Anton Vladzymyrskyy, Malina Jordanova, Frank Lievens

A Century of Telemedicine:
Curatio Sine Distantia et Tempora

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Introduction

Dear Reader,

The book “A Century of Telemedicine: Curatio Sine Distantia et Tempora” is now in your hands.

“The Past supplies the key to the Present and Future”. These words belong to an ancient historian who understood the necessity of studying history. History tells us how we came to know what we know today. The importance of history was summarized by Marcus Tulius Cicero (106-43 BC), roman writer, politician and great orator almost 2000 years ago: “Not to know what has been transacted in former times is to always remain a child. If no use is made of the experiences of past times, the world will always remain in the infancy of knowledge”. These words are especially applicable to the necessity of studying history of medicine. The latter is much more than the history of doctors, nurses and medical discoveries. The patients are actually the most important part of the broad picture. No doubt, throughout human evolution, health and diseases always were matters of main concern and had a profound effect on human society, shaping it.

This book is an overview of the scientific research in one specific field of the History of Medicine, that one of telemedicine. It is an enriched and adapted version of two previous publications (Vladzymyrskyy A. V., 2011; Dumanskyy Yu. et al., 2013), that already clearly revealed the range and complexity of Telemedicine development over the past 100 years. Yet, the book is not just a duplication of the previous publications. Researchers of telemedicine history will not be disappointed. New facts, theories, and amazing stories from different parts of the world are included. Moreover, some of them were identified even after the present book was ready for print. For example, in 1858 Dr Jabez Baxter Upham, in cooperation with the engineer Moses Gerrish Farmer, doctor William Francis Channing, Mr. Steams, Mr. Kennard and Mr. Rogers, created a telemedical device called «sphygmosphone». It allowed fixing heart pulse as a curve and sending these data via a telegraph. On January 24, 1859 the device was successfully tested, and heart rate data of a Mr. Eugene A. Groux, who suffered from congenital sternal fissure, were sent via wires from Boston to Cambridge (USA). Ten years later, in 1869, Dr. Upham repeated the experiment at the American scientists’ conference. More details, pictures and references about this event we will publish in near future.

Perhaps, at the very beginning it is necessary to clarify what is telemedicine. Telemedicine encompasses diagnostic, treatment and prevention processes within the frame of modern health care services, which are carried out primarily by means of telecommunication and

For decades there was no internationally accepted definition of telemedicine. A study published in 2007 found 104 peer-reviewed definitions of the word (Sood S. et al., 2007). Recognizing this, the World Health Organization adopted the following broad description of telemedicine:

“The delivery of health care services, where distance is a critical factor, by all health care professionals using information and communication technologies for the exchange of valid information for diagnosis, treatment and prevention of disease and injuries, research and evaluation, and for the continuing education of health care providers, all in the interests of advancing the health of individuals and their communities” (WHO, 2010).

In sum, WHO had underlined that telemedicine includes four germane elements:

- Its purpose is to provide clinical support;
- It intends to overcome geographical barriers, connecting users who are not in the same physical location;
- It involves the use of various types of information technology;
- Its goal is to improve health outcomes.

When presenting the history of telemedicine, some authors refer to the attempts to exchange messages related to medical topics by post, sound alarm (drums, bells) and even smoke alarms, in ancient times and in the middle ages. However, we consider such approach incorrect, as we firmly believe in the ultimate connection between telemedicine and electrical and/or electronic telecommunication tools. Thus, when conducting the research on telemedicine history, we have intentionally limited ourselves to the period 1850-1990. We consider that the initial use of modern telemedicine technologies began towards the end of the 1980’s and were further developed in the 1990’s. This complex process of new and recent history deserves a separate, thorough research, and is a topic for another publication. We have predominantly focused our attention on the events and processes that took place before 1990, but it should still be underlined that only the most significant facts were taken into consideration.

In each time period only the most advanced technologies were applied in telemedicine. The development of distant delivery of health care services is the prime result of progress in telecommunication facilities. Thus, history of telemedicine may be presented as the sequence of stages following the progress of telecommunications and of the remote information exchange. In brief, the development of clinical telemedicine could be classified as:
Telemedicine development based on telecommunication tools:
- Telegraph;
- Telephone;
- Radio;
- Television (cable television, with slow scanning, wireless, black-and-white to colour television);
- Satellite-link communication;
- Computer networks, internet;
- Wireless networks and data transfer protocols.

Telemedicine development based on clinical application forms:
- Teleconsultations with oral or short written description of clinical evidences;
- Distant learning (elearning);
- Teleconsultations with medical data remote transfer;
- Computing telediagnosis;
- Biotelemetry;
- Telemonitoring;
- Comprehensive clinical telemedical systems;
- Individual telemedicine (tele-homecare).

No doubt, both tracks are rather conventional, most stages interlace or can exist concomitantly. It is important to emphasize that "the distant delivery of medical aid and healthcare provision by means of telecommunication" itself started to being applied worldwide many years before the idea and understanding of telemedicine were formulated, and the term came into use.

Prior to describing the succession of events and processes, it is necessary to clarify the appearance of the term "telemedicine".

Nowadays the term "telemedicine" is applied for remote delivery of medical services and healthcare provision via computer and telecommunication technologies at any given location, in other words, wherever geographical distance is a critical factor. When this terminology appeared is an interesting question. It is obvious that the application of various electrical and electronic telecommunication tools for medical purposes started in the late 19th century; but the appearance of the specific term marks the semantic start of this phenomenon’s concept.

The Latin prefix "tele-", designating the remote delivery of medical service, was introduced by Willem Einthoven in 1906, when he suggested the term "telecardiogramme" (Vladzymyrskyy A., 2008; Bashshur R., Shannon G., 2009). It should be pointed out that already in the early 1950’s Jacob Gershon-Cohen suggested the term "telegnosis" and "videognosis" designating facsimile X-ray patterns that were received remotely by phone,
radio or television connection (ibid). Around the same time Albert Jutras offered the term "telefluoroscopy" (ibid). However, all these definitions covered a very narrow scope, referring only to radiology, and for this reason they did not reach a wide circulation. The above mentioned scientists will be discussed more in detail in the adequate chapters.

In the 1960s the term "telediagnosis" appeared. It meant distant diagnosis and follow-up of pathology with telecommunication technologies (Fabris U., Ravara A., 1968; McLaughlin L., 1969; Murphy R. Jr, Bird K., 1974). Yet, the obvious incomplete semantic constituent blocked its wide application.

What is to be said about the term "telemedicine"? Many authors dated its origin in 1974, referring to the article of R. G. Mark (Mark R., 1974). However, as we have mentioned in other publications (Vladzymyrskyy A., 2011; Vladzymyrskyy A. et al., 2012 a; b) the term "telemedical technique/technology" was used by R. L. Murphy et al. in 1970 (Murphy R. et al., 1970). But, further historical investigations have forced us to revise even this discovery. In 2014, while working with reference sources, we found that the term "telemedicine" had been used as far back as 1927!

A column of the retrospective articles and letters to the editors were published on page 47 in the newspaper "Greeley Daily Tribune", Greely Town, Colorado, USA, on November 16, 1970. They cited the story of Geo W. Gale “Wants Plane to Change Weather Here”. This information represented a rather doubtful discourse concerning meteorological changes that could be caused by planes. However, the last paragraph was of special interest as the author unexpectedly quotes the following: "If we have telephotography, why can't we have telemedicine, so that you could walk up to the radio machine, drop your dollar in the slot, take down the particular receiver required and apply it to that part of your anatomy where the pain is? (doctors, please snicker)" (Gale G., 1970) (Fig. 1). The cited article was dated December 29, 1927.

It is obvious that this material is not a scientific article. Nevertheless, we record that the term “telemedicine” was used for the first time in a publication in December 1927.
In the scientific literature we have recorded the first use of the term "telemedicine" (to be more precise "telemedical technique/technology") in the article by R. L. Murphy, D. Barber, A. Broadhurst and K. T. Bird, published in the journal "American Review Respiratory Diseases" in November 1970 (Murphy R. et al., 1970) (Fig. 2).

In December 1972 the term "telemedicine" appeared in the description of the telemedical project of the Arizona Medical University (Arizona TeleMedicine Network: Engineering Master Plan, 1972). It was also mentioned in the works of R. G. Mark (1974) and J. S. Gravenstein et al. (1974), in February and July 1974, respectively. Later it was used in numerous publications on space medicine, telemedical system in Puerto-Rico in 1975, NASA reports since 1977, etc.

Fig. 1. Fragment of the note with the term "telemedicine" dated 29.12.1927, author Geo W. Gale

If we have telephotography, why can’t we have telemedicine, so that you could walk up to the radio machine, drop your dollar in the slot, take down the particular receiver required and apply it to that part of your anatomy where the pain is? (doctors, please snicker).

I would like to hear from others on these matters and to be corrected where it is necessary to do so.

Signed: Geo. W. Gale
Tribune, Dec. 29, 1927
Utilizing a telemedical technique which consisted of a 2 way closed circuit television with transmission of the signal by a microwave, comparisons were made of the interpretations of roentgenograms viewed directly and after transmission by the closed circuit system. A remotely controlled pubicon camera with zoom lens focus control was used to obtain panoramic and detailed views of each roentgenogram.

Fig. 2. Fragment of the article, where probably for the first time ever in scientific literature the term "telemedicine" - "telemedical technique" was used

The term "teleconsultation", more specifically "teleconsultation center" was for the first time met in Russian-language literature in the publication of Zigmas I. Yanushkevichus "Teletransmission of phonocardiograms" in 1966 (Yanushkevichus Z., 1966). In 1974 this word was used the publication by E. Quinn (Quinn E., 1974). Later, "teleconsultation" appeared also in NASA reports (since 1977) and several other publications.

Thus, in following years, the remote application of medical care or services was defined by adding the Latin prefix "tele-" ("teleradiology", "telecardiology", "telesurgery", etc.) to common terminology ("radiology", "cardiology", "surgery", etc.). Yet, let’s not forget that this construction was introduced by Willem Einthoven in 1906 ("telecardiogram"). The word "telemedicine" appeared in a publication in 1927 by Geo W. Gale, and it was introduced into the scientific literature by R. Murphy, D. Barber, A. Broadhurst and K. T. Bird in 1970 (Murphy R. et al, 1970; Murphy R., Bird K., 1974).

In sum, telemedicine was brought to life by changes of technology and offered enormous possibilities to improve both access to and the standard of healthcare, and thus to close the gap between the demand for affordable, high quality healthcare to everyone, at any time, everywhere, and the lack of medical personal. Chapters in this book reveal various national and cultural points of view on how telemedicine solutions were developed and implemented in earlier decades.

Finally, the authors would like to underline that:

- The content of the book is divided in chapters covering various areas of telemedicine.
- In the text, after the title of cited papers, a maximum of 3 co-authors are listed, while the rest are marked as “et al.”
References lists are added at the end of each chapter. They contain only the details of the sources cited in the body of the chapter.

The cited sources are listed in an alphabetical order. Part of referring sources is in Cyrillic. In these cases the names of the authors are translated in English. The titles of the references are also translated in English and included in square brackets with a language descriptor at the end. In addition, the source titles and authors’ names are also given exactly as they appear in the original language.

