin by I. T. Akulinichev, A. R. Kotovskaya and F. D. Gorbov, April 11, 1961

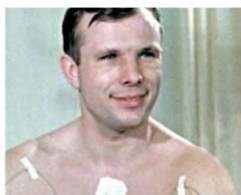


Fig 4.24. Y. Gagarin (1934-1968), the first cosmonaut before first manned-space flight April 12, 1961, www.federalspace.ru/main.php?id=342&did=1370

It is worth citing part of Academician V. V. Parin's speech on April 15, 1961 (Morning of a new era, 1961): "Continuous monitoring of Yuri A. Gagarin's health condition was being performed during his entire flight. Apart from the messages about his state of health, transmitted by him over the radio, physicians and physiologists were watching the pulse and respiration rate of the first human in space by means of radiotelemetry systems. Great experience gained by telemetry, a new scientific field, which combined the latest achievements of medicine and radio electronics, started serving humanity on April 12, 1961... Simple and comfortable transducer units were installed into a cosmonaut one-piece suit, which was able to

convert physiological parameters: heart bioelectric currents, vascular wall sphygmic vibrations, chest respiratory movements into electric signals. Special amplifying and measuring systems provided impulse generation to radio channels, which characterized respiration and blood circulation at every flight stage..."



Fig. 4.25. The results of biotelemetry during G. S. Titov's flight

During the first manned-space flights on the *Vostok* spaceship, "Vega-A" sets were used (weight 4 kg, energy consumption 5W), containing three similar ECG amplifiers, a respiratory channel amplifier and an electrocardiophone.

The latter was intended for continual pulse signal transmission to the Earth over the channel of the "Signal" on-board radio-transmitter. The registration of ECG and pneumogram (PG) of Gagarin as well as the kinetocardiogram of G. S. Titov were performed intermittently, by means of radio telemetry system (Fig. 4.25). In addition, on-board magnetic recorders were used. Electrodes, intended for ECG and pulse rate registration were stuck to Gagarin's body by an adhesive; while on Titov they were fixed by a chest bandage. This fixation system provided reliable registration of physiological parameters. When analysing telemonitoring data, the most advanced mathematical methods were applied (ibid).

Later on, the list of telemetry indicators was enlarged:

- On August 11-15, 1962 - during the first several days-long team flight: electroencephalogram (EEG), electrooculogram (EOG), electrocutaneous reaction (ECR) were registered;

- On June 12-15, 1963 - during the second several days-long team flight: seismic cardiogram, transmitted over the same channel as EOG, was telemetered for first time ever;
- During the first man's extravehicular activity, on March 18, 1965 by cosmonaut Aleksey A. Leonov, ECG, seismic cardiogram and PG were telemetered.

That is how space biotelemetry is described by I. T. Akulinichev and co-workers (Akulinichev I. et al., 1964, 1966): "Biotelemetry control during multiple days flights of the Soviet cosmonauts was based on both continual presence of all the transducers and electrodes on the cosmonaut during the entire flight and on the automatic control of the on-board equipment set. During these flights physiological and hygienic measurements were completed with video surveillance, radio communication and control of a range of physical parameters..."

During the flights of *Vostok 5* and *Vostok-6* spaceships "the transducers and electrodes were fixed partly in special chest bandage and in the helmet ... Electrodes for EOG registration were placed at the outer corners of both eyes and connected with the amplifier circuit via conductors with button terminals. Electrodes for skin-galvanic reaction examination were fixed on feet... The transmission method of two physiological parameters over single radio-telemetry channel is of great interest. Without compromising the measurement quality, the EOG and seismic cardiogram recordings were combined... An amplifying device consisted of 5 amplifiers, which were mounted on the spaceships and two preliminary amplifiers for EOG and EEG were located in the scaphander. There was also a special device - an electro-cardiophone for square-wave pulse formation, which corresponded to the heart rhythm. An electro-cardiophone was controlled by the heart biopotentials... The physiological information was transmitted to the Earth via an on-board radiotelemetry system whilst the spaceship was flying over the receiving stations... The continual pulse rate transmission was conducted by the "Signal" transmitter in the form of sound signals, corresponding to square-wave pulses, formed with the help of electro-cardiophone. During the descent phase all physiological information was recorded on a special on-board self-recorder". In summary, it should be stated, that during the first space flights the following telemetry was carried out: electrocardiogram, electromyogram, electroencephalogram, electrooculogram, pneumogram, actinogram, phonocardiogram, sphygmogram, kinetocardiogram, seismic cardiogram, arterial oscillogram, body temperature, electrocutaneous reaction, blood pressure, air humidity and temperature, oxygen and carbon content (Fig. 4.26).



Fig. 4.26. Academician Oleg G. Gazenko at the doctor's stand at the Spaceflight Medical Support Control Centre (1970s)

Fig. 4.27. Medical examination during the space flight (cosmonauts V. V. Ryumin and V. A. Lyakhov, 1979)



In 1961 it was possible to classify physiological changes under space flight conditions, according to the task defined either as "medical supervision" or "medical research", henceforth to distinguish functionally the independent systems for every task (Fig. 4.27).

The concept of physiological measurement information system was formulated, including (ibid):

- Source of information (a human or an animal);
- Transducers and electrodes;
- On-board amplifying equipment;
- Radiotelemetry devices;
- Communication and television systems;
- Devices for data recording and presentation on Earth;
- Information receiver (a doctor, a researcher).

First functionally independent Medical Control Systems (MCS) and Medical Research System (MRS) were developed under supervision of I. T. Akulinichev in 1964 for the flight of the *Voskhod-1* crew, consisting of V. M. Komarov, K. P. Feoktistov and first space physician B. B. Egorov (Fig. 4.28) To provide medical supervision of the crew members the "Vega-3" device was used (weight 5 kg, energy consumption 3W). With the help of "Vega-3" ECG, PG and SCG were recorded during the flight. The pulse and respiratory rate signals were transmitted via radio communication line by means of electro-cardiophone. Medical research was carried out by the space physician using the "Polinom" device, a prototype of the future well-known "Polinom-2M" device. "Polinom" allowed recording ECG, EOG, dynamogram and motion coordination indicators. Also, with the participation of B. B. Egorov, R. M. Bayevskiy and D. G. Maksimov telemetry analysis of motor action by means of special recoding machine was performed.

In 1967-1971, during the flight testing and system development of the *Soyuz* spaceships, the on-board MCS provided the recording of ECG, SCG, PG and heart rate throughout the flight. The heart rate and body temperature during spacecraft-to-spacecraft transfer were recorded too. All data were transmitted to Earth via the telemetry systems. The MRS consisted of the "Rezeda" device with a set of dropping glasses for external



Fig. 4.28. Boris B. Egorov (1937-1994), Professor, the first space physician (*Voskhod-1* "spaceship flight in 1964) Photo by Yu. Ustinov, artist D. Zuskov



Fig. 4.29. The space flights operative medical backup at the premises of the Institute of Biomedical Problems; (USSR, 1963-1973) (*Istoriya IMBP v fotografiiakh*, 2008)

respiration and energy expenditure study, blood pressure sensor, etc. (Fig. 4.29) (ibid).

MCS for flight support up to 20 days were under development since 1963 with the active participation of K. P. Zazykin, R. M. Bayevskiy, D. G. Maksimov, A. E. Bankov, Yu. A. Kukushkin and others. Later on, MCS were upgraded and improved multiple times. Between 1980 and 1990, Ultra Sonic Testing was added to space diagnostic techniques such as the "Argument A-1/01" device, which allowed transmitting ultrasonic images to the Earth by means of visual communication. "I have been practising for an hour searching for mitral valves, aorta and ventricle by "Argument" transducers to transmit qualified picture of the heart via video communications during communication session at once" cosmonaut V. Lebedev wrote in his diary. In this period biotelemetry included recording of the following parameters: ECG, PG, SCG, kinetocardiography, sphygmography (pulse-curve registration of femoral, radial and carotid arteries), tachoscillography (for measurement of blood pressure indicators), phlebography (for pulse-curve of jugular vein recording and venous blood pressure detecting), rheography (for stroke volume and cardiac minute output and pulse blood filling of different parts of body), body weight measurement, calf volume, blood sampling, external respiration study, microbiological study, and also water-salt metabolism examination, etc. (Gurovskiy N., Egorov A., 1981).

Taking into account an increasing volume of physiological information, coming via telemetry systems, the idea of its automated processing emerged, including the use of an on-board equipment set.



Fig. 4.30. Body temperature measurement with an intra-oral transducer (astronaut Jim Lovell, USA)

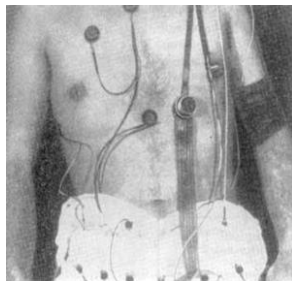


Fig. 4.31. Biosensors on the body of NASA astronaut (4 ECG biosensors on the chest, a device for blood pressure measurement and a microphone on the left arm; biosensor coordinating devices are placed in the astronaut's suit pockets)

The concept of the on-board automatic physiological data processing system (ADPS) was created. In the USA it was generated by McLennan in 1959 and Carbery in 1961. In the USSR the idea was shaped by V. V. Parin, R. M. Bayevskyy, O. G. Gazenko, K. K. Chernyshev, and V. A. Sharov in the beginning of 1960s till 1968.

In the USA research and development in the sphere of bioradiotelemetry were, in general, similarly performed. Generic methodology was studied; devices were designed, manufactured and practically approved both in clinical medicine and under space flight conditions (Medical and Biological Applications of Space Telemetry, 1965). The appropriate systems were

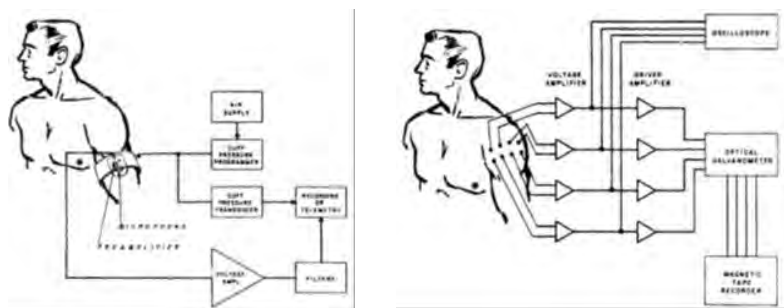


Fig. 4.32. NASA space monitoring system (Heim J., 1964)

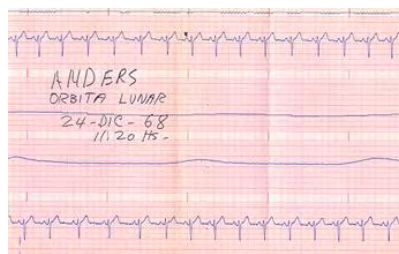


Fig. 4.33. NASA receiving biotelemetry equipment (Apollo-11), Dr J. A. Sullivan analyses the data on 16.07.1969, apollomissionphotos.com/index_org_people2.html. The first human's ECG transmitted from the Lunar orbit (24.12.1968) of the astronaut W. A. Anders medtropoli.tripod.com/imagenes/electroluna.htm

developed actively and improved during space flights of Gemini, Apollo and Discovery (Miller B., 1963). The telemetry study during the first U.S. space flights included: heart rate, ECG, oxygen and carbon dioxide concentration, space ship environment indicators. In addition, daily

individual teleconferences with a physician on Earth were conducted (Fig. 4.30-4.35) (Sharp M., 1970).



Fig. 4.34. NASA medical monitoring room; Dr J. F. Zieglschmid analysing biotelemetry data received from Apollo+16 space ship (the fifth moonfall), (18.04.1972, photo from JSC Digital Image Collection, images.jsc.nasa.gov)

Fig. 4.35. Compact biotelemetry transducer (Medical and Biological Applications of Space Telemetry, 1965)



It is notable that in 1962-1964, under NASA guidance, a three-volume work, "The Techniques of Physiological Monitoring" was prepared and published (Heim J., W., 1962), in which techniques and methods of monitoring and measuring different physiological parameters in an extreme environmental conditions, space flights included, were accurately described.

In 1968 an ECG signal was transmitted via biotelemetry from Lunar orbit to Earth (Fig. 4.33).

4.2. Biological Telemetry in Physiology and Sports Medicine

(contributing co-author O. N. Stadnik)

*When estimating a sportsman's training
status at the doctor's appointment,
which of us did not use to dream of
monitoring at least pulse rate just
during training at the stadium?
V. V. Rosenblat, 19967*

4.2.1. Key Accomplishments of Dynamic Biotelemetry

In the middle of the 20th century, physiology or more precisely the dynamic study of body reaction to external and internal physical, psychoemotional and other factors became a special sphere of biotelemetry application.

In 1953 L. Basan and I. Lovdzhiev (Sofia, Bulgaria) developed the procedure of radiotelemetry of physiological parameters on a human in motion and natural working environment. Initially the equipment allowed recording respiration duration, as well as respiration rate. By 1955, with improvement of the sequential system, the authors were able to perform telemetry of such indicators as respiration rate, air volume during respiration, inhalation duration, respiratory pause and air discharge (Fig. 4.36) (Basan L., Lovdzhiev I., 1958).

The equipment operating principle consisted in conversion of air flow vibration into electrical oscillation with the help of frequency modulation of transducer radio wave, which changed its frequency following the respiratory phases. There were several models of transducers: a small one - transmitting distance up to 150 m, dimensions 15x12x4 cm, weight 900 g and a big one - transmitting distance up to 60 km, dimensions 26x18x16 cm, weight 3 kg. This biotelemetry system was used in sports medicine and occupational physiology (ibid).

In the late 1950s, Electronic Engineer Lev P. Shuvatov (USSR) developed an ingenious set of biotelemetry devices for application in physiology. They gave the possibility to study physiological parameters under dynamic



*Fig. 4.36. Radio biotelemetry
system for respiratory function
study, Bulgaria, 1953-1955*

conditions, such as at sport and occupational loading. This work was highly appreciated by Academician and outstanding physiologist P. K. Anokhin, though later it faced definite criticism on the part of engineers and radio electronics specialists. The following biotelemetry systems were developed by L. P. Shuvatov (Shuvatov L., 1959; Shuvatov L. P., Ermakov V., 1965):

- 1-channel - for respiratory rate;
- 2-channel - for respiratory and pulse rate;
- 6-channel - for body temperature, respiratory and pulse rate, muscle and brain biocurrents, arterial oxygen saturation extent.

The weight of the above transmitting equipment was 55-70 g. The single-channel system could be used in the gym or stadium in the absence of direct obstacles between the transducers and receiving set, while the multi-channel systems could be used under any conditions. In terms of engineering, the systems took the form of a "telemetry helmet", which did not restrain the subject, even under conditions of intensive physical exercise (Fig. 4.37-4.39) (ibid).

At the beginning of the 60s L. P. Shuvatov published a monograph about his developments in biotelemetry, which contained further description of designs, calculations and application procedures for the relevant systems (Shuvatov L. P., Ermakov V., 1965).

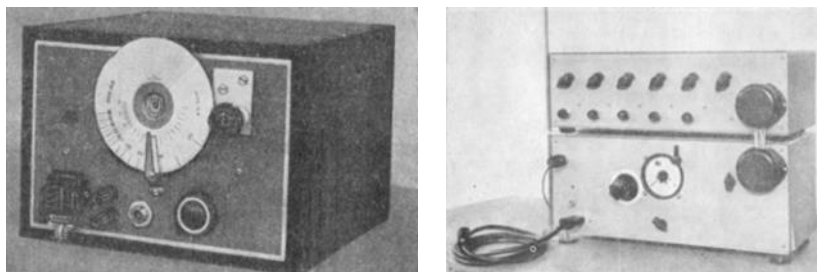


Fig. 4.37. The receivers of single- and two-channel biotelemetry system (left) and of a six-channel biotelemetry system (right)

In the 1960-1970s, a wide range of scientists from all parts of the world, used such dynamic systems as instruments for studying human physiology under physical efforts, for the arrangement of optimum training regime and sports practice (S. P. Sarychev, B. V. Panin, L. P. Shuvatov, K. D. Rose (Rose K., Dunn F., 1964), J. S. Hanson (skiers, Hanson J., Tabakin B., 1964), R. Blake (basketball players), J. R. Hughes (tele-ECG of football players during matches, Hughes J., Hendrix D., 1968).

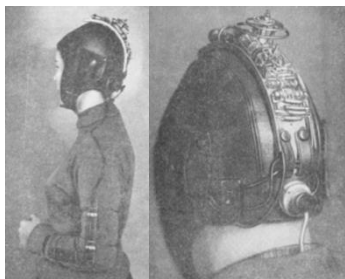


Fig. 4.38. External view of six-channel biotelemetry system and mechanogram sensor location and radio helmet



Fig. 4.39. Transmitter of 2-channel biotelemetry system (outer lid of the device is removed)

In 1960, T. E. Timofeeva and V. A. Antselevich (1960) (All-Union Scientific-Research Institute for Medical Instruments and Equipment, Moscow, Russia) developed a telemetry electrocardiograph designed for physiological studies in sports, occupational medicine, and during functional testing.

"The receiving and transmitting devices... represent a line of one-way radio communication with wavelength of about 2 m. The transmitting device contains an amplifier of bioelectric potentials, being frequency modulator of demand pulse generator. Frequency-modulated square-wave pulses are transmitted over the radio... The receiving device ... is a superheterodyne radio receiver..., which contains amplitude demodulator and frequency-discrimination circuit at the intermediate frequency amplifier output. The square-wave pulses transmitted over the radio are gated at the amplitude demodulator output..., then a useful signal, for instance ECG, is gated from these pulses" (Parin V., 1971).

The received signal was recorded on a photo film or photosensitive paper. All transducer units, apart from the storage batteries, were placed in a light duraluminum helmet weighing 500 g. The batteries were fixed to the back of the subject by means of two rubber slings, their weight being 350 g. Radius of the system action was 300-500 m (Fig. 4.40-4.42) (Timofeeva T., Atselevich V., 1960).



Fig. 4.40. TEK-1 telecardiograph - transmitter



Fig. 4.41. TEK-1 telecardiograph - receiver



Fig. 4.42 TEK-1 telecardiograph advertisement in the journal "Novosti meditsinskoy tekhniki", 1960

The device called "Telecardiograph" was tested and approved at the Central Research and Development Institute of Physical Education and V. A. Obukh Institute of Occupational Hygiene and Occupational Pathology (ibid). Telemetry of 2-lead ECG was performed according to W. Nehba on sportsmen (Matov V., 1960). The device was also tested on workers during machine operation on shopfloors. A Moscow Plant of Electromedical Equipment started serial production of TEK-1 teleradiograph (Timofeeva T., Atselevich V., 1960).

In 1966 Engineer A. B. Goodwin and Dr Gordon R. Cumming with the participation of Walter Jones (Manitoba University, Winnipeg, Canada) developed a method for radio-telemetry of cardiovascular parameters of water-polo players. The issues of a waterproof transmitter and appropriate "sensor-skin" contact in underwater conditions linked to intensive motor activity were technically solved. The best points for electrode fixing were specified on the body (Fig. 4.43) (Goodwin A., Cumming G., 1966).

The system was successfully tested on 8 juvenile sportsmen during exercise performance of different types, training and usual games (water polo tournament). Simultaneously, the oxygen uptake was measured by

telemetry (using Douglas bag). Later, the correlations between the obtained data were studied, different derivative criteria were calculated, recommendations concerning the further training regime were stated on the basis of the received information.

A. B. Goodwin wrote (ibid): "The elements of suspense and surprise can never be taken away from athletic competition, but the training of athletes is losing its aura of mystery. Development of techniques to measure accurately physiologic demands of athletic events will help in the development of new methods of athletic training, and in the assessment of the conditioning programs".

In London (U.K.) in 1967, J. Joseph and Richard Watson used biotelemetry of electromyogram simultaneously with video recording of walking to study the sequential work of different muscles when ascending and descending stairs (Fig. 4.44) (Joseph J., Watson R., 1967).

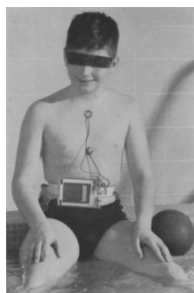


Fig. 4.43. An examined water polo player with radio-telemetry system, Canada, 1966



Fig. 4.44. Biotelemetry of electromyographic system for walking, UK 1967

In 1967 and 1968 in Leningrad (USSR) at the State North-Western Correspondence Technical Institute several radio-biotelemetry systems for physiology and sports medicine were developed. Professor Vladimir M. Akhutin, head of the Institute biomedical cybernetics laboratory, played a special role in this process (Electronics & Fitness, 1968) (Fig. 4.45). The team under his supervision, together with L. B. Stein, E. M. Bogdanovskyy, B. F. Shkapina, N. L. Ozemkova, L. F. Saydakovskyy, worked out bioradiotelemetry systems for distant control of cardiovascular parameters and ECG.

At the beginning, an original automatic pulse rate meter, weighing 300-750 g was used. The peculiarity of this device was the availability of an individual indicator for each subject. When the allowed (predefined) pulse rate was exceeded, an alarm was started. Thus not only distant control, but also self-control was implemented.

Professor Akhutin combined biotelemetry and computerized telediagnosis for ECG control. The receiving equipment was a small-size computer machine with the software for automatic ECG analysis. Therefore, the team created the opportunity not only to accumulate well defined information for further analysis, but also to interpret the changes in physiological parameters of the subject on a real time basis (Akhutin V. et al., 1968 a), b).



Fig. 4.45. Vladimir M. Akhutin

One more team from the above Institute (E. I. Leshchinskaya, M. I. Shif, A. G. Pakhomov, A. G. Kolesnikov, R. F. Kondratiev) developed and implemented biotelemetry system to control the "respiratory parameters", i.e. respiratory volumes, speed of air flow at inhaling and exhaling, chest and diaphragm breathing rate. The information could be transmitted over the radio or cable depending upon individual requirements and conditions. The most outstanding fact was the use of this development for respiratory function telemetry in divers, who worked at a depth of 300 m (Leshchinskaya E. et al., 1968).

In 1968 at the Institute of Biophysics of the USSR Academy of Sciences (Moscow) the team under supervision of T. D. Vais developed an 8-channel bioradiotelemetry system, which allowed distant recording of articular movements, directional physical exercise, respiratory chest vibration, electrocardio- and myograms, body temperature. The weight of the transmission unit was 350 g, radius of action being 300 m. The system was intended for physiological studies in sports and occupational activities (Parin V., 1971).

The sporting biotelemetry system, which was developed in the described period in Lvov, Ukraine, should be highlighted, too. In 1968 professor Vladimir S. Keller (Fig. 4.46) in partnership with L. G. Pelensky, T. I. Sinyavsky, G. B. Safronova created the



Fig. 4.46. Vladimir S. Keller

"Opyt", 4-channel radiobiotelemetry system for:

- Distant recording of any of four optional data types - electrocardiograms (up to 3 leads), electromyograms (up to 2 channels), respiratory rate and skin temperature;
- Visual indication of breathing process by pointer instrument;
- Audio and visual indication of pulse strokes by electrocardiographic wave;
- Measurement of total pulse stroke count over the working period and current value of the pulse rate.

This equipment provided steady telemetry of biological information over a distance of 150-200 m and wweight 800 g (Keller V. et al., 1968).

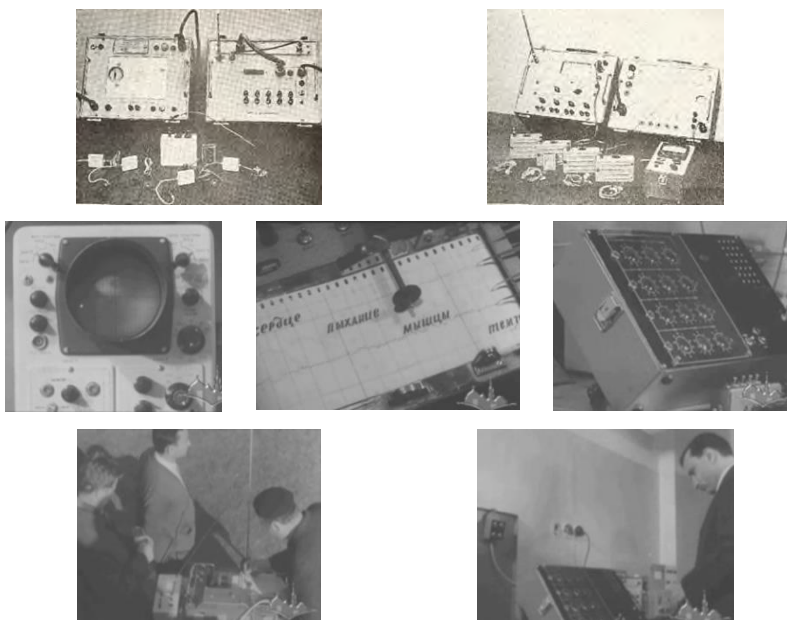


Fig. 4.47. Bioradiotelemetry systems of V. Keller "Opyt" and "Sport". Illustrations from film magazine "Radyanskiy Sport" №4 1968 (resource - Centre of city history of the Central- Eastern Europe (www.lvivcenter.org), the Central State Non-Print Media Archive Facility of Ukraine)

Based on the gained experience, a "Sport" bioradiotelemetry system was developed, which provided simultaneous transmission and receiving of one physiological parameter from four unrestrained subjects or four parameters via four transmitting components from one subject. The radius of action of this equipment was up to 150 m; transducer weight was 200 g; ECG, EMG,

respiratory and pulse rates were telemetered (Fig. 4.47) (ibid). It is quite remarkable that the authors' team headed by V. S. Keller conducted a comparative study on the diagnostic value of information transmitted by means of telemetry and received at similar fixed medical devices. Informational content adequacy of the transmitted body parameters was stated. In the process of further testing, possible problems and their solutions were discovered. The methods of appropriate usage of biotelemetry depending on the kind of sports were also determined. The system was positively evaluated and successfully introduced, including the examination with the help of some sportsmen-fencers, football players and boxers.

Basing on the received information by means of telemetry system, Keller developed new approaches to appropriate training methods. He extended the research to an independent scientific level and introduced it in the system of scientific and methodological support of national team trainings (ibid). The system "Sport" underwent further changes and became the standard one in the system of PE teaching and Physiology of sport.

Table 4.2 lists some of radiobiotelemetry systems in the USSR, applied in sport studies in the late 1960s (Elektronika i sport, 1968).

Table 4.2 Some of the sporting radiotelemetry systems developed and used in the USSR in the late 1960s

Authors & city	Findings	System
V. A. Varlamov, A. V. Slyusarev, V. I. Karyukin (Moscow)	Alteration in the angle of speed and acceleration state in joints	The high frequency vibration producer, potentiometric bridge, receiving device with differentiator, power supply units. The carrying part was fixed to the back of the examined or could be placed in a pocket
A. K. Volkov (Leningrad/St. Petersburg)	Electromyogram (simultaneous recording from two leads)	Transistor receivers and receiving devices. Radius 500 m
Yu. L. Spiridonov (Ivanovo)	Cardiovascular rate	1-channel system with optimized receiving set

Yu. R. Medinets, V. D. Monogarov (1986) (Kiev)	Bioelectric current of myocardium, power components and "other physiological indicators"	2- and 8-channel systems with resistor sensors; weight 350 g and 800 g accordingly. 8- channel system was used only under the conditions of a stadium
V. A. Tsaun (Leningrad/St. Petersburg)	Cardiovascular rate	Radius 200 m with graphic recording, 500 m with audible reception. The system generated sound signal according to every heart contraction. Size of transmission unit 92x60x27 mm, weight 180 g, portable receiver - 148x88x34 mm, weight 200 g
O. V. Kolodiy, A. A. Konstantnov (Leningrad/St. Petersburg)	Dynamotelemetry	Strain gauges (working and compensatory) were stuck to the body of a sportsman, a small-size transducer (13 transistors, weight 540 g) were fixed to the waist. Recording device - superheterodyne with fixed setting. Synchronization of biotelemetry with filming of the training process. Tensiometric telemeasurement at hammer throwing; in the result - training system improvement

Around 1967, Prof. James R. Lott (North Texas University, USA) developed its own radio-pulsemetric system (Fig. 4.48). He tested the first prototype on his own son - a football player. Later, Lott carried out heart function study to determine the resistance to physical and psychic stress with the help of radiotelemetry on University sportsmen (in particular, on sprinters and long-distance runners) (Research Concerns Effects of Physical, Mental Strain, 1968).

The prototype only allowed performing pulse radiotelemetry. Later the equipment was improved with the possibility to register ECG and EEG with the tape recording or their printout (Fig. 4.49). Professor J. R. Lott also studied the pulse rate of the pianist, Stefan Bardas during a performance.

According to the radiopulsemetry during a two-hour concert the average pulse rate was 72, sometimes reaching 120. A pulse increasing up to 168 strokes per minute was twice recorded (ibid).

Lott stated that biotelemetry should be the most important tool in sports medicine and wrote: "I want to see the time, when all young athletes will be integrated to the biotelemetry monitoring system in the period of intensive interseasonal trainings" [(ibid).



Fig. 4.48. James R. Lott



Fig. 4.49. Professor Lott is fixing electrodes on a sportsman Roger Rodriguez (Texas, USA, 1968, The North Texas welcomes letters, www.unl.edu/northtexas/archives/s02/feedback.htm)

Around 1970, a Moscow team under the supervision of Yu. N. Kamenskiy developed and successfully used equipment set for telemetry research of external respiration in physiology, clinical and functional medicine. The equipment was tested and improved over a period of 6 years. More than 400 trials, including hypertension of 3-12 G, were conducted with the participation of 100 people. The amazing performance of the telemetry system was proven.

In 1973, specialists of the medical faculty of Kansas City University performed pulse radiometry on 20 sports fans, and found out that pronounced cardiac acceleration before the match was noticed on fans over 40 years old. However, during the match there was no difference between various age groups. This work was carried out by Professor Charles Corbin and Dr John Merriman and Dr Stanley Harris (Fig. 4.50-4.51) (Just how exciting can a basketball game be, 1973).



Fig. 4.50. Professor Charles Corbin

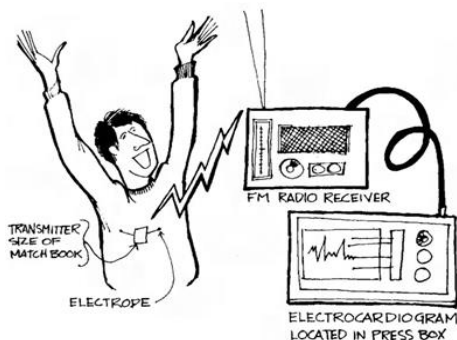


Fig. 4.51. Newspaper caricature illustrating the work of radiometry system in fans

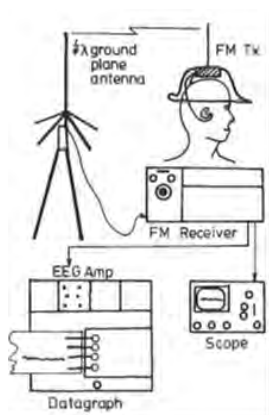


Fig. 4.52. Schematic diagram of sporting tele-ECG system, New Zealand, 1979

In 1979, in New Zealand, Don A. R. Smith and R. A. M. Gregson from the University of Canterbury used biotelemetry of EEC on skiers (Fig. 4.52) (Smith D., Gregson R., 1979). The "Biosentry" single-channel system was used. The transmission unit was placed in a special helmet, operating within a range up to 1200 m.

4.2.2. Sverdlovsk Bioradiotelemetry Group

Professor Vladimir V. Rosenblat, who organized and headed the Sverdlovsk Bioradiotelemetry group (Sverdlovsk/Ekaterinburg, Russia), played an important role in the start up of dynamic biotelemetry, including sports biotelemetry, in the middle of the 20th century. It should be pointed out that the first biotelemetry experiments in Sverdlovsk were performed by Vasilii I. Patrushev (Fig. 4.53), Director of Ural branch of Russian Academy of Sciences. Using a radiotelemetry system, i.e. a receiver, a transmission unit, a heart bioelectric current amplifier, created by Lev S. Dombrovskyy, an electrical engineer and radio amateur, an attempt to record ECG of a running horse was made.

In 1947, the same system was applied for a transmission of human ECG (of Dombrovskyy). Unfortunately the quality of the transmission was very low. In 1948, Professor V. I. Patrushev was removed from his post of Director and the biotelemetry experiments were stopped. Only in 1955, L. S. Dombrovskyy began collaborating with Vladimir V. Rosenblat, who at that time was an employee of the Sverdlovsk Municipal Medical Dispensary of Physical Education (Fig. 4.54). A new team, together with radio technician Georgiy L. Karmanov, created a radiopulsephone, which on April 29, 1957 for the first time ever allowed recording over the radio the heart rate of an ice-skater during the training on rollers. This was the pulse of Ivan V. Zykov, an outstanding sportsman and a famous coach. The device was described in a journal, won the first prize at the regional radio exhibition in May 1957, and afterwards it became an exhibit of the A. S. Popov Museum of the Radio in Ekaterinburg.



Fig. 4.53 Vasilii I. Patrushev

Using the first model, V. V. Rosenblat and L. S. Dombrovskyy studied the pulse of several sportsmen in a stadium, but the device was technically unreliable. In 1958, a new transistor model was designed. The weight of the device was reduced from 1300 g to 350 g, and the operating range was considerably enlarged. On January 20 of the same year, a successful biotelemetry of sportsmen during regular competition was performed.

The next model was created in 1969 with the participation of the engineer R. V. Unzhin, E. I. Rimskikh, V. M. Forshtadt and others. Unzhin designed a range of basic transistor circuits. The device was a multipurpose combined indicator ("KRP"), weighing 150 g, including the miniature storage battery. Pulse and respiratory rates were telemetered. Unzhin succeeded in developing a special amplifier, which enabled to telemeter

ECG (Dombrovskyy L., 1973; 1974; Pamyati Vladimira Viktorovicha Rosenblata, 2000; Parin V., 1963; Rimskikh E. et al., 1974; Rosenblat V., 1967; 1974; 1976; 1989; 2015; Rosenblat V. et al., 1979).