In order to shorten repeated references in the text 2 abbreviations are used. One is “ibid” originating from Latin ibidem, i.e. "in the same place". This repeats the previous author/s and title/s and whatever else is identical. The other one is “idem” from Latin idem "the same". It also indicates the repetition of the previous author/s.

At the end of the book a separate chapter provides a comprehensive directory of people – doctors, engineers, technicians, scientists, etc., that contributed a lot to the development of telemedicine. In several lines their works and achievements are highlighted, while their photos are usually included as illustrations in the chapters.

Despite the amount of information included in this book, no doubt that many events and facts are still out-of-sight. We hope to be able to fill in this gap in the near future.

We hope that everyone involved in telemedicine and eHealth will find this book not only interesting, but most valuable as well. We are open for collaboration, comments and joint researches. Let’s make the origin of telemedicine better known.

Enjoy your reading!

Anton Vladzymyrskyy, Malina Jordanova and Frank Lievens

References


CHAPTER 1
TELEMEDICINE DEVELOPMENT BASED ON MAIN TELECOMMUNICATION TECHNOLOGIES

In the early period of telemedicine applications, telegraph, telephone and radio connection were the main available telecommunication technologies for its implementation. Taking into account that precisely these facilities in one or another form were the main tools for information exchange during several decades, we recognize them as the basic tools during the start-up of telemedicine. It is necessary to underline that telephone has remained one of the most consistent equipment for medical information exchange, whereas radio is still being used today in transport telemedicine.

1.1. Telegraph Communications in Telemedicine

Telegraph was the first electrical telecommunication tool in the history of humanity, which provided "globalization", i.e. free communication and information exchange between any points on Earth. This type of communication is now called the "Victorian Internet" (Standage, 1999), because, for the first time, thanks to telecommunication people stopped living isolated and could "reach" any part of the globe.

In the 1860s, in the USA (the southern states, the Confederation), William S. Morris and Albert James Myer (Fig. 1.1) worked on the development of a national system of telegraph communications in war conditions. Both were medical doctors. At that time W. S. Morris was the head of the military telegraph service, while A. J. Myer invented his own system (wigwag) and special cart for providing and conducting telecommunication between the troops (http://www.mercurians.org/1999_Spring/flashback.htm). It was Myer who proposed using the telegraph for military and medical purposes such as asking for medical supplies on the front line, ordering the required quantity of bandaging materials and medicines, specifying the delivery points, coordinating the transport of patients, etc.
The first documented case of the use of telegraph for medical purposes (carrying out teleconsultation) was recorded in Australia in 1874. On Sunday 22 February 1874, the Barrow telegraph station Creek (280 km north of Alice Springs) was attacked by aborigines from the Kaytetye tribe, provoked by what some said was poor treatment of their women by white men on the fence of a water hole (Eikelboom, 2012). As a result of the attack, one employee of the station was killed, three more were wounded, and James L. Stapleton was deadly injured. A surviving policeman, Samuel Gason, sent a message about the incident via telegraph to Adelaide: “This Station has been attacked by natives at 8:00 o’clock. Stapleton has been mortally wounded, one of the men, named John Franks, just died from his wounds. Civilized native boy has 3 spear wounds. Mr. Flint, assistant operator, one spear wound in the leg, not serious. Full particulars in the morning” (Eikelboom, 2012). Doctor Charles Gosse came at night at the Adelaide telegraph station to make a distant consultation for the seriously injured J. L. Stapleton. The newspaper “South Australian Advertiser” wrote on 24 February, 1874: “We are informed by Mr. Todd that on Sunday night Dr Charles Gosse (Fig. 1.2), at his request, went to the Telegraph Office and gave instructions as to the proper treatment of the wounded, and up to about 11 o'clock all were progressing favourably. Later in the day, however, a change for the worse took place in Mr. Stapleton's condition, and notwithstanding all the assistance that was possible to render him, he sank under the effect of his injuries, and died, very quietly, at a quarter to six in the evening”. The spouse and children of the dying man were also in Adelaide during the incident, and according to newspaper publications, they kept in contact with their unfortunate relative by telegraph till the last moment (Fig. 1.3).

Another important participant in this story is the founder of the national system of cable communication in Australia (so-called Overland Telegraph), Charles Todd. After receiving the telegram about the tragedy, he personally invited Stapleton’s family in the telegraph office, and also organized the participation of Dr. Charles Gosse for distant consulting.
According to publications, Charles Todd was working closely with state worker and surgeon William Christie Gosse who was the doctor’s brother (Eikelboom, 2012). So, according to R. H. Eikelboom’s paper, the first documented case of telegraph use for teleconsultation is recorded on February 22nd-23rd, 1874 as distant consultation between Barrow Creek and Adelaide (Australia) led by Doctor Charles Gosse and probably his brother – surgeon William Gosse (ibid).

Back to the military medicine - the idea of Dr Myer gained motion in the first half of the twentieth century. Telegraph communications were widely used during war conflicts both for organizational issues of medical help and for teleconsultations. Here are some examples from army medical officers’ memoirs.

**The Russian-Japanese War (1905, Vikenty V. Veresaev, Fig. 1.4)** (Veresaev, 1986):

"The telegrams from army medical head officers were reaching the barracks over and over again: to evacuate four hundred people immediately, another one for evacuating seven hundred people immediately. The command, subject to insane delirium, could think only about one thing: to send the wounded as far away from the front as possible and in the shortest period of time..."
"...Soldiers started catching ... Siberian plague. These cases happened in our crew, too. The paper machine started to work, the telegrams were sent off from us to all directions and in reply the telegrams with strict orders came back to us: "to isolate", "to apply thoroughly disinfection", "to report about the measures taken"... We did everything and reported..." "Suddenly, at nine in the evening we received the telegram from our corps doctor, on the corps commander's order to evacuate all the wounded from the hospital, to pack spare government property and take away to the North..." (Veresaev, 1986).

The First World War (The German War, 1914-1918):

"A telegram addressed to my name has been received from the division headquarters: "To conduct medical examination of the 70th and other divisions located in Kzhishov".

"...Have you got little work to do? Help me, for Christ sake! A telegram was received. I am sending the wounded in seven trains. Though I have got just one medical attendant ... Take upon you arrangements for hospital admissions..." (Voytilovskiy, 1998).

The Secon World War (The Great Patriotic War) (1941-1945)

Numerous descriptions of teleconsultations, including the help of telegraph and teletype connection ("Baudot machine", Fig. 1.5), were given in the army diary of the great surgeon, academician Aleksander A. Vishnevsky (Fig. 1.6) (Vishnevskiy, 1970).
"...I went to Bryansk to connect with Moscow by telegraph. I was very successfully connected and was directed to Smirnov at once. He gave the exact instructions concerning what to do in priority and promised to comply with all our requests, putting us in charge of the hospitals of the Orlov Military District. Then, he informed where the frontline medical supplies storage was located and the numbers of the hospital trains transferred to us ... I always have some strange feeling, when "talking" using "Baudot". It is a wonderful device... I have just remembered Ukhta and the way I myself and Gurvich, Director of Health Services of the 9th Army, called up Smirnov and asked him the permission to plaster the wounded with extremity bone injury..."

"In the morning I performed an operation... Came back to Olonets, where I was immediately handed over a telegram: "Ushakov feels bad, consecutive hemorrhage from the residual limb, there is no granulation tissue in the wound". I told by phone what to do."

"Then a telephone call from Vidlitsa was waiting for me about the wounded with purulent pericarditis".

"I have received the telegram that Koryagina is bad. I am sure that it is nothing serious, and posted that leakages were impossible. They undid her entire wound but found nothing..." After the operation debriding the heart, during a week A. A. Vishnevskiy regularly received messages by telegraph about the health status of the patient (Vishnevskiy, 1970).

An interesting fact about the use of telecommunication for examining the wounded is mentioned by A. N. Babiychuk (Babiychuk, 1979): "...It has become more complicated to administer medical aid to the wounded pilots, who landed outside their airfields. The senior physicians from the air regiments dealt with their searching... For this purpose they used primarily communication facilities, which were available in the air regiments and divisions (telephone, radio, telegraph). The constant air surveillance was carried out by duty medical officers and by military officers of airborne surveillance and warning posts. Besides, we also received information from the flying crews, who were coming back from their combat missions..."

In the 1940s, in Germany, telegrams and telegraph communications were used to inform about epidemic and dangerous contagious diseases (http://www.holocaustforgotten.com/eugene.htm). The above described telecommunication facilities were also used in civil medicine.

There are reports of the use of telegraph communications for doctor home visits in the 1900 - 1920s (Doctor - Homeopath, 1914).

In 1929 photographic prints of two dental radiographic images were published, which had been transmitted by telegraph (involving Western Union Telegraph). The high quality of the images was pointed out (“Even
the filled root canals are seen clearly...”). This service was offered as commercial distant consultations for dentists (Kantor, 2005; Sending Dental X-rays by Telegraph, 1929), however, there is no available information about the further development of this technology.

A funny fact can be cited, too. Telegraph devices of Baudot system present some analogy with the modern social media – an hours-long “talkie-talkie” (in modern terms - chatting) feuilleton about of two telegraph operators (to be more precise "Baudot operators") from Kiev and Moscow was published by M. A. Bulgakov in 1925 (Bulgakov, 1992).

Telegraph communication played an important role in the understanding of the significant role of global telecommunications in the development of society in general and in healthcare service in particular. It was a basic telemedicine tool in the late nineteenth century and in the first third of the twentieth century, especially during war conflicts.

1.2. Radio Communications in Telemedicine

1.2.1. The formation of Air Medical Service in Australia

A sad story happened in August 1917 in the town Halls Creek, Western Australia. A twenty-nine-year-old farmer Jimmy Darcy was seriously injured, having tumbled off a horse during cattle grazing. His mate was taking the injured to the nearest town Halls Creek for 12 hours, having covered over 75 km. There was neither a hospital nor doctors in the town at all. Then a post clerk F. W. Tuckett connected with Doctor John Joseph Holland by telegraph (Fig. 1.7), who was in Perth at that time. Having heard the description of the patient's state, the doctor diagnosed the case as urinary bladder rhexis. Jimmy Darcy needed an urgent operation. A short and dramatic dialogue between the clerk and the doctor followed. Within a few minutes Tuckett operated the injured, using a penknife, a razor and potassium permanganate. In the course of the surgical intervention he called the doctor from time to time and was instructed how to do the next step in the operation. Following the telegraph consultation John Joseph Holland traveled the long road to his patient. He covered more than 5 000 kilometers in 11 days, getting to his destination by boat, car, on horseback and even on foot. Arriving in Halls Creek, the doctor found out that poor fellow Darcy died the day before due to malaria, but not as a consequence of surgical complications. The doctor conducted autopsy and
stated that the operation had been performed correctly. In his diary doctor J. J. Holland wrote: "The news disappointed me more than I could expect. I felt that I had lost somebody very close and dear to me" (Classic episodes in telemedicine, 1997; Evans, Roges, 1999; John J. Holland 2015) (Fig. 1.8).