Here is the description of pulse telemetry given by Professor V. V. Rosenblat himself: "In the late 1950s, a group of enthusiasts, brought together by the author of this book (L. S. Dombrovskyy, G. L. Karmanov, R. V. Uzhin, A. T. Vorobiev, etc.), developed and began to widely use radiopulsemetry, i.e. the pulse rate measurement of an unrestrained human, which was conducted over the radio. Special electrodes were stuck to the chest of a sportsman or worker. An amplifier with a transmission unit was placed on a cap. The sportsman was a football player, the worker was felling trees, and a researcher, holding a portable radio receiver set in his hands, was counting the heart rate. In this case ECG was the signal source" (Rosenblat V., 1989).



Fig. 4.54. Vladimir V. Rosenblat

Working thoroughly on biotelemetry equipment, the group of Rosenblat was constantly upgrading the sensors. The experimental phase of the needle options application is well known. This episode is described in the book by V. Demidov "77 Electrical Feelings" (2012): "You know, Dombrovskyy told me, at that time Vorobyov and Rosenblat were all stuck with needles. The idea that it was all because of the high resistance of the skin crossed somebody's mind. So they stuck their arms with needles to get a good contact..." (ibid).

Thanks to the initiative and work of Vladimir V. Rosenblat, the so-called "Sverdlovsk Biotelemetry Group" was organized, which united two teams of enthusiasts under his supervision: the specialists in the field of radio electronics (L. S. Dombrovskyy, R. V. Uzhin, G. L. Karmanov, B. A. Katsnelson, B. D. Kedrov, K. M. Kozlovskyy, E. I. Rimskikh, V. M. Forshtadt, Ya. V. Freidin and others) and the representatives of biomedical field (Dr A. T. Vorobyov, Yu. G. Solonin, S. S. Gofman, B. M. Stolbun and others). The group was formed, mainly around two institutions - Sverdlovsk Municipal Medical Dispensary of Physical Education and Sverdlovsk Research and Development Institute of Industrial Hygiene and Occupational Pathology (ibid).

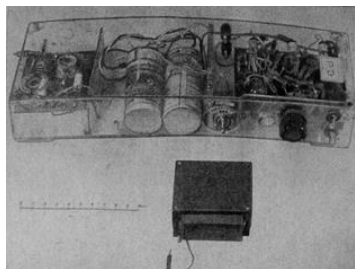


Fig. 4.55. Radiopulsephone (RP-1), radiopulsephone & electrocardiograph (REC-1)

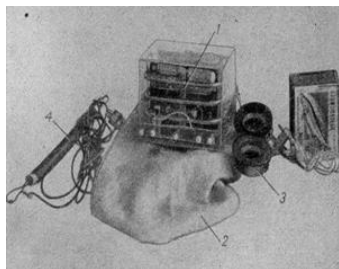


Fig. 4.56. Combined radiotelemetry device (CRD-1), fixed on cap-helmet

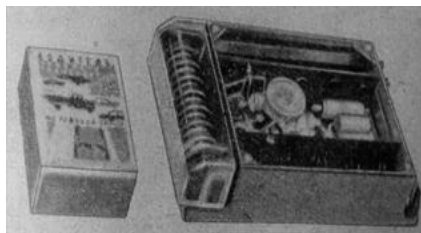


Fig. 4.57. Combined radiotelemetry device (CRD) with printed circuit

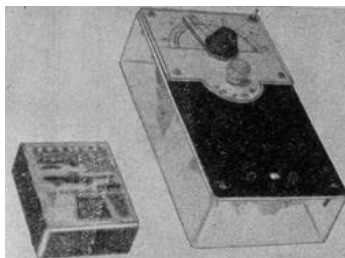


Fig. 4.58. Radio receiver set RL-7

Vladimir V. Rosenblat wrote about the work of the group: "In 1955-1964, attention was paid to the technique of radiotelemetry registration of pulse rate and heart bioelectric current. At the same time we were looking for the approach to the research of some indicators of external breathing and other functions. More than 50 devices, including 16 types of transmitting units, were developed over a period of 9 years" (Rosenblat V., 1967). It should be noted that optimal procedures of bioelectric current and biosignals were developed; unique sensors and transmission units were designed, specially intended for various operating conditions.

Table 4.3. and Fig. 4.55-4.58 provide information about basic radiotelemetry facilities developed by the group of V. V. Rosenblat.

It should be highlighted that CRD-2m and REC-1 were approved for industrial serial production in 1963 at Lvov Factory of Medical Equipment.

The Integrated decoder (ID) should be mentioned separately, as it was designed to record radiotelemetry data with the elements of automatic analysis (Fig. 4.59). The ID prototype was a semiconducting pulse rate meter, developed by L. S. Dombrovskyy in 1963. In general it was designed to work with CRD system, and the analysis of heart rate was also possible. It was a portable device sizing 360x200x160 mm and weighing 7.6 kg. A radio sphygmotachograph, a telemetry device for pulse wave velocity registration, and radio respirometer (RRM-1), which registered the basic parameters of external breathing were developed by V. M. Forshtadt and B. M. Stolbun (1964) on the basis of CRD-2M in 1963 (Dombrovskyy L., 1973; 1974; Pamyati Vladimira Viktorovicha Rosenblata, 2000; Parin V., 1963; Rimskikh E. et al., 1974; Rosenblat V., 1967; 1974; 1976; 1989; 2015; Rosenblat V. et al., 1979).



Fig. 4.59. The integrated decoder (ID)

Table 4.3 Basic information on key single-channel radiotelemetry systems developed under the supervision of Rosenblat (1954-1964)

Device	Physiological parameters	Patient's device	Researcher's device
Radio pulsephone (first model developed in 1955-1957) Leading engineer L. Dombrovskyy (Fig. 4.55)	Pulse rate	Several models were designed, practically used RP-1, 3a and 3b. RP-1: 200x100x40 mm, weight 1300 g (battery weight ~1000g), operating radius - 70-100 m, fixed on a back or on a waist; RP-3b weight 350 g, operating radius 70-100 m, fixed on a helmet; RP-3b (1959): previous characteristics, but the quality of signal transmission, stability and the running time	VHF-receiver of amplitude modulated signals; the aurally information receiving with pulse counting over a timer or graphic recording

		was greatly improved	
Radio pulmono-graph (1957-1959). Leading engineer - R. V. Unzhyn	Pneumogram	RPG-1, RPG-2. Resistance coal pulverulent transducer, total weight - 100 g, radius 70-100 m	VHF-receiver of moderate sensitivity with connected frequency counter; graphic recording
Radio pneumometer (1960)*	Respiratory rate	RPM-1, RPM-2 A face mask with valves-lockers, weight of transmitter unit 60 g	Radio receiver set Aural information receiving with respiratory rate count by a timer
Combined radiotelemetry devices (CRD) (Fig. 4.56-4.57)	Pulse rate, pneumogram and others	Several models, in practice CRD-1M, 2, 2M, 3 were used. CRD-5, silicon transistor model, was intended for use under HTHP conditions. Total weight -100-550 g, operating radius 30-100 m	VHF-amplitude-modulation receiver Later - specially designed portable transistor semiconducting radio receiver sets ("RL device" (Fig. 4.58), weight 200 g
Radio pulsephone-electrocardio~graph (REC) (February 1962) (Fig. 4.55)	Pulse rate, ECG	Several models, in practice REC-1, 3 were used. Total weight -120 g, operating radius 30-50 m	On the basis of APC-2, a modified vehicle radio set, graphic recording
Multi-purpose radiotelemetry device (MRD-1K 10)	10 parameters	Dimensions 170x100x50 mm, total weight 700 g	Similar to the previous; frequency counter-decoder

** was used in a range of research studies during respiratory rate counting in workers under factory conditions; also a radiorespirometer was developed, which differed by low measuring accuracy, but still usable for applied investigations*

Combined registration of bioelectric heart current and photoelectric digit plethysmogram over the radio was used for pulse wave speed determination under dynamic conditions. A device of RST-1 (radio sphygmotachograph) was used, which was the further development of CRD-2m, described above. Also, a multi-purpose modular radiotelemetry system (MMRS) was offered, which allowed performing synchronous registration of three parameters from those listed below to a distance up to 10 meters - ECG, phono-, kineto-, seismic cardiograms, sphygmograms, EMG, EEG, EOG, respiratory rate, actogram, contact sensor information. Later a new device version appeared in the form of a three-channel system with tape recording function (3BTS-M) (Parin V., 1971).

Between 1957-1964, the researchers of the Sverdlovsk Biotelemetry Group carried out more than 100 000 radiotelemetry supervisions over sportsmen, workers and patients (precisely at functional tests) (Fig. 4.60) (Dombrovskyy L., 1973; 1974; Pamyati Vladimira Viktorovicha Rosenblata, 2000; Parin V., 1963; Rimskikh E. et al., 1974; Rosenblat V., 1967; 1974; 1976; 1989; 2015; Rosenblat V. et al., 1979).

The team of Rosenblat was the first in the world to register a total ECG curve in skaters over the radio during competitions. A lot of sports doctors, coaches (L. M. Sanachev, in particular) and sportsmen took part in this research. On March 7-8, 1962, the first Winter Spartakiade of the Peoples of the USSR was held. Seven masters of sport, champions and record-holders of the USSR took part in the biotelemetry experiments. Two days before the competition V. V. Rosenblat and his team recorded 132 ECGs of sprinters and long-distance runners (Fig. 4.61).

After that, more than 3 000 heart operating cycles were deciphered and analysed. Two days later the information about the experiment appeared in the "Medical newspaper", and after a few days in the "New-York Times" (USA). Also, for the first time in the world, pulse rate (220 strokes per minute) of ski-jumpers during the jumping itself was recorded remotely. The following quantitative data of radiotelemetry usage in sports medicine by Rosenblat are known (Fig. 4.62-4.63) (ibid):



Fig. 4.60. Yan Kh. tiras (9(22).10.1914 -07.09.1976), an opera singer (baritone), lead singer of Sverdlovsk Opera and Ballet. The group of Rosenblat telemetered his ECG during the first performance on the stage after a myocardial infarction

- Observation on sportsmen during trainings: skating – 50, skiing – 2, ski-jumping – 6, track and field events – 3;
- Observation on sportsmen during competitions: skating – 28, track and field events – 7, table tennis – 5;
- Observation on elderly people: in the process of therapeutic physical training – 14, at functional tests – 4.

The investigations in weightlifting (A. T. Vorobyov, M. B. Kazakov, N. M. Khodakov, V. P. Khudorozhkov), in rhythmic-sportive gymnastics (R. N. Karelina) and in therapeutic physical training (F. M. Bakirova, A. P. Berseneva) are the most systemized data.

The monograph of Rosenblat "Radiotelemetry research in sports medicine" published in 1967 became a significant conceptual work. It summarized the methodology of "non-cosmic" dynamic biotelemetry in the middle of the 20th century and represented the basic physiological aspects of sports medicine. Thanks to to Rosenblat, Sverdlovsk became the so-called capital of biotelemetry. Four All-Union meetings of the specialists in this field were held there (1959, 1963, 1968 and 1976).



Fig. 4.61. Valentina S. Stenina (29.12.1934), an ice-skater, World champion, multiple champion of the USSR. The team telemetered repeatedly her physiological parameters during her trainings and competitions



Fig. 4.62. Radiotelemetry investigation of heart rate in sportsmen during ski-jumping with the help of radiopulsephone or CRD-4 mounted on helmet. The investigations were performed in winter sessions 1959/60 and 1961/62

Based on the achievements of Sverdlovsk Biotelemetry Group, in 1963-1964, S. M. Ganyushkina studied the physiological parameters of copper miners in the Urals. Eight coal miners were examined during 9 shifts at a depth of 250, 310 and 370 m. The above described combined telemetry

device (CTD-2) was used as a transmitting device, and the RL-8 radio receiver set - as a receiver unit. The research confirmed the possibility of using biotelemetry on coal miners. It revealed specific aspects of the body response to different kinds of underground work and justifying the approaches to physiological workload setting. Similar study (radiopulsometry, myogram telemetry) on workers of hot shops was carried out by Yu. G. Solonin, while mechanics and turners were studied by P. I. Gumener et al (Parin V., 1971; Ganyushkina S., 1964).

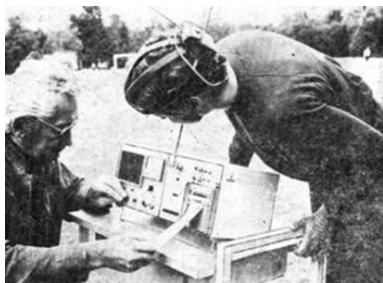


Fig. 4.63. Telemetry receiver, installed on the edge of the sports ground, registers ECG of a sportsman on the electrocardiograph (Vhut A., 2013)

It should be noted that in 1972-1975, in Donetsk, (USSR/Ukraine) Yuriy E. Lyakh (Doctor of Biological Sciences, Professor, the chairman of Medical IT, Biophysics and Medical Equipment Department of M. Gorkyy Donetsk National Medical University) also applied radiopulsometry to characterize coal miners' work and to justify its optimization in terms of physiological aspect. The biotelemetry system was used to register heart rate on coal miners during their work in the aggressive and explosive environment of Donbass coal mines (Lyakh Yu., 1975).



Fig. 4.64. Norman Jefferis Holter

The fact of using "computerized biotelemetry" by the representatives of Sverdlovsk Group in the middle of the 1970s is known: telemetry of ECG, EEG, EOG was conducted by means of 5-channel system with the data input to ECM ("Promin-2", "Mir-1", BECM-6M") and automatic analysis. The technology was used for physiological examination of work activities of operators, students and sportsmen (Rimskikh E. et al., 1974).

Radiotelemetry became a reliable routine diagnostic technique in physiology, sports and occupational medicine thanks to the work of Sverdlovsk Group. The methods of dynamic biotelemetry of Rosenblat's group became frequent practice all over the world. Vladimir Rosenblat (1967) saw its future in computerization and wrote: "...Interpretation of vast factual material, gained by dynamic biotelemetry, can be favourable only on

condition of data processing with the help of computing machines... By programming the data processing, thinking over the results and specifying programs of data reprocessing or its further steps, only in this way, we will be able to provide fruitful development and further succession and will be able to cope with the physiological data flotation, which is rather large even nowadays, and soon it will become larger by volume and content in case of multichannel dynamic radiotelemetry of different functional parameters under natural conditions of muscular activity".

4.3. Clinical Biotelemetry

In 1949 a biophysicist Norman Jefferis Holter demonstrated the possibility to transmit ECG through radio waves (Fig. 4.64-4.66) (Holter N., Generelli J., 1949; Holter N., 1957). Later a special transmitter, weighing above 30 kg, and a registering tape recorder were designed for "radioelectrocardiography".

During the next two decades the equipment was miniaturized and simplified considerably, and the practicability of this method was proved by a great amount of research works (ibid).

Based on the biotelemetry system, Professor N. Holter developed a portable device for continuous ECG monitoring, which is nowadays used all over the world.

In the beginning of the 1960s, R. A. Kapitanov (All-Union Scientific-Research Institute for Medical Instruments and Equipment, Moscow, Russia) studied the general purpose and conceptual issues of clinical telemetry (including the aspects of intra-hospital telecommunications, communication facilities, announcing and radiotelemonitoring).

The approaches to intra-hospital telemetry of blood pressure, body temperature, ECG and other parameters, principles and requirements for technical solutions, the role and place of telemonitoring in the U.S. clinical medicine were described by M. S. Molnar (1965). G. Douglas Talbott (1965) presented a biotelemetry model in intensive therapy wards and in operative theatres.



Fig. 4.65. The original telemetry system of electrocardiography in the laboratory of Dr N. Holter



Fig. 4.66. Clinical biotelemetry and teleconsultations between Mayo Clinic and Naval Hospital (the USA, 1958) (Ratcliff J., 1958)



Fig. 4.67. Orvan Walter Hess

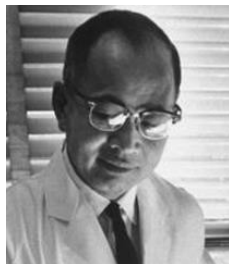


Fig. 4.68. Edward H. Hon

In the context of clinical biotelemetry it is necessary to describe the work of Professor Orvan Walter Hess and his co-authors: Engineer Wasil Litvenko (08.12.1916-01.06.1985) and Dr Edward H. Hon (Fig. 4.67-4.68). In the 1930s in the USA, Dr. Hess began to develop a device, which enabled to monitor the fetus cardiovascular system. The work was progressing very slowly.

After World War II, Dr. E. Hon joined Hess. As a result of collaborative efforts, in 1957, the first monitor was presented to the public and the experimental results were published. The device was rather large, which hindered its wide use. A few years later, Wasil Litvenko, head of the medical electronics laboratory at Yale University, joined the team. He upgraded considerably the device and miniaturized it. By 1961 the device got the radiobiotelemetry functions and allowed distant recording of fetus cardiovascular system and internal uterine pressure. The operating range was determined by the capacity of power supply (Fig. 4.69) (Hess O., Litvenko W., 1964; Hess O., 1962).

During the period between June and December 1961 a total of 187 fetus electrocardiosignals were telemetered as clinical testing. In most cases the obtained telemetry findings were of rather high quality. Rare failures were caused by muscle electrical interference or by poor signal. The results were compared with the findings, recorded by immobile diagnostic facilities. As

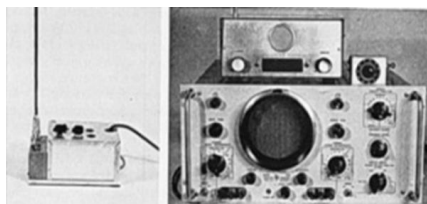


Fig. 4.69. Fetus radiotelemetry system of O. Hess et al. (USA, 1961) - a transistor transmitter (left), a receiver with oscillography (right)

a result, the general methodology of fetus radiotelemetry was specified and further improvement of the equipment was defined (ibid).

Later, in 1967, in Germany, K. Sokol, E. Rüther and K. Baumgarten also used radiotelemetry to control fetus cardiac function both during pregnancy and birth (Baumgarten K, Sokol K., 1968; Rüther E., Sokol K., 1967).

The clinical use of telemetric cardiocography to control the delivery process and optimal prescription of anaesthesia was performed in 1982 at the Helsinki University Hospital (Finland) under the supervision of Dr. Maija Haukkamaa, with the participation of Ds M. Purhonen and Dr. K. Teramo (Fig. 4.70) (1982).



Fig. 4.70. M. Haukkamaa

In the context of fetus cardiac function telemetry, special attention should be paid to the use of facsimile communication for distant transmission and interpretation of cardiocograms recorded on paper. In 1989 in the USA, Dr. S. L. Clark established a telemedicine network based on facsimile connection between 24 rural hospitals. Portable telecopying devices were used. During a 30-month period, 209 teleconsultations, including urgent ones, were held. The quality improvement on diagnostic solutions and financial availability of the system were notable (Clark S. et al., 1989).

In the 1960s, a range of devices was developed for intra-hospital telemetry - in fact, for intra-hospital telemonitoring of cardiovascular system on patients from the surgical and cardiological units (Fig. 4.71).

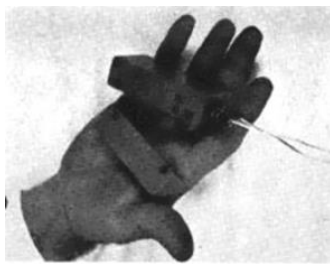
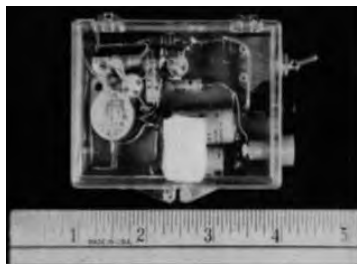


Fig. 4.71. Intra-hospital biotelemetry systems (USA, 1960s): "radiocardiography unit" - a transducer with an amplifier, telemetry system radio transmitter for surgical departments (the cables are connected to the sensors) (Winsor T. et al., 1960)

In the 1970s, a 3-channel transmission of physiological findings in analog form was performed via telephone lines between the surgical theatres of St. Peter Hospital and The Royal Surgery College (London, UK), where Elliott 903 computer machine with the medical data analysing

software was installed. The results of data interpretation "came back" via the same communication channels and were printed out or displayed on a screen.

The system was practically approved on the data of 3 patients (15 recorded electric cardiac signals). Consequently not only ECG, but EEG, blood pressure, respiratory parameters during anaesthesia, administered during surgery were telemetered. As such, telemedicine monitoring and data analysis during surgical operations were performed (Hill D., 1966). In 1976 in the USA, F. Klein and D. Davis (1976) reported about the successful use of 30 samples of intra-hospital 4-channel radiotelemetry system for parallel distant monitoring of ECG, EEG, pulse rate and blood pressure in patients, in the surgical theatres.

In the USSR, ECG telemetry ("radio-electrocardiography") was actively used in the early and mid-1970s in rehabilitation medicine (Automation of medical information collection ..., 1974) by A. F. Rusanov et al. for walking exercise tolerance assessment; by M. N. Kovblyuk - during manipulation treatment; by V. A. Mkrtychan during therapeutic physical training of patients with cardiological pathology; by V. N. Velkin during insulations (telemetry seismocardiography).

In Lithuania, around 1980, the rhythmogram biotelemetry system was developed by a team headed by Yu. I. Brozhaytene. It contained primary stations for rhythmographic findings recording, local and central stations for data analysis. The data transmission between stations could be carried out directly (on magnetic carriers) or by telephone lines. The system was practically approved based on the results on 800 subjects.

4.4. Tele-EEG - Biotelemetry of Electroencephalogram

Tele-EEG - biotelemetry of brain electrical activity both for the purpose of neurophysiology and for solutions of clinical problems - can be considered a separate significant line of research in telemedicine of the middle of the 20th century.

General methodological issues and neurophysiological results of this scientific field are described in the works, published in 1974-1977 by scientists from USA, USSR, Hungary, Germany, Canada, The Netherlands and France, such as G. Manson (1974), E. Benassi (1976), M. Déro (Dero et al., 1977), E. Ståhlberg (1969), C. W. Erwin (1970) and others. The technical description of different variants of tele EEG systems is given by F.T. Hambrecht (1965; Hambrecht et al. 1963); R. Vreeland et al. (1963; 1971); H. Fischler and E. Frei (1963); T. B. Fryer (1974); R. Cammann (1975); S. Geier (1971; 1974) and S. Greier et al. (1972; 1973 a, b, c; 1974; 1975; 1977); J. M., Simard et al. (1977); J. Huertas and R. Westbrook (1970);

Arfel G. et al. (1969; 1975). A number of authors in Europe and USA (1967-1974) presented the 6- and 8-channel EEG telephone biotelemetry systems (Bennett D., Gardner R., 1970; Gardner R. et al., 1974; Niebeling H. et al., 1967).

Tele-EEG was applied for the study of peculiarities of neurophysiological processes during different types of physical and mental activity (Konietzko H. et al., 1973; Vidart L., Geier S., 1967; 1968; 1969 a), b), 1970). But Dr. Charles Levant Yeager (Fig. 4.72), A. J. Gianascol, R. Vreeland, F. Findji, M. de Barros-Ferreira et al. (Barros-Ferreira M. et al., 1977; Findji et al. 1978; Gianascol A., Yeager C., 1964; Vreeland R. et al., 1963; 1971) used successfully EEG-telemetry in the



Fig. 4.72. Charles Levant Yeager

study of paediatric neurophysiology and psychiatry (for autism cases).

In the period 1969-1975, a number of the representatives of Sverdlovsk Biotelemetry Group (refer to "Biotelemetry in physiology and sports medicine"), S. S. Gofman, Ya. V. Freidin, E. I. Rimskikh, A. I. Turov, B. A. Men, used tele-EEG for systematic physiological studies, in particular, on workers polishing and glossing various objects, on students during neuro-emotional pressure, etc. The following equipment was applied:

- Radio-electroencephalograph (REE-2) designed by R. V. Unzhin and S. V. Suzdalova, weight of the transmission unit was 120 g, the researcher's device consisted of a modified receiving unit operating from ARS-2 vehicle radio set and a registration unit (EKPSCh ink electroencephalograph);
- 2- and 4-channel bioradiotelemetry systems (2BEP-2, 4BEP-1), the weight of the transmission units varied from 260 g to 590 g, the operating range was 25 and 100 m, respectively.

Later, ECG, EOG and EPG were transmitted and studied simultaneously with the EEG (Gofman H., 1969; Hoffmann S., 1970; Hoffmann S. et al., 1975).

In 1970, under the supervision of Neurologist Donald R. Bennett and biophysicist-bioengineer Dr Reed M. Gardner (Fig. 4.73-4.74) the "Telemedicine" project was implemented, as a part of which the tele-EEG network between the cities Salt Lake City, Utah, and Twin Falls, Idaho (USA) was created.

With the help of dataphone, the EEG transmission was performed from the Magic Valley Memorial Hospital to the Medical Centre of the Utah University, where Dr. Bennett conducted the interpretations and

teleconsultations. It was notable that the cost of tele-EEG was higher than face-to-face EEG, but patients could save substantially on transport expenses, avoiding some 1 000 km long trips. For the first 18 months of the network operation, as many as 400 tele-ECG consultations were carried out (Fig. 4.75)



Fig. 4.73. Dr. Donald Bennett



Fig. 4.74. Dr. Reed M. Gardner



Fig. 4.75. Dr. Donald R. Bennett at Clinical tele-ECG stand (photo of Independent Press-Telegram (Long Beach, California).- Sun, Apr. 12, 1970.-P.154)

So, employment issues were effectively solved - in the described period there were no neurologists in Twin Falls available at all.

The next steps in the network development were connection of the television system for video conferences and computer facilities for computerized telediagnosis.

In 1973, at the V. M. Bekhterev Scientific Research Institute of Psychoneurology (Leningrad/St. Petersburg, USSR/Russia) an original technique for EEG registration and telemetry was developed. Its authors were Professor Rem A. Kharitonov, head of the paediatric neuropsychiatry development, and M. L. Nechaev (Fig. 4.76). For more that 10 years, this method was used for differential diagnostics of epilepsy in children and determination of summarized seizure time duration (Kharitonov R. et al., 1984).



Fig 4.76. Rem A. Kharitonov



Fig 4.77. Tele-EEG in patient with epilepsy (Georgia, 1979)

In 1979, at the Institute of Clinical Experimental Neurology (Tbilisi, Georgia) under the supervision of Dr Tina Sh. Geladze the telemetry of ECG and stereo-electroencephalometry by means of 4-channel "Televar" system were widely applied (Fig. 4.77) (Geladze T. et al., 1979; 1982).

The biotelemetry was carried out during free movement, natural sleep, and voluntary activity of the patients. It provided qualitative detection of focal alterations of the brain bioelectrical activity in patients with generalized seizures, precise topical diagnostics and localisation of trigger locus for the further treatment (ibid).

In 1984 the team under the supervision of Dr. J. Dyson developed and used the 3-channel EEG -telemetry system in neonatal practice. The distinguishing feature of the equipment was the original use of infrared radiation, instead of electrical signals, for the transmission of physiological findings from an infant to a monitoring device. EEG biotelemetry in neonatal practice was considerably useful in diagnostics and treatment of infants who suffered from birth asphyxia (Dyson R. et al., 1984). Later on R. J. Dyson dealt with biotelemetry issues of swimmers and divers.

Computerized tele-EEG diagnostics was also advancing actively. Computer programs for automated analysis and interpretation of

electroencephalograms transmitted over the radio or telephone lines were developed and successfully implemented. In 1967 the team of specialists - Dr. John Hanley, Professor William Ross Adey (Fig. 4.78), P. M. Hahn, John Roderick "Rod" Zweizig - developed the original radio-biotelemetry system, mainly intended for distant EEG registration (Zweizig J. et al., 1967; 1972).

On basis of this technology in the early 1970s, the computerized EEG telediagnosis centre was established at the University of California (Los Angeles, USA) in the astrobiology laboratory (Hanley J. et al., 1972). The findings for the distant analysis were transmitted over the telephone and radio communication lines. This combined EEG-telemetry system could be used by the patients themselves, under normal life conditions (Hanley J. et al., 1969).

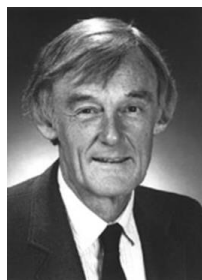


Fig. 4.78. William Ross Adey

During a rather short period of time the computerized tele-EEG center carried out a range of interesting investigations and experiments (Hanley J., 1976; UCLA clinic gets medical data via global network, 1973) such as:

- The pattern and biological rhythm studies on the participants of Antarctic expeditions (1973, together with French Antarctic expedition);
- EEG telemetry in free-swimming divers at a depth of 15 meters (Zweizig J. et al., 1972);
- Automated parallel analysis of EEG and ECG transmitted from Lund University (Sweden);
- "Looping" EEG transmission and analysis along the network Los Angeles - Australia (Melbourne and Brisbane) - Los Angeles;
- Telescreening and study of epilepsy on Chicano children (together with Dr Theodore Munsat).

Also, in the USA, J. R. Ives et al. (1973) used 4-channel EEG-telemetry system for epilepsy study and computerised diagnosis in 1973.

In 1969-1979 in the USA a group of specialists from Portland (Oregon) and Washington (D.C.) used successfully EEG telemetry to solve a number of scientific and diagnostic tasks. The team, under the supervision of Professor Janice R. Stevens, used EEG radiotelemetry for physiopathology study and topical diagnostics of paroxysmal syndrome (Fig. 4.79). A few years later Professor Stevens and Doctors Lewellyn B. Bigelow, Duane Denney, John Lipkin, Arthur H. Livermore, Fred Rauscher, and Richard J. Wyatt applied radiotelemetry of electroencephalogram and electrooculogram (EOG) on 40 patients with schizophrenia to discover brain electrical activity at the time of psychotic episodes. Each patient was examined in a period from 2 to 24 hours. Control telemetry measurements were performed on 12 healthy persons. 2-channel or 4-channel EEG and 2-channel EOG radiotelemetry systems were used (both had transmitter dimensions of 1x3x4 cm, weighing 100 g).



Fig. 4.79. Professor Janice R. Stevens at the electroencephalograph stand (in 1955-1960); a photo from the collection of OHSU Historical Collections & Archives

According to the results of the study, evident correlations between brain electrical activity alterations and psychotic episodes were recorded in approximately half of the patients. The EEG radiotelemetry method itself was acknowledged as effective and enabling to detect dependence between clinical and physiological evidences of different processes and was applicable in psychiatry (Stevens J., 1969; 1976; Stevens J., Livermore A., 1982; Stevens J. et al., 1969; 1971; 1972; 1979).

Various electroencephalogram aspects of patients with schizophrenia were studied with the help of tele-EEG by Pierre Flor-Henry (1983) (Canada) and J. D. Vincent (Vincent J. et al., 1968) too.

EEG was widely used for the study of pathogenesis and physiopathology, epilepsy and paroxysmal syndrome. The basic directions and studies are given in the table 4.4.

On the subject of tele-EEG usage during epilepsy/ paroxysmal syndrome, for both scientific and clinical purposes, the studies of the European School of neurophysiologists should be noted. In 1964-1965 W. Götze, head of the Electroencephalography Department of Neurosurgery Clinic of the Free University Berlin, M. Münter and G. Krokowski, with the

participation of U. Knudsen, E. Fuchs (Germany) conducted a range of fundamental studies of brain reaction on different irritators, vestibular loading, physical stress and hyperventilation by means of tele-EEG (Götze W. et al., 1964, 1965; Münter M. et al., 1964).

Table 4.4. The main studies in the sphere of tele-EEG in physiopathology and diagnostics of paroxysmal syndrome and epilepsy (1960-1980s)

Lines of research	Authors
General methodological, technical and basic physiological aspects	Dero M. (1975), Fisher H. et al. (1960), Suess E. et al. (1986) - 8-channel for the long-time EEG telemetry; Barnea O. et al. (1986) - EEG biotelemetry under the conditions of free-moving observed subjects
Tele-EEG and telemetry EEG monitoring under clinical conditions for topical and differential diagnostics, determination of seizure frequency and possible trigger factors	Binnie C. et al. (1981, 1985) (n=181); Stevens J. R. et al. (1969, 1971, 1979); Vignaendra V. et al. (1979); Overweg J et al. (1981) (n=212)
Tele-EEG in paediatrics and neonatology (epilepsy, paroxysmal syndrome)	Holmes G. L. et al. (1980) differential diagnostics of pseudo-epilepsy, n=53; Beaumanoir A. et al. (1982) combined psychometric tests, efficiency control of drug therapy, n=32; Arfel G. et al. (1969, 1975); Guey J. et al. (1969) – registrations of various activities, study and recreation
Electrophysiological and clinical aspects of epilepsy according to the tele-EEG results	Tomka I. (1974); Vidart L. et al. (1967, 1968; 1969 a), b)

Between 1968 and 1977, a considerable work in the sphere of neurophysiology by means of tele-EEG was performed by L. Vidart and S. Geier (France) and their colleagues.

Year after year, in-depth study of tele-EEG manifestations of epilepsy/paroxysmal syndrome was conducted: on adults (including in the course of regular work activities); comparatively between teenagers and adults; during seizures, including simultaneously with stereo-EEG (and also with radiotelemetry); comparatively with clinical symptoms; as criteria for

differential diagnostics S. Geier (1971; 1974) and S. Greier et al. (1972; 1973 a, b, c; 1974; 1975; 1977; Vidart L. et al. (1967, 1968; 1969 a), b)).

The essential work in the sphere of tele-EEG was conducted in 1969-1985 by A. Kamp at the Netherlands Organization for Applied Scientific Research /Nederlandse Organisatie voor

Toegepast Natuurwetenschappelijk Onderzoek) (Utrecht, Amsterdam University, The Netherlands). At first he developed an original 2-channel EEG radiotelemetry system; however, it was "enlarged" to 8-channel system very soon. The dimensions of the transmitting unit were 10x6x5 cm,

weight 280 g, the operating range depended on the capacity of electric power supply and varied from 30 to 90 m (Fig. 4.80) (Kamp A., 1983, 1984, 1985).

In the late 1960s, A. Kamp, in cooperation with W. Storm van Leeuwen (Fig. 4.81) (1969), conducted the comparative study of EEG on human and animal subjects, using his own system. Increase in quantity input of simultaneously telemetered parameters (within a framework of physiological experiment requirements) led to the construction of a 16-channel radiotelemetry system (Fig. 4.82).

In the mid-1980s, A. Kamp, with the participation of doctors J. W. Aitink and H. Van der Weide (1984), developed and successfully tested a 20-channel EEG-telemetry system for medical institutions and its miniature 8-channel variant for independent usage by a patient in routine conditions. The equipment revealed its reliability and user friendliness. The data transmission was carried out over the radio or over public telephone lines but the second variant was preferred. The system allowed conducting the qualitative differential diagnostics of paroxysmal syndrome (ibid).