This sad story was on the front pages of the world newspapers. For the first time the problem of medical assistance in remote and isolated residential areas came to the forefront. The tragedy inspired the reverend John Flynn (Fig. 1.9.) to create the world's first Medical Aviation Service in Australia. Ten years later, in 1928, upon his initiative, Aerial Medical Service (AMS) was organized. It is remarkable that J. Flynn combined distant consultations (by means of radio and telegraph) and doctors' air travel to patients. It took several years to organize this regular service. Now a physician can reach out to seriously ill patients quickly at any point on the Australian continent. J. Flynn supposed that the availability of "radio communication in every inhabited locality” could make AMS 75% useless" (National Archives of Australia, 2015; Royal Flying Doctor Service 2015; The John Flynn Story 2015; Turner 1935; Western Australia 2015).

Fig. 1.8. The grave of Jimmy Darcy, the ruins of the post-office, where the famous telegraph consultation and operation took place (Halls Creek, Australia)

Fig. 1.9. John Flynn (25.10.1880-05.05.195)
However, the problem of electricity supply under wildlife conditions was crucial. It was solved by Alfred Hermann Traeger (McKay 1995) (Fig. 1.10), who worked out the so-called "pedal radio" (a dynamo generator with pedal drive that was used for electricity supply, Fig. 1.11-1.13). At first this ingenuity allowed exchanging messages by means of the Morse code and later, after 1930, also by means of voice messages. In the 1940s the distant
medicine was really implemented in AMS. All inhabited localities were equipped with standard sets which contained large supplies of medicines and medical tools.

Fig. 1.13. The original panel (working place of a consulting physician for conducting of teleconsultations over the radio), Australia, the 30s of the XX century

Fig. 1.14. The pedal radio station of Aerial Medical Service was used for radio teleconsultations, Australia, the 30s of the XX century (photo by Scott Weatherson)

Fig. 1.15. An operator is using radio to connect with AMS (Broken Hill, Australia, 1955), photo from the History of Medicine collection (NLM), record UI 101407146 http://ihm.nlm.nih.gov/images/A24425

Now a physician, having received an illness description over the radio, would just have to indicate the required medicines or tools and administer the therapy. The combination of medicine, aviation and radio is called
"social revolution", which enabled to change fundamentally the healthcare system in Australia. Today this organization, which is using telemedicine very actively, is called Royal Flying Doctor Service (McKay 1995; Royal Flying Doctor Service 2015) (Fig. 1.14-1.15).

So, in the 1920s in Australia, the Aerial Medical Service was established, equipped with standard widely available telecommunication facilities. The given model of the healthcare service organization became so efficient that it is still used up till now in many countries of the world (naturally, in relation to the level of communication facilities and medicine progress).

1.2.2. Marine telemedicine

No wonder that radio communication gained a widespread circulation in marine telemedicine. An episode of radio teleconsultation, which was held on January 2, 1911, was described as follows: Captain McGray of the steamer *Herman Frasch* was stricken with serious ptomaine poisoning. A member of the crew asked the USA naval base in Dry Tortugas for help over the radio (the distance between two points was about 100 miles). His message was received on board the *Merida*, which was 800 miles away close to Yucatan. The surgeon of this ship gave his recommendations, thanks to which the captain was given the correct medicine and recovered quickly. The improvised teleconsultation occurred between the two vessels, earlier than the naval base replied (Important Events in Radiotelegraphy, 1916).

In 1920 in the hospital of Haukeland (Bergen, Norway) for the first time radio teleconsultations were held for seamen. Physicians not only made remote diagnoses and recommendations for treatment but also guided complicated surgical operations via Bergen Radio (Rafto T., 1955).

In 1949 two doctors of this hospital - Jon Reinert Myhre and Johannes Boe - established a special service for marine radio consultations (Fig. 1.16-1.17).

J. Boe left the hospital and the country after a while, and Dr. Jon Myhre continued rendering the service single-handed during 35 years. Primarily, the enthusiastic doctors worked for free, but after some years they started to get sponsorship from the Naval Department of the Royal Norwegian Ministry of Trade, and then from the National Social Security.

In 1984 Dr. J. Myhre retired, and the service, now called “Radio Medico Norway”, was headed by Prof. Aksel Schreiner together with Prof. Alfred Halsteinsen, Erik Florvåg and Dr. Kjell Gisholt (Norwegian Center for maritime Medicine, 2016).
In 1920 in New York (USA), upon the initiative of Captain Robert Huntington, the world's first service of marine radio consultations was arranged on the premises of the Seamen’s Church Institute. At the beginning of his marine career Robert Huntington gained hard experience. As second officer on a small trading vessel, he had to manage and steer the ship by himself for several days, because the whole crew, including the captain, were infected with yellow fever. People were suffering and dying, without any chance to get at least some medical aid. Huntington had not only to steer the ship, but also to look after the seriously ill mates (Coulter, Stone, 1937; Medical Advice by Radio at Sea 1925).

During almost thirty years the question “how to help seamen?” remained open. And the answer came only after the invention of the radio and when on November 3, 1920 at the Seaman's Church Institute, Robert Huntington (a principal of the Merchant Navy School, Head of the courses of medical and first aid help for seamen and a Navigation teacher) organized the service for radio consultations at sea for crews of merchant vessels. (Fig. 1.18-1.19) (Captain Hintington Retires, 1942).
The initial idea was heartedly supported by the superintendent of the Institute Dr. Archibald R. Mansfield, and the financial grant for its realization was donated by a businessman, Henry A. Laughlin. The radio station with the call signal KDKF was located in the Institute building. At the beginning it provided consultations every day from 9.00 to 17.00, and starting April 20, 1921, it went on around-the-clock. After one year, the Radio Corporation of America and the Health Service joined the project. Radio medical consultation service had improved its own infrastructure by involving all coastal radio stations and a telephone connection with the New York Naval Hospital. All radio teleconsultations were provided to seamen free of charge. Initially, only the staff of the Institute provided all radio consultations, however, during the next 5 years, naval hospitals, organized by the public health service system, joined the network, as well as medical centres in Columbia, Panama, Costa Rica, Norway and Sweden. Consulting physicians had to deal with contagious diseases, traumas, acute surgical pathologies and even with childbearing. In the course of time a special doctor's bag was developed, which allowed to improve partly...
teleconsultations: seamen could follow the instructions carefully, using the standard doctor's bag with medications and instruments (Covers Seas with Medical Aid by Mary Phillips, 1926; Medical Advice by Radio at Sea, 1925). Also, a special manual on emergency aid under the conditions at sea was written up (Fig. 1.20 - 1.23).

Fig. 1.21. Dr. Ezra K. Sprague (New York Naval Hospital) is conducting radio teleconsultation for an ill seaman. A liaison officer is providing medical wireless consultation services; coastal radio service, where medical messages came in (Seamen’s Church Institute, 2016; The Original Radio Outfit, 1923; When Radio Turns Doctor, 1925)
Captain Robert Huntington used to say: "It does not matter, where a vessel can be, after a captain asks for help over the radio, an ill seaman can get the most qualified medical consultation within 13 minutes".

On February 16, 1935, in Italy, the International Medical Radio Centre (Centro Internazionale di Radiocomunicazione Mediche - CIRM) for providing distant medical assistance to seaship crews and island inhabitants (Fig. 1.24) was founded upon the initiative of Prof. Guido Guida (Fig. 1.25).
The famous scientist Guglielmo Marconi became the first President of the Centre (Fig. 1.26) (Guida 1968).

According to recollections of his contemporaries, Guida's idea of the centre foundation was connected with his childhood impressions - his father was a seaman and he told many horrible and tragic stories about ship crews dying of different injuries and diseases at sea. In some sources it is said that Guido Guida's father died of bleeding at sea. In 1935 Guido Guida (an otolaryngologist by occupation) put together a squad of like-minded people, who agreed to provide seamen with consultations free of charge. Doctors M. Acqua, A. Bensoir, G. Bernieri, F. DeGennaro, G. DiBlasi, M. DiRorai, A. Dubinsky, G. Goretti, F. Gruccione, V. Lanza, E. Lipani, G. Mavagna, P. Monchi, G. Musti, L. Priore, A. Razza, A. Rizutti, Sallustri, Sciafra, A. Scontrino, B. Sparacio were among the volunteers (Amenta et al. 1996; Centro Internazionale Radio Medico 2016; Library of Congress 2016; Modern Mechanics 1953; Rizzo et al. 1985).

On April 7, 1935 CIRM received its first message in Morse code from the Italian steamship, the Perla, which made possible distant consultation between the ship captain and the CIRM medical team. Later on, CIRM received the call signal "Medrad". During World War II the activity of the centre was interrupted. It was reopened in 1946 (Fig. 1.27).
extremely important centre existed only thanks to its founder - Professor Guida paid all expenses himself.

And only in 1955 the Italian government started providing financial support for CIRM. Thanks to the new budget the centre developed and in 1957-1958 a scientific department was established there, which enabled to move on from simple teleconsultations to the study of seamen's occupational pathology. A scientifically based conception of medical assistance at sea was developed (Blisters are laid to butterfly dust 1948). The staff of consulting doctors was enlarged to 50 physicians, who had to deal with the widest range of diseases and injuries. Once, experts had to guide the actions of a captain's mate of one of the merchant vessels over the radio, which had to perform appendectomy on a sailor. In 1948 Prof. Guida consulted over the radio a seaman with the symptoms of acute allergic response to butterflies: a tanker was sailing from Venezuela to Sweden, when, in the Caribbean Sea a big swarm of insects "attacked" the ship, as a result one of the crew got high fever, blisters and ulcers on his skin. After the administered treatment according to the radio consultation, the seaman recovered (Blisters are laid to butterfly dust 1948). It is known that in 1959 the doctors of CIRM conducted 7 055 radio teleconsultations and more than 9 000 in 1978. The unique work of Prof. Guida was recognized by the WHO in 1965. It was not until the end of the 1960s that Guido Guida published CIRM working experience (Guida 1968) (Fig. 1.28).

CIRM continues its activity nowadays as well. Dozens of thousands of radio teleconsultations have been conducted since that time (Guida 1968; Amenta et al. 1996; Centro Internazionale Radio Medico 2016; Library of Congress 2016; Modern Mechanics 1953; Rizzo et al. 1985)
The results achieved by the CIRM over 61 years include medical assistance to 42,935 patients on board ships (as well as on small islands and

Fig. 1.27. Prof. Guido Guida while giving teleconsultation using the radio station (Italy, the 1930s) (Amenta et al., 1996; Centro Internazionale Radio Medico, 2016; Library of Congress, 2016; Modern Mechanics, 1953; Rizzo et al., 1985)

Fig. 1.28. A doctor on duty at CIRM is teleconsulting over a wireless telephone. A telecommunication operator is assisting the physician in his activity

“The results achieved by the CIRM over 61 years include medical assistance to 42,935 patients on board ships (as well as on small islands and
aircraft) with 37,526 medical messages received and transmitted. In terms of the number of patients assisted by radio, the Center is the foremost organization in the world. During the years before World War II, there was an average workload of about 60 cases and 250 medical messages per year. This rose steadily, to peak during the early 1970s at an average of about 1,400 cases and 11,000 medical messages per year. Since then it has declined slightly to its present volume of about 700 cases and 7,000 messages per year. The reduction in the number of cases can be attributed to the growing number of national radio medical centres around the world, and to the decrease in the number of sailors at sea due to the high degree of automation on modern vessels, a factor which also helps the shipping companies to select personnel in good psychological and physical health” (Amenta et al., 1996).