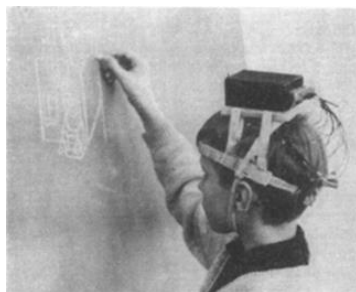


Fig. 4.80. EEG-radiotelemetry system of A. Kamp, 1969



Fig. 4.81. W. Storm van Leeuwen



Fig. 4.82. Tele-EEG system of Kamp-van Leeuwen. Fragment of telecast "Verschuivende Grenzen" dated 21.05.1965, document ID 51812, - www.beeldengeluid.nl

Thanks to the works of A. Kamp in the 1960-1980s, a model for independent EEG recording by the patients themselves under every-day life conditions, the so-called "out-patient EEG", was used. In this case there were two ways to transmit the result to the medical facilities: as tape recordings or with the help of biotelemetry systems. Various types of hardware solutions were offered, including video monitoring, though, they were more suitable for clinical conditions. Almost nothing is known about the results of out-patient tele-EEG usage (Bickford R. et al., 1969; Campbell K. et al., 1979; Deutsch S., 1979; Ebersole J. et al., 1985; Wroe S. et al., 1987).

In 1974 Professor R. W. Gilliatt, doctors and Engineers A. N. Bowden, P. Fitch, R. G. Willison (Neurology Institute, London, UK) specified the concept of intra-hospital "video and EEG telemonitoring" in the most complete way. By means of combined usage of the closed-circuit cable television and 8-channel EEG radiotelemetry, long-time distant monitoring of hospitalized patients was carried out (Fig. 4.83) (Bowden A. et al., 1975). The main purpose of this method was differential diagnosis with the further arrangement of the most appropriate scheme of treatment and patient surveillance.

By the mid-1980s, out-patient EEG telemetry mainly turned into intra-hospital telemonitoring of patients. The most impressive examples refer to 1985. At the London National Hospital (UK) "video-EEG telemetry" was used on approximately 100 in-hospital patients and 40 outpatients a year. Results, significant for patients' treatment were recorded in almost 50% of the cases (Roberts R., Fitch P., 1985).



Fig. 4.83. Combined intra-hospital video and tele-EEG radiomonitoring: screen-shot of the telemonitoring system Run Screen (the picture of a patient during eating and parallel EEG-image)

At the University of California (USA) a long-time intra-hospital cable and radio EEG telemonitoring for differential diagnostics and specification of surgical treatment was applied (Nuwer M. et al., 1985). Also, in the USA, at Yale University, an experience of video and EEG telemonitoring of 2 800 patients was accumulated (totally - around 130 000 recording hours). An important component of the system was a computer with automated data analysis program (Ebersole J., 1987; Ebersole J. et al., 1985).

Doctors from Switzerland reported about a successful five-year experience of EEG telemonitoring. For the long-time monitoring a 21-channel EEG was applied, for the out-patient telemonitoring - 4-channel, while for the intensive one - 16-channel EEG was used. On average the technique was practiced on 550 patients a year. In more than in 50% of the cases, the usage of tele-EEG influenced positively the diagnostic and treatment process (Egli M. et al., 1985).

At the Institute of Epilepsy (The Netherlands), the synchronized distant video and tele-EEG monitoring was used for diagnostic purposes. The system supported clinical decisions in 79% of the cases, while in 65% - patient surveillance was significantly improved due to the tele-EEG monitoring (Binnie C. et al., 1981, 1985).

So, the intensive development of physiology in the 20th century required absolutely new approaches and methods for assessment of body functions under various activities. This stimulated the appearance of dynamic radiobiotelemetry, which enabled to record and monitor the parameters of life-sustaining activity of a free-moving subject.

Bioradiotelemetry was mostly valuable for man-in-space programs and for physiological study of sportsmen. Due to this technology, two new fields in science were developed - cosmic medicine and physiologically based training system for sportsmen.

References

- [1] [April 12, 1961 The first human space flight], <http://www.federspace.ru/main.php?id=342&did=1370>, (in Russian), 12 апреля 1961 года - первый полет человека в космос, <http://www.federspace.ru/main.php?id=342&did=1370>
- [2] [Automation of medical information collection, processing and use in practice biotelemetry resorts], Mater. II Ukr.resp.simp. Kiev, 1974, p. 122 (in Russian), Автоматизация сбора и обработки медицинской информации и применение биотелеметрии в практике курортов, Матер. II Укр. респ. симп. Киев, 1974, с. 122
- [3] [Electronics & Fitness], Mater. nauch. tekhn. konf., Leningrad, 16-19 April, 1968, pp. 84-93 (in Russian), Электроника и спорт, Матер. науч.-техн. конф.-Ленинград, 16-19 апреля 1968, с. 84-93
- [4] [History of IBMP in photos. The first decade (1963-1973)], М.: "Slovo", 2008, p. 14 (in Russian), История ИМБП в фотографиях. 1-е десятилетие (1963-1973 гг.), М.: «Слово», 2008, с. 14
- [5] [In memory of Vladimir Viktorovich Rosenblatt], Fiziologiya cheloveka, 2000, 26, 5, p. 160 (in Russian), Памяти Владимира Викторовича Розенבלата, Физиология человека, 2000, 26, 5, с. 160
- [6] [Morning of a new era: Press conference dedicated to the successful implementation of the first manned space flight in the world in space], Izvestiya, 15 April 1961, 91, 13637, p. 1 (in Russian), Утро новой эры». Пресс-конференция, посвященная успешному осуществлению первого в мире космического полета человека в космическое пространство, Известия, 15 апреля 1961 г., 91, 13637, 1
- [7] [Preliminary results of the research with the help of the first Soviet artificial earth satellites and rockets], М.: AN USSR, 1958, 1, pp. 130-149 (in Russian), Предварительные итоги научных исследований с помощью первых советских искусственных спутников Земли и ракет, М.: АН СССР, 1958, 1, с. 130-149
- [8] [Space medicine and biology], М.: Izd-vo "Znanie", seriya "Kosmonavtika, astronomiya", 1978, 10, p. 64 (in Russian), Космическая медицина и биология, М.: Изд-во "Знание", серия «Космонавтика, астрономия», 1978, 10, с. 64
- [9] Akhutin V. M., Shkapkin B. F., Ozemkova N. L., Saydakovskaya L. F. [The system of automatic heart rate monitor for continuous monitoring of the load on the moving distance athlete], Elektronika i sport. Mater. nauch. tekhn. konf., Leningrad, 16-19 April, 1968, pp. 90-91 a) (in Russian), Ахутин В. М., Шкапин Б. Ф., Оземкова Н. Л., Сайдаковский Л. Ф. Система автоматического пульсотонометра для непрерывного контроля за нагрузкой движущегося по дистанции спортсмена, Электроника и спорт, Матер. науч.-техн. конф. Ленинград, 16-19 апреля 1968 г., с. 90-91
- [10] Akhutin V. M., Stein L. B., Bogdanovskiy E. M. [The device for the automatic control of the change electrocardiosignal athlete during the performance of physical exercise], Elektronika i sport, Mater. nauch.-tekhn. Konf, Leningrad, 16-19 April, 1968, pp. 92, (in Russian), Ахутин В. М., Штейн Л. Б., Богдановский Э. М. Прибор для автоматического контроля за изменением электрокардиосигнала спортсмена в период выполнения им физических упражнений, Электроника и спорт, Матер. науч.-техн. конф., Ленинград, 16-19 апреля 1968 г., с. 92, b)

- [11] Akulinichev I. T., Bayevskiy R. M., Zazykin K. P., Freidel V. R. [Electronics in space medicine], M.: Izd-vo "Energiya", 1964, p. 50 (in Russian), Акулиничев И. Т., Баевский Р. М., Зазыкин К. П., Фрейдель В. Р. Радиоэлектроника в космической медицине. М.: Изд-во «Энергия», 1964, с. 50
- [12] Akulinichev I. T., Zhdanov A. M., Popov I. I. [Biotelemetry problems in long-term space flights], Span, Madrid, 1966, p. 203 (in Russian), Акулиничев И. Т., Жданов А. М., Попов И. И. Проблемы биотелеметрии в длительных космических полетах, Матер. XVI конгресса Междунар. астронавт. федерац. Испания, Мадрид, 1966, с. 203
- [13] Allen R. T., Hanson M. L., Kresge D. J. Biotelemetry in medicine. Biomed Instrum, 1964 Dec, 1, 3, pp. 15-19
- [14] Altukhov G. V. [Bio-telemetry control over human condition in space flights], Aviatzionnaya i kosmicheskaya meditsina. M., 1963, pp. 15-18 (in Russian), Алтухов Г. В. Биотелеметрический контроль за состоянием человека в космических полетах, Авиационная и космическая медицина. М., 1963, с. 15-18
- [15] Andreeva V. G., Odinokov G. I., Skiba E. A. [Complex equipment for remote study of external respiration], Meditsinskaya tekhnika. 1976, 3, pp. 49-51 (in Russian), Андреева В. Г., Одинокоев Г. И., Скиба Э. А. Комплекс аппаратуры для дистанционного исследования внешнего дыхания, Медицинская техника, 1976, 3, с. 49-51
- [16] Arfel G., Casanova C., Coulmance M. [Dynamic aspects of electroencephalography. 1st results of a telemetric study]. Rev Neurol (Paris), 1969 Jun, 120, 6, pp. 429-430
- [17] Arfel G., Laurette G. [Evolution of paroxysmal discharges during radiotelemetry in a child suffering from "gelastic epilepsy"], Rev Electroencephalogr Neuropsychiol Clin, 1975 Jan-Mar, 5, 1, pp. 73-81
- [18] Ax A. F., Andreski L., Courter R. et al. The artifact problem in telemetry of physiological variables. Biomed Sci Instrum, 1964, 2, pp. 229-233
- [19] Bachmann B. US Stratosphere balloon flights in the 1950's to 1960's Precursors to Manned Spaceflight, http://www.space-unit.com/articles/manned_pioneer_flights_in_the_usa.pdf
- [20] Barnea O., Deutsch S. Telemetry system for stimulation and monitoring of freely moving patients. IEEE Trans Biomed Eng, 1986 Mar, 33, 3, pp. 320-326
- [21] Barry W. A radio telemetering device. J Appl Physiol, 1964 May, 19, pp. 528-530
- [22] Bartlett R. G. Jr. Pulmonary function evaluation in air and space flight. Ind Med Surg, 1963 Jan, 32, pp. 2-8
- [23] Basan L., Lovdzhiev I. [Methodology for research on radio breathing during labor and physical exercises], Fiziologicheskii zhurnal USSR im. I. M. Sechenova, 1958, 8, pp. 773-775 (in Russian), Басан Л., Ловджиев И. Методика для исследования по радио дыхания во время труда и спортивных упражнений, Физиологический журнал СССР им. И. М. Сеченова, 1958, 8, с. 773-775
- [24] Bauer H., Knoblich K. [1st results of evaluation of the physical stress on nurses by telemetric transmission of heart rate], Sante Publique (Bucur), 1977, 20, 2, pp. 201-208
- [25] Baumgarten K., Sokol K. [Wireless transmission of the fetal electrocardiogram and fetal heart beat during pregnancy and labor], Arch Gynakol, 1967, 204, 2, pp. 267-268
- [26] Bayevskiy R. M. [Theoretical and applied aspects of the assessment and prediction of the functional state of the organism under the influence of long-duration space flight factors (speech acts)], 2005, http://www.imbp.ru/WebPages/win1251/Science/UchSov/Docl/2005/Baevski_speech.html (in Russian), Баевский Р. М. Теоретические и прикладные аспекты оценки и прогнозирования функционального состояния организма при действии факторов длительного космического полета (актовая речь), 2005, http://www.imbp.ru/WebPages/win1251/Science/UchSov/Docl/2005/Baevski_speech.html

- [27] Beaumanoir A., Nahory A., Potalicchio S. [Indication of tele-electroencephalography coupled to videoscropy in the study of higher functions in the epileptic child], *Rev Electroencephalogr Neurophysiol Clin*, 1982 Dec, 12, 4, pp. 315-318
- [28] Bednenko V. S. [Medical monitoring of the cosmonaut's condition and medical research in flight], V kn. *istoriya otechestvennoy kosmicheskoy meditsiny*, Ushakov I. B., Bednenko V. S., Lapayev E. V. (Eds.), M., Voronezh, 2001, p. 320 (in Russian), Бедненко В. С. Медицинский контроль за состоянием космонавта и медицинские исследования в полете, В кн. *История отечественной космической медицины*, Под ред. Ушакова И. Б., Бедненко В. С., Лапаева Э. В., М., Воронеж, 2001, с. 320
- [29] Bell D., Stratbucker R. A. Digital data transmission of physiologic parameters. *Biomed Sci Instrum*, 1971, 8, pp. 48-49
- [30] Benassi E., Ottonello G. A. [EEG telemetry: new prospects]. *Riv Neurobiol*, 1976 Jul-Dec, 22, 3-4, pp. 207-216.
- [31] Bennett D. R., Gardner R. M. A model for the telephone transmission of six-channel electroencephalograms. *Electroencephalogr Clin Neurophysiol*, 1970 Oct, 29, 4, pp. 404-408
- [32] Benson V. G., Squires R. D. Aerospace Medical Aspects U.S. Navy Manned Balloon Flight of May 4, 1961, "Strato-Lab High No. 5", Abstracts of Papers from Scientific Program of 1962 Meeting of Aerospace Medical Association, Atlantic City, April 9-12, Aerospace medicine, 1962, pp. 326-356
- [33] Bergey G. E., Sipple W. C., Hamilton W. A., Squires R. D. A personal FM/FM biotelemetry system. NADC-MR-6624. NADC-MR Rep, 1965 Jun, 30, pp. 1-27
- [34] Bickford R. G., Melby G., Karnes W., Groover R. Teleprocessing of the EEG from the patient's residence. *Electroencephalogr Clin Neurophysiol*, 1969 Jun, 26, 1, pp. 117-118
- [35] Binnie C. D., Aarts J. H., Van Bentum-De Boer P. T., Wisman T. Monitoring at the Instituut voor Epilepsiebestrijding Meer en Bosch. *Electroencephalogr Clin Neurophysiol*, Suppl. 1985, 37, pp. 341-355
- [36] Binnie C. D., Rowan A. J., Overweg J., Meinardi H., Wisman T., Kamp A., Lopes da Silva F. Telemetric EEG and video monitoring in epilepsy. *Neurology*, 1981 Mar, 31, 3, pp. 298-303
- [37] Blake R. Distance traverseit by basketball players indifferent types of defence, *Athletic Journal Chicago*, 1941, vol.XXI, 5, pp. 18 and pp. 38-40
- [38] Blanc C., Gravier H., Geier S. [Radiotelemetric recordings of the EEG of pilots in the course of flights of long duration]. *Rev Neurol (Paris)*, 1967 Jul, 117, 1, pp. 222-225, a)
- [39] Blanc C., Gravier H., Geier S. Radiotelemetric recordings of the electroencephalograms of civil aviation pilots during flight. *Electroencephalogr Clin Neurophysiol*, 1967 Dec, 23, 6, pp. 580, b)
- [40] Blanc C., Lafontaine E., Medvedeff M. Radiotelemetric recordings of the electroencephalograms of civil aviation pilots during flight. *Aerosp Med*, 1966 Oct, 37, 10, pp. 1060-1065
- [41] Bolshov V. M., Tsvetkov A. A. [Geotelemetriya to determine the impact (CRM) and minute (IOC) blood flow, "Automation of medical information collection, processing and use in practice biotelemetry resorts"], *Mater. II Ukr. resp. symp.*, Kiev., 1974, pp. 108-109 (In Russian), Большов В. М., Цветков А. А. Реотелеметрия для определения ударного (УОК) и минутного (МОК) объемного кровотока, «Автоматизация сбора и обработки медицинской информации и применение биотелеметрии в практике курортов», *Матер. II Укр. респ. симп.*, Киев, 1974, с. 108-109
- [42] Bowden A. N., Gilliatt R. W., Willison R. G. The place of EEG telemetry and closed-circuit television in diagnosis and management of epileptic patients. *Proc R Soc Med*, 1975 Apr, 68, 4, pp. 246-248
- [43] Bradfute G. A. Jr., Wright J. L. System for beat-to-beat blood pressure telemetry in ambulatory humans. *Biomed Sci Instrum*, 1968, 4, pp. 7-20