Centers of marine telemedicine have been established and operating efficiently following the CIRM example all over the world. It is almost unknown that since February 2, 1931 the Cuxhaven Medical Center (Lower Saxony, Germany) operates as a hospital-based radio medical advice center for ships worldwide. This center is known as Medico Cuxhaven.

Fig. 1.29. Meinhard Kohfahl (13.03.1926-01.08.2013, Germany; “Father of the Naval Medicine in Germany”, (Flesche et al., 2004; Meinhard Kohfahl, 2016; Kohfahl, 2016)

Fig. 1.30. Biotelemetry from the rescue boat “Hermann Ritter” to Medico Cuxhaven, 1978. Medical kit on the rescue boat: box with medications and tools, respiratory machine, and tele-ECG device, 1990 (Germany) (Flesche et al., 2004; Meinhard Kohfahl, 2016; Kohfahl, 2016)
For a long time this task was performed on an honorary basis by the hospital's physicians. Only in 1994 Germany accepted the International Maritime Organisation and International Labour Organisation resolution 164. Therefore, in 1998 a formal contract of the German Ministry of Transport officially installed Medico Cuxhaven. In the 1950s, Dr. Meinhard Kohfahl (Fig. 1.29) developed a special check-list (algorithm) for radio medical advising which made teleconsultations much more efficient (Fig. 1.30). In 1976 he and Dr. Peter Koch developed a special medical kit (box) for sea vessels. This kit allows procuring aid at sea more easily and safely, especially during radio consultations when there is no doctor on board. In the 1970s Medico Cuxhaven team (under supervision of Dr. Koch and Dr. Kohfahl) started to develop a biotelemetry system of twelve-lead ECG, blood pressure, CO₂, SaO₂, pulse and respiration rates. In general, more than 42 000 radio teleconsultations were lead by Medico Cuxhaven between 1960 and 2005 years (ibid).

In the context of the marine telemedicine one must also mention a telemedicine system, which was developed in Greece approximately in 1946 by Skevos Georges Zervos, Prof. of History of Medicine at the School of Medicine at the University of Athens (Fig. 1.31).

Using radio station with microphones, dynamic speaker, headphones and special recording device, Professor Zervos performed broadcasting of auscultation of lungs and pulse. In 1946-1956 a new technology was demonstrated repeatedly at the meetings of the Athens Medical Society and other scientific and practical events, when telemedicine sessions were conducted between different cities.

Fig. 1.31. Skevos Georges Zervos (1875-1958 or 1966)

Fig. 1.32. Professor Skevos Zervos is performing "tele-examination" by means of radio connection (Athens, Greece, 1936)
Professor Zervos affirmed that he could “broadcast auscultation of lungs and heart rate to any point of land and sea, without any doubt, absolutely distinctly. This special tele-examination is of utmost importance for humanity” (Fig. 1.32) (Autobiography of Skevos Zervos, 2003). It was proposed to use the system of "tele-examination" on marine vessels, cruising across the Atlantic Ocean from Piraeus to New York, and also to hold teleconsultations between Athens and Paris. However, according to Professor Zervos himself, because of "heartlessness and criminality... of the state science" at that time, the project was not put into action.

In the middle of the XX\textsuperscript{th} century, the services of marine teleconsultations operated in all countries of the world. For instance, in Great Britain free service of radio marine teleconsultations was founded in 1964. In the first year it conducted 365 teleconsultations. In addition to KDFK, in the USA, marine consultations were conducted by coast guard (AMVER service from Atlantic Merchant Vessel Report). In 1963 they conducted 240 sessions.

The experiments with biomedical information transmission from the sea to coastal medical centre can be considered as a separate chapter in marine telemedicine. There is a report about radio transmission of auscultation of heart beating in 1921 by S. R. Winters from the United States Navy board to the coastal medical centre.

In 1964 a team consisting of Dr. Albert-Jean Monnier (SS France liner), Prof. Irving S. Wright, Dr. Donald J. Cameron (both from medical college of Cornell University, New York, USA), Prof. Jean Lenegre, Dr. Bertrand Coblentz (both from Paris University, France) made it their mission to carry out transmission of ECG and X-ray images from sea to shore (Monnier et al., 1965) (Fig. 1.33-1.34). The transmissions were carried out from the SS France liner in New York and Paris by means of national telecommunication companies. Technically the process of image transmission (in fact, scanned X-ray patterns and ECG curve tapes) represented facsimile transmission (Fig. 1.35). The pilot testing was performed in July and August 1964, ECGs were transmitted on November 13 and 27 in the same year. After first successful sessions the liner changed its location in the ocean several times, but the transmission was properly repeated. In all cases the quality of the medical information received on the continents was similar (Fig. 1.36). The overall time of the marine teleconsultation using facsimile transmission was about 1.5 hours (from the start of the image delivery to the moment of its receiving by an expert), the further case discussion was held over wireless telephone.
On June 14, 1965 ECG was transmitted from the *SS France* to New York. It was retransmitted to Doctor Jean Lenegre in Paris via the "Early Bird" satellite. The data quality was good enough for interpretation, and the consultant informed over the phone the analysis results to Doctor Albert Jean Monnier, the head of Maritime Medical Service. As such, the researchers proved the possibility of qualitative telediagnositics by means of facsimile and radio transmissions. This case focused on X-ray patterns and ECG, because cardioligic pathology and bone fractures were considered the most widespread problems in marine medicine.

Similar experiments were held by the team under supervision of Doctor Winsor on September 17, 10 and 25 and also on December 1, 1964, performing facsimile transmission of medical data at different distances between sea vessels and the a shore.
Albert-Jean Monnier himself informed about this fact, with reference to the oral conversation with T. Winsor on February 8, 1965 (Monnier et al., 1965).

Fig. 1.36. Facsimile of X-ray pattern and ECG, transmitted from the SS France liner to New York and Paris on 27.11.1964 (Monnier et al., 1965)

Fig. 1.37. Examples of medical transmitted for teleconsultations in RMDS system (USA, 1982)

Between 1972 and 1982 (or possibly longer) in San Diego (California, USA) the "Navy Remote Medical Diagnoses System" (RMDS) was established for teleconsultations between coastal points and marine vessels. Will T. Rasmussen, Ilya Stevens, F. H. Gerber, Jayne A. Kuhlman, J. Silva were the authors of this telemedicine system. Black-and-white slow-scan television communication and biotelemetry were applied for the exchange of X-ray patterns, ECG, auscultation (electronic stethoscope) and other physiological data. Satellite technologies and radio served as communication means. The marine vessels Juneau (LPD-10), Fort Fisher (LSD-40) and Alamo (LSD-33), located on the southern coast of California
and on the western part of the Pacific, participated in the first system testing. The exchange of audio- and video-information between the vessels and the coast (Regional Maritime Medical Centre in San-Diego) was performed successfully with the help of the above mentioned technologies and involving telecommunication stations in the Philippines (Bennett, 1978; Stevens and Rasmussen, 1962) (Fig. 1.37).

Based on the results of the testings, the system was improved, special terminals for radiological image exchanges were developed; a retesting was involving the Enterprise (CVN-65). The authors undertook a thorough study of diagnostic value, specified scientifically based technical requirements, as a result of which the system was widely introduced in the form of telemedicine network between the naval medical centres in California, San Nicolas and San Clemente Islands. The network worked irregularly; for instance, 37 ECG of 18 patients were transmitted for teleconsultations from March 1977 to November 1979 from San Nicolas Island, whereas in San Clemente Island the terminal was almost not used and soon it was dismantled. In general, the system was acknowledged as the most efficient for preventative medicine in the isolated and remote localities with the focus on teleradiology.

In the 1980s in the USSR, at the Main Military Clinical Hospital named after N. N. Burdenko, the establishment of the common Naval Consultative Medical Centre, automated management systems were introduced to support the medical service. In average, more than 50 consultations to the stuffs of marine vessels and submarines were conducted annually. Regular day-and-night duty was provided (Main Military Clinical Hospital. NN Burdenko, 2016).

So, radio communication remains one of the basic telemedicine facilities. Medical Aviation Service combined with radio communications represents an efficient model of medical aid arrangement under certain geographical conditions. This mode of communications was used actively in hard-to-reach areas and isolated districts till the 1960-1970s, i.e. until alternative satellite transmission facilities appeared. Naval medicine services have been operating on the basis of the radio (since the 1920s up to now).
1.2.3. Radio communication in distant medical learning and management

In the 1930-1940s radio broadcasting, dedicated to different issues of the healthcare system, became popular. Radio was used in training of physicians and in holding distant round tables on different clinical questions, popular radio shows for the public were organized (Anterior poliomyelitis, 1939; Bauer, 1935; Blanchard, 1937; Turner et al., 1935). It is worth mentioning that as early as 1939 the statement concerning inadmissibility of advertising for medicines and self-medication propaganda by mass media (radio) was discussed by medical communities (Joint Committee on Professional Relations, 1935). Later, in the USA, academic teaching hospitals began creating their own wireless networks, which were used mainly for educational purposes (Fig. 1.38).

For instance, they were operating in Philadelphia under the supervision of Doctor Fred Richardson, in North Carolina (Dr. William P. Richardson), in Ohio (Drs. John A. Prior and William Pace), Utah (Dr. C. Hilmon Castle), California (Dr. Seymour M. Farber), in Maryland (Dr. Fred J. Heldrich), in Wisconsin (Dr. Thomas S. Meyer) (Woolsey, 1960).

Starting from 1955, radio connection was used in Albany (NY, USA) to implement distant learning (Fig. 1.39). The equipment was placed in the local medical college and in 24 hospitals, the total audience of the daily 20-minutes' lectures with the subsequent interactive discussion counted 200 physicians (not including the interns and residents) (Hospital hookup saves much travel, 1957). This work was carried out under direction of Dr. Frank M. Woolsey Jr. (Associate Dean, Professor and Chairman, Department of Postgraduate Medicine). Initially, an amateur equipment set was used, but in 1957 a professional radio center was created at the college (Nelson, 1958; Woolsey, Strauss, 1964; Woolsey, 1958; 1960; 1967; Woolsey, Ruhe, 1956).
Later 5-7 medical universities joined the program. The hospital network was constantly enlarging, up to 800 physicians could take part in the interactive teaching radio conferences simultaneously. The evident disadvantage of such type of teaching was the absence of visual aids. This problem was solved by sending out beforehand copies of tables and illustrations, which were carefully listed. The audience could watch such "charts", following the instructions of the reader (ibid).

In 1973, in Ohio, a microwave radio network was applied for medical data exchange between five hospitals. Several years later closed-circuit television network replaced it, which allowed making color video conferences (Stamford radio unit to aid 5 hospitals, 1973).

Between 1975 and 1989 the Mexican government established the radio network «IMSS-Coplamar» for health care coordination and epidemiological control in isolated areas (Decree decentralizing to the state governments … 1984; DeEsparza, 1985).

1.2.4. Emergency radio communication by amateurs

In the 20th century, radio amateurs from all parts of the world made a certain contribution to the development of medical telecommunications. A number of episodes are known where in cases of natural or technologic disasters, some territories practically lost communication with the outside world. The simple voice communications (via amateur, so-called “ham”, radio stations) were used for spreading information, coordination of rescue
teams, simple teleconsultations and management of emergency care (including the evacuation of victims).

The earliest episode (non documented) of amateur radio use in an emergency situation happened in 1906. Barney Osborne set up and operating amateur wireless station which he used to pass on emergency traffic after the huge earthquake and fire in San-Francisco (April 18, 1906). The information is from the family archives (Fig. 1.40) (Lee 2016).

The first real documented case dates from 1913. Herbert V. Akerberg was the first person reported to use amateur radio in disaster relief (this fact was recorded). As a 15 year old, Herbert used his modest radio to transmit information to the Overland radio station in the Huntington Bank Building near the Columbus, Ohio, City Hall in March 1913 during a terrible flood. During three days the young man was on duty at his radio set, in communication with the “outside” radio station, sending messages to the mayor and keeping the public advised as to the conditions in the devastated areas (Fig. 1.41-1.42) (Tebben, 2013).
On May 27 1925, Santa Barbara (California, USA) was completely destroyed by an earthquake which cut off the city from the rest of world. Just in a couple of hours after the hit, a few radio enthusiasts led by 19 years old Graham D. George (Fig. 1.43) built up a working radio station (from various stations in the city), and did what was necessary to communicate with the outside to inform them about the disastrous situation in Santa Barbara.

A citation describes this fact in an original way. Quote from Radio News Bulletin published by M. Jogoleff in 2008 (Jogoleff, 2008): “The first news telling the outside world about the city’s ordeal … Within an hour after the first shock they [B. Wentworth Jr. and G. George] had assembled a three inch spark coil … twelve volt battery and a key for transmission of an SOS. An undamaged super heterodyne receiver from the store stock took care of the reception, and the busy pair of radio men immediately started sending out their SOS. The tanker H. M. Story, station KDVV, and the tug Pencock, station KDKY, were the first two to pick up the calls. The tug acted as a relay station in the call for naval aid and in sending out the news of the disaster. The emergency station continued its work until other communication was restored” (Fig. 1.44-1.45).

Fig. 1.43. Graham D. George (06.01.1906-29.05.1982, USA)

Fig. 1.44. Brandon Wentworth Jr., photo courtesy provided by Neal Graffy collection
http://www.edhat.com/site/tidbit.cfm?nid=34112

The radio-enthusiast Clinton B. De Soto has to be mentioned, too. He (Fig. 1.46) was the assistant to the secretary of The American Radio Relay League, editor of the QST magazine, and author of a large number of papers and books. In a few excellent articles he gave us an opportunity to read about amateur radio operators’ participation in emergency situations in the first half of the 20th century (DeSoto, 1933; 1935, 1936).
The Long Beach earthquake (California, USA) took place on March 10, 1933, and a huge number of radio amateurs came to help establishing the emergency communications: Francis M. Sarver, Don Wallace, Al Martin Jr., W. A. Adams, Vernon Keays, Ludwig A. Hedstrom, A. W. Fuller, George F. Moynahan Jr., C. N. Fisher, Covina, Vernal Routh, Martin Corcoran, Artesia, Edward Seeley, M. J. Campbell, Ed Stevens, Dwight B. Williams, George W. Bailey, and a few hundreds (!) others (Fig. 1.47-1.49) (DeSoto, 1933; 1935, 1936; Lee, 2010). NB: The reader interested of the signcall of all people cited in this article, please contact the authors. The signcalls will be provided.

Within a couple of days the amateur radio networks were built for official and private communications between damaged territories, authorities, medical and military services, as also with relatives and friends. Thousands of messages were sent via radio during just a few days after the disaster (ibid).

Two years later (September 1935) the so-called Labor Day hurricane hit Florida (USA). There is a description how radio amateurs were dealing with the disaster (ibid): “For twenty-three hours, while buildings crashed around him, Fred E. Bassett, Jr., of Eustice, Fla., described scenes of horror and gave directions for relief over his 50-watt portable transmitter, W4AKI. In Miami, Alonzo O. Bliss, Jr., operator of W4COT picked up the messages and relayed them to the Red Cross and army relief workers. Other amateurs in the hurricane area also carried out heroic work wherever it was possible to erect emergency transmitting equipment... Death by storm, flood, earthquake, and disease is followed by the ever-watchful radio amateurs. When other means of communications fail, they fill the gap. Their emergency call, QRR, often restores the link to information over which the relief and reconstruction work is carried on...” (ibid).
Fig. 1.46. Clinton B. De Soto (W1CBD) (1912-1949, USA), http://www.arrl.org/desoto

Fig. 1.47. Emergency radio and telephone communication point during The Long Beach earthquake (1933), left to right: Edward Seeley, M. J. Campbell ((DeSoto, 1933; 1935, 1936)

Fig. 1.48. W6GJO handling emergency radio communication during The Long Beach earthquake (1933, USA http://fd.ema.arrl.org/hd/CD-FD.html)

Fig. 1.49. Don Wallace’s (W6AM) radio station in a field (his family and “house” in the background) during The Long Beach earthquake (1933) (Lee, 2010)
Table 1.1 shows more or less documented episodes of amateur radio stations participation in emergency communications during disasters in the 20\textsuperscript{th} century.

Table 1.1. Amateur radio for an emergency communications during natural disasters in 1913-1989 years (Bajenov, 2010; History of RAS, 2015; Amateur Radio Emergency Service of Russia (ARES Russia), 2015; DeSoto, 1933, 1935, 1936, Lee, 2010; Local radio hams assist with traffic relays in earthquake, 1959; Pasternak, 1976; VK4JK, 2014)

<table>
<thead>
<tr>
<th>Date</th>
<th>Place</th>
<th>Disaster</th>
<th>Participants</th>
</tr>
</thead>
<tbody>
<tr>
<td>18.04.1906</td>
<td>San-Francisco, USA</td>
<td>Earthquake and fire</td>
<td>Barney Osborne</td>
</tr>
<tr>
<td>23-26.03.1913</td>
<td>USA</td>
<td>«The Great Flood»</td>
<td>Herbert V. Akerberg</td>
</tr>
<tr>
<td>27.05.1925</td>
<td>Santa Barbara, USA</td>
<td>Earthquake</td>
<td>Graham George, Brandon Wentworth Jr., A.B. (Bennie) Lopez, Archie Banks, Jim</td>
</tr>
</tbody>
</table>

Fig. 1.50. Disaster communication unit by the American Radio Relay League (April, 1928)
<table>
<thead>
<tr>
<th>Date</th>
<th>Location</th>
<th>Event</th>
<th>Contributors</th>
</tr>
</thead>
<tbody>
<tr>
<td>February-March 1929</td>
<td>Lwow, Poland/Ukraine</td>
<td>Floods in highland regions</td>
<td>Vlodzimej Levitskiy, Jacub Khenner, Alfred Kranzler, Julius Kolachek, Adam Ligeza</td>
</tr>
<tr>
<td>Winter 1929</td>
<td>Tula, Russia/USSR</td>
<td>Floods</td>
<td>-</td>
</tr>
<tr>
<td>July 1929</td>
<td>Leningrad, Russia/USSR</td>
<td>Floods</td>
<td>-</td>
</tr>
<tr>
<td>1931</td>
<td>New Zealand</td>
<td>Earthquake</td>
<td>-</td>
</tr>
<tr>
<td>10.05.1933</td>
<td>Long Beach, USA</td>
<td>Earthquake</td>
<td>A few hundreds radio amateurs</td>
</tr>
<tr>
<td>Spring 1934</td>
<td>Duluth (Minnesota)</td>
<td>Sleet storm</td>
<td>James H. Leach (Fig. 1.52), T. O. Jorgenson</td>
</tr>
<tr>
<td>September 1935</td>
<td>Florida, USA</td>
<td>Labor Day hurricane</td>
<td>Fred E. Bassett, Alonzo O. Bliss, Jr.</td>
</tr>
<tr>
<td>1936</td>
<td>USA</td>
<td>“North-West Flood”</td>
<td>400 radio stations (Fig. 1.51)</td>
</tr>
<tr>
<td>1939 (Black Friday)</td>
<td>Australia</td>
<td>Bush fires</td>
<td>-</td>
</tr>
<tr>
<td>1948</td>
<td>Washington, USA</td>
<td>Flood</td>
<td>ARES USA**</td>
</tr>
<tr>
<td>1957</td>
<td>USA</td>
<td>Malibu fires, Hurricane Audrey</td>
<td>ARES USA**</td>
</tr>
<tr>
<td>17.08.1959</td>
<td>Montana, USA</td>
<td>Hebgen Lake earthquake (or Yellowstone earthquake)</td>
<td>E. Carl Lanzendorfer, Bill Hammond, John Bielenberg, Florence Majerus</td>
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<td>27.03.1964</td>
<td>Alaska, USA</td>
<td>The Great Alaska Earthquake and Tsunami</td>
<td>Lenore Jensen, Steve Jensen, Bob Ringwald, Al Hershberger, Ed Back, Zilla Maile (Fig. 1.59)</td>
</tr>
<tr>
<td>1967</td>
<td>Central Americas</td>
<td>Earthquake</td>
<td>College Station W5AC, Texas, USA</td>
</tr>
<tr>
<td>1972</td>
<td>USA</td>
<td>Hurricane Agnes</td>
<td>David Otey, ARES USA** (Fig. 1.55)</td>
</tr>
<tr>
<td>23.12.1972</td>
<td>Managua, Nicaragua</td>
<td>Earthquake</td>
<td>Nate Brightman (K6OSC) (Fig. 1.58)</td>
</tr>
<tr>
<td>1974</td>
<td>Darwin</td>
<td>Cyclone</td>
<td>-</td>
</tr>
<tr>
<td>Date</td>
<td>Location</td>
<td>Event</td>
<td>Details</td>
</tr>
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<td>------------</td>
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<td>-------------------------------------------------------------------------</td>
</tr>
<tr>
<td>4.02.1976</td>
<td>Guatemala</td>
<td>Earthquake</td>
<td>Bella Russ, Texas College Station, Radio Amateurs of Southern California, Doug McDowell</td>
</tr>
<tr>
<td>1978</td>
<td>Los Angeles</td>
<td>Torrential rains and flooding</td>
<td>Len Drayton</td>
</tr>
<tr>
<td>15.04.1979</td>
<td>Montenegro</td>
<td>Earthquake</td>
<td>Amateur Radio Club in Žabljak</td>
</tr>
<tr>
<td>1983</td>
<td>Australia</td>
<td>Bush fires</td>
<td>-</td>
</tr>
<tr>
<td>20.09.1985</td>
<td>Mexico-city</td>
<td>Earthquake</td>
<td>Lenore Jensen (Fig. 1.54), San Fernando Valley Amateur Radio Club (Len Drayton, Bill Bell, Esther Wolf, Texas College Station, William Dave Paperman (Fig. 1.57); and more than 10 thousands radio amateurs</td>
</tr>
<tr>
<td>07.12.1988</td>
<td>Spitak, Leninakan, Armenia/USSR</td>
<td>Earthquake</td>
<td>ARES/RARES*, Karen A. Karapetian, Gennadiy Grigorievich Shul’gin, Constantine Kh. Khachaturov, radio station RK4CXH, Viktor Petrovich Jirnov, Valeriy Bazhenov, Anatoliy (Toly) Nikolaevich Bayakin (Fig. 1.53) etc</td>
</tr>
<tr>
<td>1989</td>
<td>Loma Prieta, USA</td>
<td>Earthquake</td>
<td>ARES USA** (Fig. 1.56)</td>
</tr>
<tr>
<td>1989</td>
<td>Tatarstan, Russia</td>
<td>Floods</td>
<td>ARESR/RARES*</td>
</tr>
<tr>
<td>1989</td>
<td>Newcastle, Australia</td>
<td>Earthquake</td>
<td>ARESR/RARES*</td>
</tr>
<tr>
<td>1989</td>
<td>Iran</td>
<td>Earthquake</td>
<td>ARESR/RARES*</td>
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* - ARES: Amateur Radio Emergency Service of Russia, RARES: Russian Amateur Radio Emergency Service
** - ARES USA: Amateur Radio Emergency Service of USA

In the second half of the 20th century, a lot of associations and societies for emergency communications were founded by radio amateurs worldwide (such as MARA: Medical Amateur Radio Association in 1990 in USSR by
Anatoly Ivanovich Podolyan and 80 other radio-enthusiasts from different health care institutions (Fig. 1.60).