- [44] Bratt H. R., Kuramoto M. J. Development of biomedical measuring, telemetry techniques, and monitoring systems for the X-15 and future aerospace vehicles, Biomedical Flight Data Collection, ISA Journal, Oct. 1963, pp. 57-62
- [45] Bratt H. R., Kuramoto M. J. Review of in-flight biomedical data collection systems at AFFTC, May 1960-December 1962. Biomed Sci Instrum, 1963, 1, pp. 445-459
- [46] Byford G. H. Medical radio telemetry. Proc R Soc Med, 1965 Oct, 58, 10, pp. 795-798
- [47] Cammann R. [Possibilities for the use of a wireless telemetric technic in electroencephalography], Psychiatr Neurol Med Psychol (Leipzig), 1975 Dec, 27, 12, pp. 737-746
- [48] Campbell K., Weller C., Wilkinson R. T. A portable pulse-interval modulation telemetry/multiplexing EEG recording system for use in the home. Electroencephalogr Clin Neurophysiol, 1979 Nov, 47, 5, pp. 623-626
- [49] Chut A. Yu. [Instrumental methods of monitoring the physical condition of the sport], Fozicheskaya kultura, sport kak sotsialnye fenomeny obshchestva: retrospektiva, realnost i budushchee, Irkutsk, 2013, 2, <http://www.potext.ru/kultura/46/index.html> (in Russian), Чут А. Ю. Инструментальные методы системы мониторинга физического состояния в спорте, Физическая культура, спорт как социальные феномены общества: ретроспектива, реальность и будущее, Иркутск, 2013, 2, <http://www.potext.ru/kultura/46/index.html>
- [50] Clark S. L., DeVore G. R., Sabey P., Jolley K. N. Fetal heart rate transmission with the facsimile telecopier in rural areas. Am J Obstet Gynecol, 1989 May, 160, 5, Pt1, pp. 1040-1042
- [51] Cromwell Tr., Arditti M., Baybell F. et. al. [Medical electronics for healthcare], (translation from English), L. Tr. editorship by R. I. Utyamyshev, M.: Radio i sviaz, 1981, p. 344 (in Russian) Медицинская электронная аппаратура для здравоохранения: Пер. с англ., Кромвелл Л., Ардитти М., Вейбелл Ф. и др.; Пер. под ред. Р. И. Утымышева, М.: Радио и связь, 1981, с. 344
- [52] Czaplicki S. [The use of radio electrocardiography in the exercise test]. Pol Tyg Lek, 1967 Jul 17, 22, 29, pp. 1097-1100
- [53] Davis D. A. The monitoring of hospital patients, with remarks on radio techniques. Clin Pharmacol Ther, 1964 Sep-Oct, 5, pp. 546-552
- [54] Davis D. A., Thornton W., Grosskreutz D. C. et al. Radio telemetry in patient monitoring, Anest, 1961, 22, 6, pp. 1010-1013
- [55] De Barros-Ferreira M., Findji F., Bittner-Manicka M., Harison-Covello A. [Biotelemetric studies in an autistic child]. Rev Electroencephalogr Neurophysiol Clin., 1977 Apr-Jun, 7, 2, pp. 217
- [56] Deangelis A. M. [Contribution to cardio-vascular function tests of military jet pilots]. Riv Med Aeronaut Spaz, 1965 Jan-Mar, 28, pp. 46-61 (in Italian)
- [57] Degre S., Messin R., Denolin H. [Recording at a distance of cardiac rate and the electrocardiogram. Some technical aspects of telemetry]. Acta Cardiol, 1966, 21, 5, pp. 588-598 (in French)
- [58] Demidov V. [77 electric sense], <http://www.proza.ru/2012/08/24/268> (Svidetelstvo o publikatsii №212082400268), 2012 (in Russian), Демидов В. 77 электрических чувств, <http://www.proza.ru/2012/08/24/268> (Свидетельство о публикации №212082400268)
- [59] Dero M. EEG surveillance of young epileptics using telemetry: technical and methodological aspects]. Rev Electroencephalogr Neurophysiol Clin, 1975 Oct-Dec, 5, 4, pp. 399-405.
- [60] Déro M., Laudet P., Darcos M. [A comparative study of standard electroencephalographic techniques and telemetry]. Rev Electroencephalogr Neurophysiol Clin, 1977 Oct-Dec, 7, 4, pp. 522-528
- [61] Deutsch S. Fifteen-electrode time-multiplex EEG telemetry from ambulatory patients. IEEE Trans Biomed Eng, 1979 Mar, 26, 3, pp. 153-159.

- [62] Dombrovskyy L. S. [On the construction of bio-amplifier for radiation research in sports medicine and physiology], *Fiziologicheskiye mekhanizmy adaptatsii k myshechnoy deyatel'nosti*, Nauchnye Trudy, Sverdlovsk, 1974, pp. 40-46 (in Russian), Домбровский Л. С. К вопросу построения биоусилителя для радиотелеметрических исследований в спортивной медицине и физиологии, *Физиологические механизмы адаптации к мышечной деятельности*, Научные труды, Свердловск, 1974, с. 40-46
- [63] Dombrovskyy L. S. [Questions of construction of telemetry systems for Applied Human Physiology Research], [Tekst]: avtoref.dis. ...kand.biol.nauk (PhD): 03.00.13, Sverdlovsk gos. med. in-t, Sverdlovsk, 1973, p. 23 (in Russian), Домбровский Л. С. Вопросы построения радиотелеметрических систем для исследований по прикладной физиологии человека [Текст]: автореф. дис. ... канд. биол. наук: 03.00.13 / Свердлов. гос. мед. ин-т, Свердловск, 1973, 23 с.
- [64] Dyson R. J., Weller C., Lawrence C., Whitelaw A. Monitoring of the neonatal electroencephalogram using an infrared multichannel telemetry system. *Electroencephalogr Clin Neurophysiol*, 1984 Oct, 58, 4, pp. 382-384
- [65] Ebersole J. S. Ambulatory EEG: telemetered and cassette-recorded. *Adv Neurol*, 1987, 46, pp. 139-155
- [66] Ebersole J. S., Mattson R. H., Williamson P. D., Spencer S. S., Glaser G. H. Monitoring at the West Haven VA/Yale University School of Medicine Epilepsy Center. *Electroencephalogr Clin Neurophysiol.Suppl*, 1985, 37, pp. 357-369
- [67] Egli M., O'Kane M., Mothersill I., O'Kane F., Rai V. P. Monitoring at the Swiss Epilepsy Center. *Electroencephalogr Clin Neurophysiol.Suppl*, 1985, 37, pp. 371-384
- [68] Erwin C. W., Zung W. W. Behavioral and EEG criteria of sleep in humans. Comparison using radiotelemetry. *Arch Gen Psychiatry*, 1970 Oct, 23, 4, pp. 375-377
- [69] Fabris F., Morea M., Todesco S., Vincenzi M. [Application of radioelectrocardiography in surgical practice]. *Acta Chir Ital*, 1964 Jul-Aug, 20, pp. 511-515 (in Italian)
- [70] Fascenelli F. W. Electrocardiography by do-it-yourself radiotelemetry. *N Engl J Med.*, 1965 Nov 11, 273, 20, pp. 1076-1079
- [71] Findji F., de Barros-Ferreira M., Bittner-Manicka A. M., Joseph J. P., Harrison-Covello A. [Temporal organization of paroxysmal discharges in the child. I. Biotelemetric recordings during wakefulness]. *Electroencephalogr Clin Neurophysiol*, 1978 Mar, 44, 3, pp. 281-298
- [72] Fischler H., Frei E. H. Subminiature apparatuses for radio-telemetering of EEG data. *IEEE Trans Biomed Eng*, 1963 Jan, 10, pp. 29-36
- [73] Fisher H., Blum B., Frei E. H., Streifler M. Electroocorticogram transmission by a transistorized subminiature amplifier-transmitter for the normal and epileptic range. *Bull Res Counc Isr Sect E Exp Med*, 1960 Apr, 8E, pp. 101-104
- [74] Flor-Henry P. Telemetered EEG in schizophrenia. *J Neurol Neurosurg Psychiatry*, 1983 Mar, 46, 3, pp. 287-288
- [75] Fryer T. B. A multichannel EEG telemetry system utilizing a PCM subcarrier. *Biotelemetry*, 1974, 1, 4, pp. 202-218
- [76] Furman K. I., Lupu N. Z. Cardiac monitoring and telemetering system. *J Appl Physiol*, 1963 Jul, 18, pp. 840-842
- [77] Ganyushkina S. M. [Radio telemetry equipment for the study of pulse and respiration of the miners in the labor process], *Gigiena i sanitariya*, 1964, 29, 11, pp. 71-74 (in Russian), Ганюшкина С. М. Радиотелеметрическая аппаратура для исследования пульса и дыхания у шахтеров в процессе труда, *Гигиена и санитария*, 1964, 29, 11, с. 71-74
- [78] Gardner R. M., Bennet D. R., Vorce R. B. Eight-channel data set for clinical EEG transmission over dial-up telephone network. *IEEE Trans Biomed Eng.*, 1974 May, 21, 3, pp. 246-249

- [79] Gauthier P., Jouffray L., Rodi M., Gottesmann C. [Radiotelemetric study of heart rate and electroencephalogram during parachute jumping (author's transl)]. *Rev Electroencephalogr Neurophysiol Clin.*, 1977 Apr-Jun, 7, 2, pp. 219-224
- [80] Gauthier P., Jouffray L., Rodi M., Gottesmann C. Electroencephalographic recordings during parachute jump sessions. *Aviat Space Environ Med.*, 1980 Apr, 51, 4, pp. 336-338
- [81] Gzenko O. G., Kakurin L. I., Kuznetsova A. G. [Space flights of "Soyuz"], M.: Nauka, 1976 (in Russian), Газенко О. Г., Какурин Л. И., Кузнецов А. Г. Космические полеты на корабле «Союз». М.: Наука, 1976.
- [82] Gzenko O. G., Malashekov D. K. [Milestones of Space Medicine (History of the Institute of Bio-medical Problems 1963-96)], *Zemlya i Vselennaya*, 1996, 6 (in Russian), (Газенко О. Г., Малашенков Д. К. Вехи развития космической медицины (история Института медико-биологических проблем, 1963-96 гг.), Земля и Вселенная, 1996, 6
- [83] Geier S. [The epileptic patient in crisis. Tele EEG and tele SEEG Study]. *Rev Neuropsychiatr Infant*, 1974 Mar, 22, 3, pp. 155-161 (in French)
- [84] Geier S. A comparative tele-EEG study of adolescent and adult epileptics. *Epilepsia*, 1971 Sep, 12, 3, pp. 215-223
- [85] Geier S., Bancaud J. [Study of the mode of onset of the first 159 partial epileptic attacks recorded by tele-EEG]. *Rev Electroencephalogr Neurophysiol Clin.*, 1973 Oct-Dec, 3, 4, pp. 343-352 (in French) b)
- [86] Geier S., Bancaud J., Bonis A., Enjelvin M. [Tele-E.E.G. recordings of three epileptic attacks classified as episodes of PM status]. *Rev Electroencephalogr Neurophysiol Clin*, 1977 Apr-Jun, 7, 2, pp. 201-202 (in French)
- [87] Geier S., Bancaud J., Enjelvin M. [Observation and tele-EEG recording of a partial complex epileptic crisis]. *Rev Electroencephalogr Neurophysiol Clin.*, 1972 Apr-Jun, 2, 2, pp. 161-164 (in French)
- [88] Geier S., Bancaud J., Talairach J., Bonis A., Szikla G., Enjelvin M. [Significance of electroclinical correlations during visual attacks registered by tele-EEG]. *Rev Electroencephalogr Neurophysiol Clin.*, 1973 Oct-Dec, 3, 4, pp. 355-359 (in French) c)
- [89] Geier S., Bancaud J., Talairach J., Bonis A., Szikla G., Enjelvin M. Clinical note: clinical and tele-stereo-EEG findings in a patient with psychomotor seizures. *Epilepsia*, 1975 Mar, 16, 1, pp. 119-125
- [90] Geier S., Bancaud J., Talairach J., Enjelvin M. [Radio-telemetry in EEG and SEEG. Technology and material]. *Rev Electroencephalogr Neurophysiol Clin*, 1973 Oct-Dec, 3, 4, pp. 353-354, (in French) a)
- [91] Geier S., Bancaud J., Talairach J., Enjelvin M. A complete EEG radio-telemetry equipment. *Electroencephalogr Clin Neurophysiol*. 1974 Jul, 37, 1, pp. 89-92
- [92] Geladze T. Sh., Chkhenkeli S. A., Toidze O. Sh. Telemetric electroencephalographic and stereoelectroencephalographic investigations in the topical diagnosis of the epileptic focus. *Neurosci Behav Physiol*, 1982 Mar-Apr, 12, 2, pp. 118-122
- [93] Geladze T. Sh., Chkhenkeli S. A., Toidze O. Sh. [Telemetric electroencephalographic and stereoelectroencephalographic studies in topical diagnosis of epileptics], *Zhurnal nevropatologii i psikiatrii im. S. S. Korsakova*, 1979, 79, 6, pp. 685-690 (in Russian), Геладзе Т. Ш., Чхенкели С. А., Тоидзе О. Ш. Телеметрические электроэнцефалографические и стереоэлектроэнцефалографические исследования в топической диагностике эпилептического очага, *Журнал невропатологии и психиатрии им. С. С. Корсакова*, 1979, 79, 6, 685-690
- [94] George R. E., Joseph J. A radio-telemetering electromyograph. *J Physiol.*, 1967 May, 190, 2, 1P-3P
- [95] Gianascol A. J., Yeager C. L. Telemetry and child psychiatry: a psychosomatic approach. *Psychosomatics*, 1964 Sep-Oct, 5, pp. 317-321
- [96] Giron T. C., Thornton W. E., Algary W. P., Craig E. Telecardiographic Device. *New Eng J Med.*, 1962, 267, pp. 1218-1224

- [97] Glatt R. [Electrocardiogram of pilots in flight transmitted by radio]. *Cardiologia*, 1953, 22, 4, pp. 238-246
- [98] Glatt R., Wiesinger K., Pircher L. [Wirely transmission of the ECG from a pilot in flight]. *Helv Physiol Pharmacol Acta*, 1953, 11, 2, p. 3-4
- [99] Gofman H. S. S. [Register Radio electroencephalogram in humans at work in a production environment], *Byul. eksp. biol. Med*, 1969, 34, 7, pp. 13-18 (in Russian), Гофман С. С. Регистрация радиоэлектрэнцефалограммы у человека при трудовой деятельности в производственных условиях, *Бюл.эксп. биол. мед.*, 1969, 34, 7, с. 13-18
- [100] Goodwin A. B., Cumming G. R. Radio telemetry of the electrocardiogram, fitness tests, and oxygen uptake of water-polo players. *Can Med Assoc J.*, 1966 Aug 27, 95, 9, pp. 402-406
- [101] Götze W., Knudsen U., Krokowski G., Münter M. [On the telemetric detection of the effect of circular positive and negative acceleration on the EEG in man]. *Elektromed Biomed Tech*, 1964 Dec, 9, pp. 185-188
- [102] Götze W., Münter M., Knudsen U., Fuchs E. [Comparative telemetric EEG studies during physical stress and hyperventilation]. *Elektromed Biomed Tech*, 1965 Oct, 10, 4, pp. 189-192.
- [103] Guey J., Bureau M., Dravet C., Roger J. A study of the rhythm of petit mal absences in c A study of the rhythm of petit mal absences in children in relation to prevailing situations. The use of EEG telemetry during psychological examinations, school exercises and periods of inactivity. *Epilepsia*, 1969 Dec, 10, 4, pp. 441-451
- [104] Gurovskiy N. N., Egorov A. D. [Some of the problems of space medicine], *Sb. stat. "20 let polyotu Gagarina"*, M.: Znaniye, 1981, p. 64 (in Russian), Гуровский Н. Н., Егоров А. Д. Некоторые проблемы космической медицины, *Сб. стат. «20 лет полету Гагарина»*, М.: Знание, 1981, с. 64
- [105] Hambrecht F. T. Multi-channel telemetry systems. *Prog Brain Res*, 1965, 16, pp. 297-300
- [106] Hambrecht F. T., Donahue P. D., Melzack R. A multiple channel EEG telemetering system. *Electroencephalogr Clin Neurophysiol*, 1963 Apr, 15, pp. 323-326
- [107] Hanley J. Telemetry in health care. *Biomed Eng.* 1976 Aug, 11, 8, pp. 269-272
- [108] Hanley J., Rickles W. R., Crandall P. H., Walter R. D. Automatic recognition of EEG correlates of behavior in a chronic schizophrenic patient. *Am J Psychiatry*, 1972 Jun, 128, 12, pp. 1524-1538
- [109] Hanley J., Zweigiz J. R., Kado R. T., Adey W. R., Rovner L. D. Combined telephone and radiotelemetry of the EEG. *Electroencephalogr Clin Neurophysiol*, 1969 Mar, 26, 3, pp. 323-324
- [110] Hanson J. S., Tabakin B. S. Electrocardiographic telemetry in skiers. Anticipatory and recovery heart rate during competition. *N Engl J Med.*, 1964 Jul, 23, 271, pp. 181-185
- [111] Haukkamaa M., Purhonen M., Teramo K. The monitoring of labor by telemetry. *J Perinat Med.*, 1982, 10, 1, pp. 17-22
- [112] Heim J. W. (Ed.) *Techniques of physiological monitoring*, RCA Service Company, 3, 1962-1964
- [113] Helvey W. M., Albright G. A., Axelrod I. A review of biomedical monitoring activities and reports on studies made on F-105 pilots. *Aerosp Med.*, 1964 Jan, 35, pp. 23-27
- [114] Herman J. K. *Strato-Lab High 5: Triumph and Tradey*, Navy Medicine, 1998, pp. 6-11
- [115] Herron R. E., Ramsden R. W. A telepedometer for the remote measurement of human locomotor activity. *Psychophysiology*, 1967 Jul, 4, 1, pp. 112-115
- [116] Hess O. W. Radio-telemetry of Fetal Heart Energy, *Obstetrics and Gynecology*, 1962, 20, 4, pp. 516-521
- [117] Hess O. W., Litvenko W. Radio transmission of fetal electrocardiography and intrauterine pressure. *Conn Med*, 1964 Jun, 28, pp. 427-434
- [118] Hill D. W. The use of radio-telemetry in the monitoring of babies. *Acta Anaesthesiol Scand Suppl*, 1966, 25, pp. 127-129