1.3. Telephone Communications in Telemedicine

At the end of the 19th century the Italian Antonio Meucci and the American Alexander Graham Bell almost simultaneously presented a new technology of sound communication to the world - the telephone. This term was introduced by the German Johann Philipp Reis.

It is often cited that Bell made the first telephone call to his friend and assistant Doctor Watson, asking him to provide aid (probably in a case of chemical burn). The famous scientist and telemedicine historian, Professor Rashid Bashshur supposes this story to be an apocryphal one. In 2005 professor Magnus Hjelm dispelled this myth. In the original paper he had cited the working diary of Alexander Bell, with the description of procedure and stages of the first call. The medical component in these authentic records is completely absent. Moreover, M. Hjelm found out that the «legendary» episode was actually taken from the movie «The Story of Alexander Graham Bell» made in 1939 in the USA (http://www.youtube.com/watch?v=9WDyKO7GQ70). Thus, it is the unfair relation of the Hollywood’s screenwriter of historic facts that led to emergence of this myth (Hjelm, 2005).
Fig. 1.51. Original pictures from papers by Clinton B. DeSoto: radio amateurs fights with floods in 1936 (DeSoto, 1933; 1935, 1936)
There is a documented proof of the first use of telephone communication for medical purpose in the USA in 1879: a short note was published in “The Lancet” with the description of the situation, when relatives of a little child called their family doctor at night with a complaint about severe cough. The doctor told to hold a receiver close to the child’s head for him to hear the coughing, which was done. In a few minutes the doctor announced, that the
child did not have croupous cough and that the matter could be postponed till the morning (Practice by telephone, 1879) (Fig. 1.61).

Fig. 1.55. Emergency amateur radio communications during natural disasters in USA; up, from left to right: flood in 1948, fires in 1957, hurricane in 1957; bottom: hurricane in 1972 (Lee, 2010)
In 1887, a telephone communication, probably for the first time ever, was used for communication of patients from a contagious isolation ward (especially, those with scarlet fever) with their relatives (Aronson, 1977).

In fact, in the 1880s, the possibility and even the necessity to use telephone for communication between doctors and patients were discussed actively. One of the zealous supporters of the installation of a telephone system in medicine was the British Doctor Alfred H. Twining, who recommended in 1888 to use widely the new mode of communication, especially in the rural areas, for “long lasting social or professional conferences around-the-clock” (ibid). The remarkable thing is that a few years before its appearance the telephone became an integral part of a doctor's office; in particular, there is a fact of total installation of telephone system in Birmingham Women's Hospital in 1880 - "all internal and external departments, and also doctors' residences" were connected online (Aronson, 1977; Swoyer, 1949).

In 1891 the famous English orthopaedic surgeon Richard Davy insisted on the development of telephone communications between hospitals for the purpose of logistics optimization, and to prevent refusals in hospital admission and patient transportation between health care institutions. As an argument the doctor suggested the description of a clinical case: a boy with lower limb fracture, who was transported several times from one hospital to another for the
reason "no beds available". Doctor Richard Davy (1839-1920), by the way, invented a special medical vehicle for transportation of the injured, and a range of methods for surgical treatment of osseous-articular tuberculosis, and on the other hand, he was a vigorous critic of the antiseptics theory. In one form or another, the discussion regarding the appropriate installation of telephone system in healthcare service continued up to the 1950s. Yet, emergency medical service, fire emergency and police started to be equipped with telephone communications during the 1920-1930s.

Fig. 1.59. Al Hershberger, Ed Back, 2000s (photo by M. Scott Moon), Zilla Maile, 1954 (photo courtesy of Donna Van Lone) – they used amateur radio to communicate with the outside world following the 1964 Alaska earthquake (Hermanek, 2006)

Fig. 1.60. Medical Amateur Radio Association (MARA) official badge, 1990, USSR
At the end of the 19th century an interesting deontological dilemma was recorded. In the described period, doctors were not allowed to use public advertising for their activity in the newspapers or by other means, for ethical reasons. But in order to connect to a telephone company it was required to give full information about oneself (including address and occupation) in the telephone directory, which could be regarded as advertising. However, within time, the dilemma was solved in favor of the installation of a telephone system and availability of doctors' contact information. There was another ethic problem - in 1911 “The Lancet”
highly recommended doctors not to interrupt examination of a patient by answering the telephone calls (Aronson, 1977).

As far back as in 1878 the ideas about combining the stethoscope and the telephone for distant auscultation were expressed (ibid), though they were implemented only in the beginning of the 20th century when in Europe and America several similar stethoscopes and devices were patented. This allowed the transmission of heart and lungs auscultation over the telephone. Among these devices was the "electrical relay" of S. G. Brown, recognized as the first device to enable auscultation transmission over telephone. (Fig. 1.62-1.63) (Brown, 1915).

In 1910 in Great Britain an engineer Sydney-George Brown conducted the first world's teleconsultation with the help of his own inventions (an electrical relay and an electrical stethoscope): auscultation of heart tones was transmitted over the telephone between London Hospital and the Isle of Wight for a distance over 50 miles. After that S. G. Brown concluded: “This trial proved that it is now possible for a specialist, say, in London, to examine a patient, say, in the country, stethoscopically, and to arrive at a correct diagnosis” (Bashshur and Shannon, 2009). Five doctors participated in the session, who appreciated favorably the quality of this device (Brown, 1912; Gregory, 1951; National Portrait Gallery, 2014). Also, similar experiments were conducted between several points within London (Brown, 1912).

In 1928, (patent priority of 1924) Harold F. Dodge and Halsey A. Frederick in the USA patented “Stethoscopic apparatus”, which “...may be connected to the telephone lines for consulting with remote physicians and for the transmission of heart and chest vibrations to a central laboratory equipped to make permanent records” (Dodge, Frederick, 1924). Later a range of similar inventions were made by C. A. Mason, H. von Baussen and others appeared (Mason, 1935, Von Baussen, 1938) (Fig. 1.64-1.65).

In the 1930-1940s cable communications were used to solve practical arrangements in Healthcare Service, to conduct research and to collect epidemiology data (Coulter, Stone, 1937; Health Organizations and the Telephone, 1941).

In the 1950-1970s there were programs for distant medical learning entirely on the basis of voice communication.
For instance, around 1958, the medical centre of Nebraska University (Omaha, USA) performed distant learning. Lectures were presented by phone for doctors from four local hospitals and three hospitals from the neighbouring states (Hospital hookup saves much travel, 1957). In 1972 in Oklahoma (USA) the distant learning network for doctors was developed in 10 regional hospitals. Technically the process was implemented based on a telephone conference line, which allowed carrying out “collaborative conversation” of all the participants of a lecture (Education via teleconference, 1972).
Starting in the 1960s telephone communication and the information transmission services on this basis (telemetry, dataphones, fax machines, teletype machines, etc.) have been used in full scale all over the world for various health information exchanges (Bachmann, Thebis, 1968; Hoffman, Cosby, 1964; Levine, 1964; Maier, 1976; Melvin, 1964) (Fig. 1.66).
Telephone is the most widespread and the oldest telemedicine device providing voice communication. It serves as a data transmission feature (distant-reading instruments, dataphones, slow-scan television systems, facsimile machines, teletype machines, IP-Protocol, etc.). In the beginning of the 21st century the mobile phone became the technical ground for a radically new technology in healthcare service - mHealth (mobile health).

In conclusion: Between 1880 and 1945 the main telecommunication facilities in telemedicine were the telegraph, the telephone and radio communications.

Telegraph was used for medical purposes from time to time, primarily during war conflicts.

In the 1920s models for healthcare service were developed, which used radio for care delivery wherever and whenever necessary, such as the system of emergency medical consultations in the transport field (marine medicine) and medical aviation service in combination with teleconsultations and instructions. The above models are still fully performing even now.
Telephone communication was initially used as a mean for simple consultations and coordination of healthcare practitioners’ actions; however, it has become a multi-purpose telecommunication tool for various health information exchanges (primarily in biotelemetry systems and telecardiology).

Fig. 1.66. A doctor is using wireless telephone in a medical vehicle (the 1950-1960s); photo of Chris Ware Gallo Images (http://www.timeslive.co.za/lifestyle/health/2011/04/19/telemedicine-time)

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Chapter 2
Telecardiology

Among the clinical disciplines, the widest use of telemedicine in the twentieth century has been in cardiology. The main reason for this is the necessity of urgent diagnosis of acute pathology of the cardiovascular system, especially with the involvement of high-level experts. At the other hand, telemetry of electrocardiosignals (ECS or ECG) for the remote interpretation and analysis was most consistent with the technical capabilities of electrical engineering in the last century.

2.1. Early Stage of Telecardiology

(Contributing co-authors O. Stadnyk, M. Karlinska)

Most researchers consider March 22, 1905 as the birthday of telemedicine. On this day, in The Netherlands, Wilhelm Einthoven, professor of physiology at Leiden University, and Professor Johannes Bosscha, Director of the Delft University of Technology, transmitted a regular electrocardiogram and phonocardiogrammes via an protected telephone cable at a distance of about 1500 meters from the University Hospital to the physiological laboratory at W. Einthoven’s house (Fig. 2.1) (Einthoven, 1906).

Einthoven is considered one of the main founders of electrocardiography. For this invention he was awarded the Nobel Prize in 1924. The basic technological component of Einthoven's electrocardiograph was the so-called string galvanometer. It was a very accurate and qualitative, but rather cumbersome device mounted in his home laboratory (Fig. 2.2 - 2.3).

As technology developed, the ECG registrations of patients with various diseases became of greater interest, but to move the string galvanometer to the clinic was an almost impossible task. Then Professor Johannes Bosscha suggested using a remote broadcasting, which enabled to examine patients in the clinic with a device that was physically located at a distance of 1.5 kilometres (Barold, 2003; Einthoven, 1906; Miami Fire Department’s First
The cable was laid partially under ground and partially on the surface. It belonged to the Leiden Telephone Company and was mounted by Ribbink and Yan Bork. Much effort was spent to ensure noise immunity. In the end, the researchers achieved the desired quality of the data transmission, and Einthoven claimed that by using such cable it became possible to connect Leiden with Rotterdam or Amsterdam.

So, on March 22, 1905 Einthoven and Bosscha performed an ECG remotely on a healthy male volunteer (according to some data, this was W. Einthoven's assistant named C. J. de Jongh) (Fig. 2.4).

Here is the description of this moment, made by the outstanding physiologist in person: “The patient is comfortably sitting in the arm-chair with his both hands immersed into large glass jars, which are attached to the wires going to the laboratory. The electrocardiogram, in this case the "telecardiogram", is being transmitted to the laboratory. The procedure carried out in such a way is practical and simple and its advantage is the quick performance as compared to the use of a galvanometer at a patient's bed” (Barold, 2003; Einthoven, 1906; Miami Fire Department’s First Paramedic Program 1967; Taylor et al. 1976). It is to be pointed out that W.
Einthoven was the first to use the Latin prefix «tele-« to denote distant medical care. He named the system that he had invented “telecardiogram”.

In 1906 Einthoven published an article in the journal “Archives Internationales de Physiologie” describing the first telemedical technology and the electrical and physiological phenomena revealed with its help (Einthoven, 1906). It should be pointed out too, that the tele-ECG system of Einthoven-Bosscha existed for a rather short time. It was created as part of a small project upon completion of which the work was stopped.

Wilhelm Einthoven spent lots of efforts to restore it, however, the result was negative as he did not get any financial or moral support. Nevertheless, a new diagnostic method was created and approved successfully, i.e. the first telemedical transtelephonic electrocardiography. The method has been actively used worldwide since 1950s, and proved to be one of the most reliable and efficient telemedicine tools.

In 1910, in New York (USA), two cardiologists Walter Belknap James and Horatio Burt Williams (Fig. 2.5) created the first intra-hospital tele-ECG system. They described the advantages of the system as follows: “We have the wards of Presbyterian Hospital connected with the laboratory by a system of wiring which permits the taking of any patient’s electrocardiogram without removing him from his bed… Most of our records are telecardiograms. The chief advantages of this method are the saving of time and labor for the operator, the additional convenience and comfort of the patient and the additional chance of obtaining records free from evidence of voluntary muscle tension”. W. B. James and H. B. Williams revealed their experience with the transmission of electrocardiograms for analysis of a wide range of cardiac issues (Fig. 2.6) in two papers (James W. B, Williams H. B. 1910 a; 1910 b).

There are some data about the experimental use of transtelephonic ECG at the campus of Lund University (Sweden) around 1915, but detailed information is absent (Peter T. et al., 1973).

Fig. 2.5. Walter Belknap James (11.05.1858-06.04.1927) and Horatio Burt Williams (17.09.1877-01.11.1955)
After several years, the method of “tele-electrocardiography” gained recognition in the clinical practice in Eastern Europe. Approximately in 1935 in Lvov (today Ukraine) Professor Marian Franke and Professor Witold Lipinski (Fig. 2.7, Zimenkovskyy et al., 2006; Zinchuk O., Yavorskyy I., 2016; Biblioteka Narodowa, 2016; Bibliografia Polska 2006; Biogramy uczonych polskich, 1990) organized constant usage of tele-electrocardiography (tele-ECG). The transmitting station was located in the department of infectious diseases of Lvov General Hospital, while the receiving station was installed at the Chair for General and Experimental Pathology of the Lvov University Medical Faculty. This historical fact was published for the first time in 2012 (Vladzymyrskyy et al., 2012 a) and b).

In the publication of Polska Gazeta Lekarska (Polish Medical Newspaper, No.27, 1937, page 515) the article of the Lvov State General Hospital stated: “For the last two years tele-electrocardiographic research was conducted systematically in the department of infectious diseases. The patients remained in the department and the research results were transmitted over 500 metres to the Institute of Pathology. The research was organized by Professor Franke” (Oddzial Zakazny Panstwowego Szpitala 1937) (Fig. 2.8 - 2.9).

In 1936 M. Franke and W. Lipinski published an article about variations in tele-electrocardiogram of patients with infectious diseases (in particular with scarlet fever and diphtheria) This work titled «Zmiany elektrokardiograficzne w chorobach zakaźnych» was issued in two parts in Polska Gazeta Lekarska (Franke M., Lipiński W., 1936; Franke M., Lipiński W., 1993) (Fig. 2.10). The authors specify...
tele-electrocardiography as the main instrument for carrying out this research. ECGs were transmitted via “special wires” to a distance of “about 500 metres”; an “Elkahraph” lamp electrocardiographic apparatus manufactured by F. Hellige & Sons (Freiburg, Germany) was used. Having examined remotely a group of 109 patients (including several children aged under 14, as well as several intubated patients and terminal patients) Franke and Lipinski revealed and carefully described a wide range of variations typical for the infectious diseases ECGs (ibid).

It is important to note that the authors highlighted the significance of the telemedical method as such. According to M. Franke, “keeping the patient in one place [thanks to the use of tele-ECG - authors’ note] allowed avoiding adverse events, associated with the patient's transportation” (ibid). Figure 2.11 shows the ECG examples of patients with infectious diseases transmitted and interpreted with the help of Franke-Lipinski telecardiological system. Taking into account that a wide range of remote examinations was conducted on patients who are in critical conditions (ventilation) or in agony, it has to be underlined that the authors, in addition to the work in the field of telecardiology, were also the first in the world to demonstrate the application of telemedicine in intensive care (Fig. 2.12) (ibid).
Tele-electrocardiography (tele-ECG) is one of the most reliable and efficient telemedicine applications that has been intensively used up till now. Although the method was created in the Netherlands in 1905 by Einthoven and Bosscha, it was used as a routine clinical tool, for the first time in 1935-1937, by Professor of Physiology Marian Franke and Professor of Infectious Diseases Witold Lipinski. Both were able to confirm brilliantly W. Einthoven’s statement: “Where there is a connection, a physical or virtual one, between the laboratory and the hospital, the cooperation between a physiologist and a clinician, where each of them remains responsible in its own field, only then the successful use of electrical methods of examination is possible” (Einthoven, 1906).

Fig. 2.10. Title page and fragments of the original text with description of clinical tele-ECG system by M. Franke and W. Lipinski (Lvov, Ukraine, 1936)
Fig. 2.11. ECG examples transmitted and interpreted with the help of telecardiological system of Prof. M. Franke and Prof. W. Lipinski

Fig. 2.12. ECG examples (transmitted and interpreted with the help of telecardiological system of Prof. M. Franke and Prof. W. Lipinski) of terminal patients during intensive care
2.2. Telecardiology in the Middle of the 20th Century

“One of the characteristic features of medicine of our time is authoritative, irresistible penetration of mathematics and cybernetics into medicine”

E. Sh. Halfen, 1980

It is practically impossible to establish a clear geographic predominence in the emergence of one or another telemedicine technology. The majority of ideas and their practical implementations appeared almost simultaneously in the various parts of the Earth.

In 1952, Dr W. E. Rahm, Dr John Lucian Barmore and Dr F. Lowell Dunn from the Medical College of Nebraska University (Omaha, USA) carried out successfully ECG transtelephonic transmission using frequency modulation. Within a year the method was improved. Reliable devices for signal modulation and demodulation and ECG reception with sufficient diagnostic value, when it is broadcasted over long distances, were developed. The technique has been tested by telemetry on more than 50 separate electrocardiograms between the settlements of Nebraska and South Dakota over a distance of 500 to 1 200 kilometres (Fig. 2.13) (Remote monitors unite service 1974; Rossi P. et al., 1989).

![Fig. 2.13. Examples of tele-ECG transmissions (Nebraska, USA, 1952-1953)](image)

Probably one of the first serial devices for ECG transmittance via telephone appeared in 1953 in the Medical Centre of Kansas University (USA). An original transistor device for heart tone and ECG transfer via telecommunication channels was developed by Dr Edmunds Grey Dimond (Fig. 2.14), the electronic engineer Fred M. Berry and John L. Walker, engineer, businessman and pastor (Dimond E. G., Berry F. M. 1953; Dimond E., 1958). They worked on this system about six months. In fact, it was a transmitter connected to a standard ECG machine and a telephone communication channel, and also a receiving device with a modified self-recorder.

On October 13, 1952 with the help of Dr. Dimond's system ECG was transmitted from Lawrence to Kansas City (over a distance of about 70 km), or more precisely from Watkins Memorial Hospital to the laboratory, where the instrument was developed (Heart call could save your valentine, 1970) (Fig. 2.15).
On March 13, 1953 test transmissions were repeated many times between Kansas City, Wichita and Hays, as well as Joplin (Massachusetts). The testing results were encouraging, and somewhat later Johnnie Walker Cardiovascular Engineering company started serial production and sales of this equipment. Nine vacuum lamps were used in the first prototypes, later they were substituted by 15 transistors and storage battery power supply was installed. A distinctive feature of the device was the possibility to temporarily interrupt ECG transmission “for questions and comments”, followed by the resumed transmission without loss of diagnostic quality and data integrity. The cost of the system was about USD 450-500 (Fig. 2.16-2.18) (Dimond E. G., Berry F. M., 1953; Dimond E., 1958; Heart call could save your valentine, 1970).

In April 1954 «the first commercial transmittance», i.e. business presentation of the system, was held: ECG was transmitted from the workshop of John L. Walker to the Argyle Building (Kansas City). And a few days later the system was implemented in the clinical work - the first network was created between the tuberculosis sanatorium (Norton) and the office of Dr. J. L. Morgan (Emporia), who supervised and consulted patients of these institutions. Regular tele-ECG consultations began (Fig. 2.19) (Heart call could save your valentine, 1970; Dimond E., Berry F., 1953; Dimond E., 1958). The equipment was acquired and installed under the supervision of Dr Taylor and Dr George W. Jackson. This was followed by numerous introductions in hospitals and offices of family doctors. As a result, by 1958, about 70 devices were in use in many states and the opportunity to apply tele-ECG in military medicine was considered as well.
Fig. 2.16. ECS-transmitting device with telephone apparatus connected developed in the Medical Centre of Kansas University (USA, 1958)

Fig. 2.17. Tele-ECG transmitting device of Dr Dimond’s system

Fig. 2.18. Tele-ECG transmitting device of Dr Dimond’s system

Fig. 2.19. Practical application of tele-ECG apparatus by E.G. Dimond et al. (Kansas, USA, 1958)
According to E. Grey Dimond, ECG transmission via telephone allowed solving efficiently diagnosis issues, especially in the rural areas. Approximately in 1961 a device modification was developed for ECG transmission over radio (Fig. 2.20-2.21) (Hirschman J. et al., 1974). It became possible to implement real-time telemetry of heard activity while the examined patient was doing physical exercises or simply during usual daily life activities. However, this modification failed to reach a large commercial success.

Some interesting facts should be highlighted too. Dr. E. Grey Dimond developed and successfully implemented a special system for teaching students and interns. It included an electrical stethoscope, television screen, tape recorder for remote transmission in the auditorium. It was possible to transmit auscultations and phonocardiograms from a ward to the auditorium.