- [119]Hoffmann H. [Biotelemetrical studies in pilots of propellor planes, helicopters and jets]. Hefte Unfallheilkd., 1967, 91, pp. 99-107 (in German)
- [120]Hoffmann. S. S., Freidin Ya. V. [Data from multi-channel radio EEG in humans with neuro emotional stress], Byul. eksp. biol. med., 1970, 35, 11, pp. 19-22 (in Russian), Гофман С. С., Фрейдин Я. В. Данные многоканальной радиоэлектроэнцефалографии у человека при нервноэмоциональном напряжении, Бюл. экп. биол. мед, 1970, 35, 11, с. 19-22
- [121]Hoffmann. S. S., Rimskikh E. I., Turov A. I., Men B. A. [Portable device for telemetry recording of physiological functions during mental stress], Kosmicheskaya biologiya i aviakosmicheskaya meditsina, 1975, 9, 4, pp. 65-68 (in Russian), Гофман С. С., Римских Э. И., Туров А. И., Мень Б. А. Портативная установка для телеметрической регистрации некоторых физиологических функций при нервно-психических напряжениях, Космическая биология и авиакосмическая медицина, 1975, 9, 4, с. 65-68
- [122]Holmes G. L, Sackellares J. C, McKiernan J., Ragland M., Dreifuss F. E. Evaluation of childhood pseudoepilepsies using EEG telemetry and video tape monitoring. J Pediatr, 1980 Oct, 97, 4, pp. 554-558
- [123]Holter N. J. Radioelectrocardiography: a new technique for cardiovascular studies. Ann N Y Acad Sci, 1957 Aug 9, 65, 6, pp. 913-923
- [124]Holter N. J., Generelli J. A. Remote recording of physiological data by radio. Rocky Mt Med J, 1949 Sep, 46, 9, pp. 747-751
- [125]Huertas J., Westbrook R. C. A system for sensing and transmitting EEG. Electroencephalogr Clin Neurophysiol, 1970 Jun, 28, 1, pp. 102-103
- [126]Hughes J. R., Hendrix D. E. Telemetered EEG from a football player in action. Electroencephalogr Clin Neurophysiol, 1968 Feb, 24, 2, pp. 183-186
- [127]Ivanov A. [Preliminary results of the research with the help of the first Soviet artificial earth satellites and rockets missiles], M.: Molodaya gvardiya, 1975, <http://nplit.ru/books/item/f00/s00/z0000006/st004.shtml> (in Russian), Иванов А. Предварительные результаты исследований с помощью первых советских искусственных спутников Земли и ракет ракет, М.: Молодая гвардия, 1975, <http://nplit.ru/books/item/f00/s00/z0000006/st004.shtml>
- [128]Ives J. R., Thompson C. J., Woods J. F. Acquisition by telemetry and computer analysis of 4-channel long-term EEG recordings from patients subject to "petit-mal" absence attacks. Electroencephalogr Clin Neurophysiol, 1973 Jun, 34, 6, pp. 665-668.
- [129]Jones J. W., Glassford E. J., Hillman W. C. Remote monitoring of free flaps with telephonic transmission of photoplethysmograph waveforms. J Reconstr Microsurg, 1989 Apr, 5, 2, pp. 141-144
- [130]Joseph J., Watson R. Telemetering electromyography of muscles used in walking up and down stairs. J Bone Joint Surg Br, 1967 Nov, 49, 4, pp. 774-780
- [131]Judica-Cordiglia A. [More information on space medicine. 2. Application of biotelemetry to aerospace research]. Cardiol Prat, 1967 Apr, 18, 2, pp. 61-65 (in Italian)
- [132]Just how exciting can a basketball game be, The Hutchinson News, Hutchinson, Kansas, Mon, Jan 15, 1973, p. 19
- [133]Kamp A, Aitink JW. Improved telemetric EEG monitoring in epileptic patients. Electroencephalogr Clin Neurophysiol. 1983 Aug;56(2):254-5.
- [134]Kamp A. Amplification and transmission of the EEG. Electroencephalogr Clin Neurophysiol.Suppl. 1985 ;37:27-60.
- [135]Kamp A. Long-term supervised domiciliary EEG monitoring in epileptic patients employing radio telemetry and telephone telemetry. II. Radio telemetry system. Electroencephalogr Clin Neurophysiol, 1984 Jun, 57, 6, pp. 584-586
- [136]Kapitanov R. A. [State and prospects of application of means of communication, alarm and telemetry in the treatment process], 162, 10, pp. 52-58 (in Russian), Капитанов Р. А.

Состояние и перспективы применения средств связи, сигнализации и телеметрии в лечебном процессе, Советское здравоохранение, 1962, 10, с. 52-58

- [137] Kashin V. A., Gagen I. E. [Construction of optimal variants of biotelemetric measuring systems, "Automation of medical information collection, processing and use in biotelemetry practice at resorts"], Mater. II Ukr. resp. symp., Kiev., 1974, p. 97 (in Russian), Кашин В. А., Геген И. Е. Построение оптимальных вариантов биотелеметрических измерительных систем, «Автоматизация сбора и обработки медицинской информации и применение биотелеметрии в практике курортов», Матер. II Укр. респ. симп., Киев, 1974, с. 97
- [138] Keller V. S., Pelenskiy L. G., Sinyavskiy T. I., Safronova G. B. [Four-channel radio-telemetry system for human physiological studies in the process of motor activity], Elektronika i sport, Mater. nauch. tekhn. konf., Leningrad, 16-19 April, 1968, pp.85-86 (in Russian), Келлер В. С., Пеленский Л. Г., Синявский Т. И., Сафронова Г. Б. Четырехканальная радиотелеметрическая система для физиологических исследований человека в процессе его двигательной активности, Электроника и спорт, Матер. науч.-техн. конф., Ленинград, 16-19 апреля 1968 г., с. 85-86
- [139] Kharitonov R. A., Gorina E. V., Iovlev B. V. [Frequency and duration of small seizures during treatment under the supervision of multi day telemetric EEG], Zhurnal nevropatologii i psikiatrii im. S. S. Korsakova, 1984, 84, 10, pp. 1470-1474 (in Russian), Харитонов Р. А., Горина Е. В., Иовлев Б. В. Частота и длительность малых эпилептических припадков во время лечения под контролем многосуточной телеметрической регистрации ЭЭГ, Журнал невропатологии и психиатрии им. С. С. Корсакова, 1984, 84, 10, с. 1470-1474
- [140] Kitamura K. Symposium of new diagnostic procedures in internal medicine. 3. Clinical application of the telemetering method. Nihon Naika Gakkai Zasshi, 1963 Sep 10, 52, pp. 610-616.
- [141] Kitamura K., Yamakura K., Furuya H. et al. [Clinical use of telemetering]. Naika, 1963 Jul, 12, pp. 75-85.
- [142] Klein F. F., Davis D. A. A 4-channel telemetry system for hospital patient monitoring. Biotelemetry, 1976, 3, 2, pp. 98-103
- [143] Ko W. H. Progress in telemetering muscle potentials. Biomed Sci Instrum, 1964, 2, pp. 267-273
- [144] Kobayashi T., Taksuchi M. The clinical application of telemetering. Nihon Naika Gakkai Zasshi, 1963 Sep 10, 52, pp. 616-617
- [145] Konietzko H., Elster I., Vetter K., Weichardt H. [Field studies in solvent-factories. 2. Telemetric EEG-control in solvent factory workers of trichloroethylene-water purification plants]. Zentralbl Arbeitsmed, 1973 May, 23, 5, pp. 129-133
- [146] Kuck A., Liebman F. M., Kussick L. A miniature transmitter for telemetering muscle potentials. IEEE Trans Biomed Eng, 1963 Jul, 10, pp. 117-119
- [147] Kydd W. L., Mullins G. A telemetry system for intraoral pressures. Arch Oral Biol, 1963 Mar-Apr, 8, pp. 235-236
- [148] Leshchinskaya E. I., Shif M. I., Pakhomov A. G., Kolesnikov A. G., Kondratiev R. F. [A device for continuous automatic measurement of pulmonary ventilation parameters of athletes], Elektronika i sport, Mater. nauch.-tekhn. konf., Leningrad, 16-19 April, 1968, pp. 92-93 (in Russian), Лещинская Э. И., Шиф М. И., Пахомов А. Г., Колесников А. Г., Кондратьев Р. Ф. Прибор для непрерывного автоматического измерения параметров легочной вентиляции спортсмена, Электроника и спорт, Матер. науч.-техн. конф., Ленинград, 16-19 апреля 1968 г., с. 92-93)
- [149] Lewillie L., Sneppe R. Telemetric measurement of the respiratory function. Ergonomics, 1968 Jun, 11, 1, pp. 77-81
- [150] Litovchenko V. V., Malinin I. D., Mnatsikan'ian A. Z. [Operative medical control of the status of the pilot in flight]. Voen Med Zh., 1981 Nov, 11, pp. 71-73

- [151] Lota M. J. Portable radio-spirometer for telemetric studies of pulmonary ventilation. Arch Phys Med Rehabil, 1967 Jun, 48, 6, pp. 311-316
- [152] Lyakh Yu. E. [Radiopulsometric characteristics of miners as a basis of their physiological optimization], avtoref.dis...kand.biol.nauk (PhD Thesis), Donetsk, 1975, (in Russian), Лях Ю. Е. Радиопульсометрическая характеристика труда шахтеров как основа его физиологической оптимизации, Автореф. дис...канд. биол. наук, Донецк, 1975
- [153] Manson G. EEG radio telemetry. Electroencephalogr Clin Neurophysiol, 1974 Oct, 37, 4, pp. 411-413
- [154] Marko A. R. Multi-channel personal telemetry system using pulse position modulation. Aerosp Med, 1961 Nov, 102, 32, pp. 1019-1022
- [155] Marko A. R., McLennan M. A., Correll E. G., Potor G., Gibson J. M. Research and development of pulse-modulated personal telemetry systems. AMRL TR, 1963 Oct, pp. 1-19
- [156] Matov V. V. [A study of the distance electrocardiogram in the athletes], Novosti meditsinskoj tekhniki., 1960, 3, pp. 42-45 (in Russian), Матов В. В. Исследование электрокардиограммы на расстоянии у спортсменов, Новости медицинской техники, 1960, 3, с. 42-45
- [157] McPetrie J. S. Telemetry Applied to Engineering and Medicine. Nature, London, 1963 Sept 14, 199, pp. 1047-1048
- [158] Medical and Biological Applications of Space Telemetry. NASA Technology Utilization Report, Nasa, Washington D.C., 1965, pages 69
- [159] Medinets Yu. R., Monogarov V. D. [Multi-channel radio telemetry system to record some physiological parameters in athletes], Nauchno-tekhnicheskaya konferentsiya "Elektronika i sport", Leningrad, 1986, p. 88 (in Russian), Мединец Ю. Р., Моногаров В. Д. Многоканальные системы для радиотелеметрии некоторых физиологических показателей у спортсменов, Научно-техническая конференция "Электроника и спорт", Ленинград, 1986, с. 88
- [160] Miller B. Appolo Bio-Telemetry System Developed. AvMolnar M. Siat Week Space Techn, 1963, 78, 11, pp. 80-81
- [161] Molnar M. S. Telemetry in surgery and anesthesiology, In Medical and Biological Applications of Space Telemetry. NASA Technology Utilization Report, NASA, Washington D.C., 1965, pp. 11-15
- [162] Moore M. L., Farrand S., Thornton W. The use of radio telemetry for electromyography. J Am Phys Ther Assoc, 1963 Nov, 102, 43, pp. 787-791
- [163] Morgenstern J., Czerny H., Schmidt H. An eight channel telemetry system for the transmission of biomedical signals. J Perinat Med, 1978, 6, 1, pp. 59-62
- [164] Morhardt J. E. Temperature transmission from biopotential radiotelemetry transmitters. J Appl Physiol, 1972 Sep, 33, 3, pp. 397-399
- [165] Müller C. [Cardiotelemetry]. Tidsskr Nor Laegeforen, 1965 Apr 1, 85, 7, pp. 628-629 (in Norwegian)
- [166] Münter M., Götze W., Krokowski G. [Telemetric EEG studies during rotator vestibular stimulation]. Dtsch Z Nervenheilkd, 1964 Jul, 6, 186, pp. 137-148
- [167] Murooka H., Fujita K. [Application of telemetry in obstetrics]. Sanfujinka No Jissai, 1966 Jun, 15, 1, pp. 31-34
- [168] Nagasaka T., Ando S., Takai T., Hara M., Takagi K. An analysis of EKG recorded by radiotelemetry on Mt. Aconcagua and in a low pressure chamber at sea level. Nagoya J Med Sci, 1967 Mar, 29, 4, pp. 377-384
- [169] Nevison T. O. Jr. Space flight biotelemetry. Biomed Sci Instrum, 1968, 4, pp. 127-131
- [170] Niebeling H. G., Laux H. J., Thieme W., Killus K. [EEG by phone. 3. Practical application of wire transmission of brain currents]. Dtsch Gesundheitsw, 1967 Jun 15, 22, 24, pp. 1133-1139 (in German)

- [171]Nuwer M. R., Engel J. Jr., Sutherling W. W., Babb T. L. Monitoring at the University of California, Los Angeles. *Electroencephalogr Clin Neurophysiol.Suppl*, 1985, 37, pp. 385-401
- [172]Overweg J., Binnie C. D., van der Geest P., Meinardi H., van Parys J. A., Rowan A. J., Wisman T., Kamp A., Lopes da Silva F. [Clinical evaluation of EEG telemetry and videomonitoring in 212 patients with epilepsy]. *Ned Tijdschr Geneesk*, 1981 Oct 3, 125, 40, pp. 1600-1604
- [173]Parin V. V. (Ed.) [Radio telemetry in Physiology and Medicine], *Mater. II simpoz.* 9-11.12.1963, Sverdlovsk, 1963, p. 189 (in Russian), Радиотелеметрия в физиологии и медицине, Матер. II симпоз. под ред. В. В. Парина, 9-11.12.1963, Свердловск, 1963, с. 189
- [174]Parin V. V., Bayevskyy R. M. [Development of diagnostic criteria and algorithms for medical monitoring] *RGANTD.F.4op.1N d.106 LL*, 1, 21 (in Russian), Парин В. В., Баевский Р. М. Разработка диагностических критериев и алгоритмов для врачебного контроля, РГАНТД.Ф.4оп.1N д.106 ЛЛ.1, с. 21
- [175]Parin V. V., Bayevskyy R. M., Chernyaeva S. A. [Study of new channels of communication between humans and technical systems], М., 1966, pp. 1-22 (in Russian), Парин В. В., Баевский Р. М., Черняева С. А. Исследование новых каналов обмена информацией между человеком и техническими системами, М., 1966, с. 1-22
- [176]Parin V. V., <http://www.imbp.ru/WebPages/win1251/IBMP-50/50-Parin.html>, 2016 (in Russian), Парин В. В., <http://www.imbp.ru/WebPages/win1251/IBMP-50/50-Parin.html>, 2016
- [177]Parin. V. V (Ed.) [Biological telemetry], М., "Meditsina", 1971 (in Russian), Биологическая телеметрия, Под общ. ред. В. В. Парина, М., изд-во: «Медицина», 1971
- [178]Parker C. S., Breakell C. C., Christopherson F. The radio-electrophysiologogram; radio transmission of electrophysiological data from the ambulant and active patient. *Lancet*, 1953 Jun 27, 1, 6774, pp. 1285-1288
- [179]Pessar T., Kroboth H., Yanover RR. The application of telemetry to industrial medicine. *Am J Med Electron*, 1962 Oct-Dec, 1, pp. 287-293
- [180]Pircher L. An instrument for registration of heart frequency at the working place and during sport activity. *Helv Physiol Pharmacol Acta*, 1964, 22, pp. 4-6 (in German)
- [181]Pruett C. E., Shellabarger J. N. Challenge to Missile Range Technology to Military Medicine, *US Navy Medical News Letter*, 1963, 42, 8, pp. P.32- 36
- [182]Ratcliff J. D. *Medicine's New*, Popular Mechanics, 1958 Dec, 110, 6, pp. 77
- [183]Ration D. A., Marko A. R., Kaufman W. C. Description and operating instructions for a 7-channel telemetry system for physiological temperatures and the electrocardiogram. *AMRL-TR-68-140. AMRL TR*, 1969 Feb, pp. 1-18
- [184]Research aviation medicine, *Naval Aviation News*, Feb 1957, pp. 1-7
- [185]Research Concerns Effects of Physical, Mental Strain, *Garden City Telegram*, Garden City, Kansas, Wed, May 8, 1968, p. 9
- [186]Rimskikh E. I., Gofman H. S. S., Turov A. I., Men B. A., Dronov A. P. [Removing the electrograms and processing (EEG, ECG, ...) in humans during normal everyday activity], "Avtomatizatsiya sbora i obrabotki meditsinskoy informatsii i primeneniye biotelemetrii v praktike kurortov", *Mater. II Ukr. resp. symp.*, Kiev., 1974, pp. 53-54 (in Russian), Римских Э. И., Гофман С. С., Тузов А. И., Мень Б. А., Дронов А. П. Съем и обработка электрограмм (ЭЭГ, ЭКГ, ЭОТ) у человека в условиях естественной активности, «Автоматизация сбора и обработки медицинской информации и применение биотелеметрии в практике курортов», Матер. II Укр. респ.симп, Киев, 1974, с. 53-54
- [187]Roach C. J., Eilestad M. H., Lake R. B. Medical Data Processing and Computer Automated Hospitals. *Datamation*, June 1962, pp.25-28.

- [188]Roberts R., Fitch P. Monitoring at the National Hospital, Queen Square, London. *Electroencephalogr Clin Neurophysiol, Suppl*, 1985, 37, pp. 423-436
- [189]Rose K. D., Dunn F. L. Telemeter electrocardiography: a study of heart function in athletes. *Nebr State Med J*, 1964 Sep, 49, pp. 447-456
- [190]Rosenblat V. V. [Radio telemetry studies in sports medicine], М.: Изд-во "Медицина", 1967, p. 208 (in Russian), Розенблат В. В. Радиотелеметрические исследования в спортивной медицине, М.: Изд-во «Медицина», 1967, с. 208
- [191]Rosenblat V. V. [Some urgent issues of development of dynamic bioradiotelemetry], "Автоматизация сбора и обработки медицинских данных и применение биотелеметрии в практике курортов", Матер. II Ukr. resp. symp., Kiev., 1974, pp. 88-89 (in Russian), Розенблат В. В. Некоторые насущные вопросы развития динамической биорадиотелеметрии, «Автоматизация сбора и обработки медицинской информации и применение биотелеметрии в практике курортов», Матер. II Укр. респ. симп., Киев, 1974, с. 88-89
- [192]Rosenblat V. V. [Symphony of Life (a popular human physiology)], М.: Fizkultura i sport, 1989, p. 239 (in Russian), Розенблат В. В. Симфония жизни (популярная физиология человека), М.: Физкультура и спорт, 1989, с. 239
- [193]Rosenblat V. V. [The present and the future of dynamic bioradiotelemetry], *Bioradiotelemetriya, Pod obshch. red. V. V. Rosenblata, Ya. V. Freidina, Sverdlovsk*, 1976, pp. 14-29 (in Russian), Розенблат В. В. Настоящее и будущее динамической биорадиотелеметрии, *Биорадиотелеметрия, Под общ. ред. В. В. Розенблата, Я. В. Фрейдина, Свердловск*, 1976, с. 14-29
- [194]Rosenblat V. V., [Spot activities in the Urals], <http://sportufo.ru/persony/26-persony-r/1367-rosenblat-vladimir-viktorovich.html>, 2015 (in Russian), Розенблат В. В., Спорт на Урале, 2015, <http://sportufo.ru/persony/26-persony-r/1367-rosenblat-vladimir-viktorovich.html...>
- [195]Rosenblat V. V., Povodator A. M., Kuznetsova Z. M., Vepreva V. M., Blokhin A. V., Yanenko B. I. [Dynamic radio-reo pneumography and its application in sports], *Fiziologiya cheloveka*, 1979, 5, 4, pp. 708-718 (in Russian), Розенблат В. В., Поводатор А. М., Кузнецова З. М., Вепрева В. М., Блохин А. В., Яненко В. И. Динамическая радиореопневмография и ее применение в спорте, *Физиология человека*, 1979, 5, 4, с. 708-718
- [196]Rothfeld E. L., Bernstein A., Crews A. H. et al. Telemetric monitoring of arrhythmias in acute myocardial infarction. *Am J Cardiol*, 1965 Jan, 15, pp. 38-44
- [197]Rowen B. Bioastronautics Support of the X-15, *Aerospace medicine*, 1962, pp. 326-356
- [198]Rowen B. Human Factors Support of the X-15 Program, *Aerospace medicine*, Nov. 1959, pp. 816-820
- [199]Rubenstein L. Continuous radio telemetry of human activity, *Nature*, 1962 Mar, 3, 193, pp. 849-850
- [200]Rüther E., Sokol K. [Continuous telemetric surveillance of the fetal heart during labor]. *Arch Gynakol*, 1967, 204, 2, p. 268 (in German)
- [201]Seliger V., Hrdlicka J. [Wireless transmission of pulse frequency] *Prac Lek*. 1965 Apr, 17, pp. 109-111 (in Czech)
- [202]Shafer W. A. Telemetry on man without attached sensors. *N Y State J Med*, 1967 Nov 1, 67, 21, pp. 2832-2837
- [203]Sharp M. R. [Man in Space], М.: "Mir", 1970, p. 200 (in Russian), Шарп М. Р. Человек в космосе, М.: «Мир», 1970, 200 с.
- [204]Shuvatov L. P. [Mico device for radio recording of some physiological parameters], М.: Medgiz, 1959, p. 124 (in Russian), Шуватов Л. П. Микроаппаратура для регистрации по радио некоторых физиологических функций, М.: Медгиз, 1959, с. 124

- [205] Shuvatov L. P., Ermakov V. V. [Biotelemetry system "Sport"], Mater. nauch. konf., M., 1965, pp. 109-111 (in Russian), Шуватов Л. П., Ермаков В. В. Биотелеметрическая система «Спорт», Кибернетика и спорт, Матер. науч. конф., М., 1965, с. 109-111
- [206] Simard J. M., Turbes C. C., Schneider G. T. Three channel brain wave telemetry with automatic noise rejection. Biomed Sci Instrum, 1977 Apr 25-27, 13, pp. 119-122.
- [207] Simmons K. R., Dracy A. E., Essler W. O. Recording uterine activity by radio telemetry techniques. J Dairy Sci, 1965 Aug, 48, 8, pp. 1126-1128
- [208] Simons D. G. Use of personalized radio telemetry techniques for physiological monitoring in aerospace flight. J Miss State Med Assoc, 1962 Sep, 3, pp. 413-420
- [209] Simons D. G., Prather W. A personalized radio telemetry system for monitoring central nervous system arousal in aerospace flight. IEEE Trans Biomed Eng, 1964 Jan-Apr, 11, pp. 40-51
- [210] Slater L. E. Biotelemetry and the physician. N Y State J Med, 1965 Dec 1, 65, 23, pp. 2893-2901
- [211] Smith D. A. R., Gregson R. A. M. Technical Note: The Measurement of Electroencephalographic Functioning During Motor Activity, New Zealand Psychologist, 1979, 8, pp. 28-30
- [212] Stålberg E. Telemetric long-term EEG recording. Electroencephalogr Clin Neurophysiol, 1969 Mar, 26, 3, p. 341
- [213] Stattelman A., Buck W. A transmitter for telemetering electrophysiological data. Proc Soc Exp Biol Med, 1965 Jun, 119, pp. 352-356
- [214] Stevens J. R. Computer analysis of the telemetered EEG in the study of epilepsy and schizophrenia. Acta Neurochir (Wien), 1976, 23 Suppl, pp. 71-84
- [215] Stevens J. R. Localization of epileptic focus by protracted monitoring of EEG by radio telemetry. Epilepsia, 1969 Sep, 10, 3, p. 420
- [216] Stevens J. R., Bigelow L., Denney D., Lipkin J., Livermore A. H. Jr., Rauscher F., Wyatt R. J. Telemetered EEG-EOG during psychotic behaviors of schizophrenia. Arch Gen Psychiatry, 1979 Mar, 36, 3, pp. 251-262
- [217] Stevens J. R., Kodama H., Lonsbury B., Mills L. Ultradian characteristics of spontaneous seizure discharges recorded by radio telemetry in man. Electroencephalogr Clin Neurophysiol, 1971 Oct, 31, 4, pp. 313-325
- [218] Stevens J. R., Livermore A. Telemetered EEG in schizophrenia: spectral analysis during abnormal behaviour episodes. J Neurol Neurosurg Psychiatry, 1982 May, 45, 5, pp. 385-395
- [219] Stevens J. R., Lonsbury B. L., Goel S. L. Seizure occurrence and interspike interval. Telemetered electroencephalogram studies. Arch Neurol, 1972 May, 26, 5, pp. 409-419
- [220] Stevens J. R., Milstein V. M., Dodds S. Prolonged recording of EEG by radiotelemetry: an aid to localization and treatment of epilepsy. Electroencephalogr Clin Neurophysiol, 1969 Nov, 27, 5, p. 544
- [221] Stolbun B. M., Forshadt B. M. [Radio registration of pulse wave velocity in freely moving person], Byulleten eksperimentalnoy biologii i meditsiny, 1964, 29, 10, pp. 116-119 (in Russian), Столбун Б. М., Форштадт Б. М. Регистрация по радио скорости распространения пульсовой волны у свободно передвигающегося человека, Бюллетень экспериментальной биологии и медицины, 1964, 29, 10, с. 116-119
- [222] Straneo G., Taccola A., Andreuzzi P. [Radio-electro-cardiography during exertion for the functional exploration of the heart]. Minerva Cardioangiol, 1963 Aug, 11, pp. 436-440
- [223] Suess E., Goiser P. Miniaturized eight-channel telemetry system for long-term EEG registration of humans and laboratory animals. Eur Neurol, 1986, 25 Suppl, 2, pp. 53-55
- [224] Talbott G. D. Practical problems of using telemetry in intensive-care wards, In Medical and Biological Applications of Space Telemetry. NASA Technology Utilization Report, NASA, Washington D.C., 1965, pp. 5-10

- [225]Tatoyan S. Kh. [Miniature single-channel radio telemetry transmitter for ECG recording in animals and humans], *Fiziologicheskiy zhurnal USSR* im. I. M. Sechenova, 1971, 25, 1, pp. 130-132 (in Russian), Татоян С. Х. Миниатюрный одноканальный радиотелеметрический передатчик для регистрации ЭКГ у животных и человека, *Физиологический журнал СССР* им. И. М. Сеченова, 1971, 25, 1, с. 130-132
- [226]Tejerina R. M. [Cardiac telemetry in miners who work between 4,160 and 4,800 meters above sea level]. *Rev Clin Esp*, 1967 May 31, 105, 4, pp. 273-276
- [227]The North Texas welcomes letters, <http://www.unt.edu/northtexan/archives/s02/feedback.htm>
- [228]Timofeeva T. E., Atselevich V. A. [A device for remote recording of human electrocardiogram], *Novosti meditsinskoj tekhniki*, 1960, 3, pp. 27-41 (in Russian), Тимофеева Т. Е., Анцелевич В. А. Аппарат для дистанционной регистрации электрокардиограммы человека, *Новости медицинской техники*, 1960, 3, с. 27-41
- [229]Tolles W. E. Telemetry in medical research and patient care. *Prog Cardiovasc Dis*, 1963 May, 5, pp. 595-609
- [230]Tomka I. [Electric and clinical aspects of petit mal epilepsy based on telemetric studies]. *Orv Hetil*, 1974 Jul, 115, 29, pp. 1688-1691
- [231]UCLA clinic gets medical data via global network, *The Van Nuys News*, Van Nuys, California, Thu, Feb 8, 1973, p. 54
- [232]Ueda H., Murayama M., Sato C. Medical application of telemetry with special reference to electrocardiography. *Naika*, 1964 Nov, 102, 14, pp. 1119-1139 (in Japanese)
- [233]Van der Weide H., Kamp A. Long-term supervised domiciliary EEG monitoring in epileptic patients employing radio telemetry and telephone telemetry. I. Telephone telemetry system. *Electroencephalogr Clin Neurophysiol*, 1984 Jun, 57, 6, pp. 581-583
- [234]Van Leeuwen W. S., Kamp A. Radio telemetry of EEG and other biological variables in man and dog. *Proc R Soc Med*, 1969 May, 62, 5, pp. 451-453
- [235]Vidart L., Geier S. [Results of tele-encephalographic studies in adult epileptics]. *Rev Neurol (Paris)*, 1969 Jun, 120, 6, pp. 429, a)
- [236]Vidart L., Geier S. [Tele-electroencephalographic study of epileptic adult subjects during a working day]. *Ann Med Psychol (Paris)*, 1968 Jul, 2, 2, pp. 267-274
- [237]Vidart L., Geier S. [Telencephalographic recordings in epileptic subjects during work]. *Rev Neurol (Paris)*, 1967 Sep, 117, 3, pp. 475-480
- [238]Vidart L., Geier S. From epilepsy to the epileptic: a tele-EEG study of adult epileptic subjects. *Electroencephalogr Clin Neurophysiol*, 1970 Jul, 29, 1, p. 103
- [239]Vidart L., Geier S. Radiotelemetric EEG study of adult epileptics. *Electroencephalogr Clin Neurophysiol*, 1969 Jul, 27, 1, p. 108, b)
- [240]Vignaendra V., Walsh J., Burrows S. The application of prolonged EEG telemetry and videotape recording to the study of seizures and related disorders. *Clin Exp Neurol*, 1979, 16, pp. 81-94
- [241]Vincent J. D., Favarrel-Garrigues B., Bourgeois M., Dufy B. [The night sleep of schizophrenics in the early stage of development. Polygraphic study by telemetry]. *Ann Med Psychol (Paris)*, 1968 Jul, 2, 2, pp. 227-236
- [242]Volynkin Yu. M., Gazonko O. G., Agadzanyan N. A., Baevskiy R. M. [Results from medical and biological studies of Space Flights], *Voen.-med. zhurnal*, 1962, 7, pp. 3-9 (in Russian), Волинкин Ю. М., Газенко О. Г., Агаджанян Н. А., Баевский Р. М. Некоторые итоги медико-биологического изучения космических полетов, *Воен.-мед. журн.*, 1962, 7, с. 3-9
- [243]Vreeland R. W., Yeager C. L., Henderson J. Jr. A compact six-channel integrated circuit EEG telemeter. *Electroencephalogr Clin Neurophysiol*, 1971 Mar, 30, 3, pp. 240-245
- [244]Vreeland R., Collins C., Williams L., Yeager C. et al. A subminiature radio EEG telemeter for studies of disturbed children. *Electroencephalogr Clin Neurophysiol*, 1963 Apr, 15, pp. 327-329

- [245]Ware R. W., Kahn A. R. Automatic indirect blood pressure determination in flight. J Appl Physiol, 1963 Jan, 18, pp. 210-214
- [246]Winsor T., Sibley E. A., Fisher E. K. Electrocardiograms by telemetry. Calif Med, 1961 May, 94, pp. 284-286
- [247]Wroe S., Roberts G., Weston R., Gibbs J., Richens A. Video EEG telemetry using an ambulatory EEG cassette recorder. Electroencephalogr Clin Neurophysiol, 1987 Jun, 66, 6, pp. 583-585
- [248]Yazdovskyy V. I. [On the trail of the Universe: The contribution of space biology and medicine to the space exploration], Izd-vo Firma "Slovo", 1996, 200 pages (in Russian), Яздовский В. И. На тропях Вселенной. Вклад космической биологии и медицины в освоение космического пространства, Изд-во Фирма «Слово», 1996, 200 с.
- [249]Yazdovskyy V. I., Bayevskyy R. M. [Medical and biological control in space flight. Vesta], AN USSR, M., 1962, 9 (in Russian), Яздовский В. И., Баевский Р. М. Медико-биологический контроль в космическом полете, Веста. АН СССР, М., 1962, 9
- [250]Yazdovskyy V. I., <http://www.imbp.ru/WebPages/win1251/Congratulations/Yazdovsky.html> (in Russian), Яздовский В. И., <http://www.imbp.ru/WebPages/win1251/Congratulations/Yazdovsky.html>
- [251]Yushchenko A. A., Chernavkin L. A. [The new method of studying the unconditioned and conditioned reflexes of freely moving animals], Sovetskaya nevrapatologiya, psikhatriya i psikhologiya, 1932, 8, pp. 327-332, (in Russian) Ющенко А. А., Чернавкин Л. А. Новая методика изучения безусловных и условных рефлексов, свободно передвигающихся животных, Советская невропатология, психиатрия и психология, 1932, 8, с. 327-332, b)
- [252]Yushchenko A. A., Chernavkin L. A. [The new radiometric technique in psychophysiology of labor], Sots. rekonstruktsiya i nauka, 1932, 1, pp. 217-220 (in Russian), Ющенко А. А., Чернавкин Л. А. Новая радиометодика в психофизиологии труда, Соц. реконструкция и наука, 1932, 1, с. 217-220, a)
- [253]Zemlyakov K., Ivanov D., Fedorov T. [Teleradio installation, recording the heart activity], Voenno-sanitarnoye delo, 1938, 2, (in Russian), Земляков К., Иванов Д., Федоров Т. Телерадиостановка, регистрирующая работу сердца, Военно-санитарное дело, 1938, 2
- [254]Zweizig J. R., Adey W. R., Hanley J., Hahn P. M., Pilmanis A. A., Given R. R., Cockett A. T. EEG monitoring of a free-swimming diver at a working depth of 15 meters. Aerosp Med, 1972 Apr, 43, 4, pp. 403-407
- [255]Zweizig J. R., Kado R. T., Hanley J., Adey W. R. The design and use of an FM-AM radiotelemetry system for multichannel recording of biological data. IEEE Trans Biomed Eng, 1967 Oct, 14, 4, pp. 230-238.