And an episode of an unusual telephone consultation happened in 1954. At that time artificial cardiac valves were used, producing loud clicks during operation, which was heard at a distance. One of E. Grey Dimond's patients complained over the phone about irregularities in the valve operation. However, after listening to the clicks remotely (using the handset) the doctor made sure that everything was in order and fully reassured the patient (Dimond E., Berry F., 1953; Dimond E., 1958; Heart Data by Phone, 1952; Heart call could save your valentine, 1970; Hirschman et al., 1974).
In 1963-1966 studies on transtelephonic ECG transmission and telemetry of phonocardiographic research were carried out at the Kaunas Medical Institute (Lithuania, USSR) under the supervision of Zigmas Ippolitovich Yanushkevichus (Fig. 2.22). Yanushkevichus was the rector of Kaunas Medical Institute and headed the Chair of Hospital Therapy. A few years later, in 1969, Academician Yanushkevichus received the State Prize of the USSR for the development of new diagnostic methods and treatment procedures for patients with myocardial infarction. Under the supervision of Professor Yanushkevichus, one of the first ECG automated analysis systems, using first generation computer, was developed. That was a telemetry system transmitting electrocardiograms effectively, supplemented with a computerized tool for its decryption and fast interpretation (Yanushkevichus, 1965; 1966; Yanushkevichus Z., Stasiunas A. S., 1963; Yanushkevichus et al., 1977; Yanushkevichus et al., 1966; Yanushkevichus, 1980). Total teleconsultation time using automated ECG analysis took 15-17 minutes, and «answers - diagnostic ECG opinions - were transmitted by telephone, teletype, or mail and issued by means of dataphones, if the processing centre was situated in the clinic» (Chireikin L. et al., 1977; Chireikin L., Dovgalevskyy P., 1995).

In 1966 Prof. Yanushkevichus stated that the issue of ECG transmission via telephone may be considered settled... «It is also not difficult to transmit via telephone communication channels other curves as well: ballistocardiograms, sphigmorecardiograms, phlebograms and electroencephalograms». However, it was conceded that transmission of such an important curve as phonocardiogramme (PCG) for diagnosis was rather complicated. Professor Yanushkevichus successfully solved this problem in collaboration with G. Vitenshteynas and K. Valuzhis, using the «PCG envelope» with frequency response of «0.1100 Hz». It was described as follows: «In the teleconsultation Centre the PCG envelope will be recorded on any electrocardiograph... or magnetic tape. The narrow character of the PCG envelope will contribute to transmitting it via telephone channels to the electro-diagnostic machine...» (Yanushkevichus et al., 1966).

There is one more notable fact in the above mentioned publication by Yanushkevichus et al. «Tele-transmission of phonocardiograms» (1966), i.e. for the first time in the Russian language the term «teleconsultation», and more specifically «teleconsultation centre», was used.

As a result of long-lasting work Zigmas Yanushkevichus created a new section and his own school of telecardiology and medical cybernetics. This was enhanced by the numerous thematic books and multiple research and training conferences and meetings held in Kaunas in 1970-1980. At the end
of the 1970s the team headed by Prof. Yanushkevichus conducted study of the diagnostic value of tele-ECG by comparing automated opinions and interpretations of cardiologists. «ECG Control System of 5600C Hewlett-Packard model (manufactured in the USA) was approved. The system made ECG registration, transmission, interpretation and control in 12 standard leads... ECGs were recorded on the 1517A telephone terminal and transmitted via local telephone lines to the Centre. In the centre (mini-computer ...) ECGs were interpreted and mecanography conclusions were printed..., provision was made on the control panel of a doctor-editor who could change the conclusions, if needed. This made possible to formulate the final conclusion on the ECG». Sufficient diagnostic value of automated ECG diagnostics was proved (Yanushkevichus, 1965; 1966; Yanushkevichus Z., Stasiunas A. S., 1963; Yanushkevichus et al., 1977; Yanushkevichus et al., 1966; Yanushkevichus, 1980).

Although the earliest works on the use of first generation computers for automated ECG analysis appeared in the late 1950s, the commercial production of such systems started in the USSR and the USA about 10 years later. At least 20 major Centers for automated ECG analysis were already active in 1976, conducting up to 5 million evaluations per year (Kaseres and Dreifus, 1974).

In the 1960s telecardiology developed in North America quite actively. A special role in this process was played by a telecommunications company Bell (Fig. 2.23). It offered the so-called «dataphone» for the medical market - a proprietary design, intended for data exchange over telephone lines at a rate of the order of 1 200 bits per second (Nose et al., 1986).
As far back as 1953 the Northwestern Bell Company and the Medical College of Nebraska University (USA) performed experiments on transtelephonic transmission of electrocardiograms and electroencephalograms using Bell dataphones. Transmission quality was very good and this technology was acknowledged as potentially important for communication between physicians on rural settlements and large medical Centers. (Fig. 2.24) (ibid).

In spring 1961, Dr True W. Robinson (Birmingham, Alabama) addressed the Southern Bell Telephone and Telegraph Company with a request about possibility to transmit ECG via telephone communication channels. A working group of company engineers consisting of B. P. Elder, J. W. Joyner and D. L. Bonner was organized. The technical problem to «connect» ECG machine with the Bell dataphone and to transmit ECG by telephone was solved successfully. The system was tested on December 20, 1961 in Birmingham. ECG was successfully transmitted from West End Baptist Hospital to Highland Baptist Hospital. Following the positive results the decision was made to start serial production of transtelephonic ECG-diagnostic systems (Hill D. et al., 1970).

In 1963, at the Creighton University (Nebraska, USA) the first Regional Cardiac Center was established, and under the supervision of Richard W. Booth (Fig. 2.25) with the participation of John Glaser (Northwestern Bell engineer). The «dataphone network» for tele-ECG diagnosis was deployed (Hill D. et al., 1970; Nose Y. et al., 1986). Remote ECG-interpretation was combined with transmission and discussion of general information about the patient with the help of voice communication. Initially the network connected only two hospitals, but it worked out so efficiently that by 1970 the network covered 178 medical facilities in ten states of the Midwest and by 1980 about 84000 tele-ECG consultations took place. The «dataphone centre» of telecardiology diagnostics at the Creighton University existed until 1993.

Fig. 2.25. Richard W. Booth (Professor, an employee of the Creighton University since 1961, founder and director of the Cardiac Center, creator of one of the largest tele-ECG networks in the USA)
In 1964, a portable ECG transmitter (developed in Bell Laboratories Data Communications) was used for the demonstration of the transmission of electrocardiosignal between two hospitals in New York City and Long Island. In 1966 the Southern Bell dataphone tele-ECG system was tested in Miami. ECG telemetry was performed between the offices of Dr Loius Lemberg (Fig. 2.26) and Dr Paul D. Unger. Following the successful results of the new technology, it was decided to introduce it at Jackson Memorial Hospital (Electrocardiogram by Phone Foreseen in near Future, 1966).

A telecardiology network was set up in November 1968 in Wisconsin. At St. Elizabeth Hospital (Appleton). A consultation centre for remote connection with 5 local district hospitals (at a distance of 16 to 80 km) was established. A so-called «Remote Coronary Monitoring System» based on ECG transmission via dataphones was applied. Centralized telemonitoring of cardiac function in patients was carried out around-the-clock. Episodes of heart rate variability were automatically detected and recorded separately. Medical interpretation of the data recorded during a day was carried out by cardiologists throughout regular working hours. Nurse teleconsultations referring to intensive healthcare were carried out too (Fig. 2.27-2.28) (Sakurai Y. et al., 1975).
In 1973, another hospital-user was connected to the network, and also tele-ECG system was introduced. The consultation center was based at the Memorial Hospital (Appleton). A three-channel ECG was transmitted via telephone and interpreted within a few hours. Emergency diagnoses were not carried out. Physical transmission took about 10 seconds. In the first months of operation (August-November 1973) only, about 3 100 tele-ECG consultations were performed (ibid).

In 1970 the dataphone tele-ECG network appeared in Arizona connecting the University of Arizona College of Medicine (Tucson) and St. Joseph's Hospital located at a distance of 130 km (Fig. 2.29-2.30). It can be stated that Bell dataphones were used in the vast majority of tele-ECG networks in North America (Fig. 2.31).

In 1965 Eugene L. Nagel, (Fig. 2.32), Assistant professor at the University of Miami School of Medicine, invited Dr James Hirschman and radio engineer Ben Denby for joint work on the creation of an USW-ECG radio-telemetry for prehospital examination (Nagel E. et al., 1968; Nagel E., 1972; Niitani H. et al., 1969; Northwestern Bell Telephone Company Part 4, 1964).
The early modification of the instrument was really amateuristic: an ECG machine, Motorola VHF-radio station and a BIOCOM demodulator were placed in a milk-bottle box. Later the milk box was substituted by an aluminum one and an ECG printer was added. This telemedical system was introduced in March 1967 when ECG-telemetry and voice communication being implemented between the fire rescue department and the expert center at Jackson Memorial Hospital (Miami) (Fig. 2.33-2.35) (Nagel E. et al., 1968;

Fig. 2.32. Eugene L. Nagel

Fig. 2.33. Call-center of tele-ECG system in Jackson Memorial Hospital (Miami, USA), photo courtesy by National EMS Museum (http://emsmuseum.org)

Fig. 2.34. The first test of Nagel-Hirschman telemetry system for prehospital stage (USA, about 1967), an early modification of the device in a the milk bottle box, tested in the garage of prof. Nagel

Fig. 2.35. Prof. E. Nagel and Jim Hirschman with different groups of rescuers (training in radio telemetry system use - serial apparatus model in aluminum case)

Nagel E. et al., 1970; Nagel E., 1972; Niitani H et al., 1969). Prof. E. Nagel and Dr. J. Hirschman jointly carried out a great job, equipping rescue teams
with fundamentally new medical kits, defibrillators and ECG telemetry systems. In addition systematic first aid essential training was organized.

The first field application of radio telemetry system took place in summer 1968 (according to other data - in June 1969) – when after an ECG transmission directly from a Miami street, an acknowledgement was given for carrying out defibrillation and saving patient's life.

Soon after that, the tool developed by J. Hirschman and E. Nagel was introduced successfully in rescue services of Washington, Seattle, New-York, Los Angeles districts, Nassau, etc., as a model of telemetry support for paramedics (ibid; Hollos O., 1966). Medical, psychological and social importance of a pre-hospital telemedicine system was best shown in the statement by Dr. James Hirschman: «In those early years of the system development, the telemetry was like shaking hands, denoting infinite trust between paramedics in the streets and consulting doctors in the hospital».

In spring 1972 E. Nagel and J. Hirshman developed tools for radio-teleconsultation at the Orange Bowl Stadium in Miami as annually 3-5 acute coronary deaths were registered during football matches. To improve and bring cardiac care closer to the point of impact, E. Nagel and J. Hirshman offered mobile emergency cardiac care systems, which included a training program for the stadium staff and guards, special medical kits and radio telemetry system with the possibility of real time teleconsultations/briefings during the direct implementation of resuscitation services. The system was introduced successfully in August that year.

In 1970, Dr Herman N. Uhley (Fig. 2.36) from the UCSF Medical Centre at Mount Zion together with Electra-Biometrics of Lancaster introduced an ECG telemetry system in the

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**Fig. 2.36. Herman Noah Uhley**

**Fig. 2.37. General operation scheme of tele-ECG system of the first aid service according to H. N. Uhley (USA, 1970)**
first aid service in San-Francisco. The equipment performed signal modulation/demodulation and its acoustic transmission between the mobile coronary care unit and the infarction department (Fig. 2.37-2.39) (Visser J, Schuilenburg R., 1984; Vladzymyrskyy A. et al., 2012). The system efficiency was analyzed on teleconsultation materials from 50 patients. The important role of biotelemetry in increasing the scope of pre-hospital care and the provision of more adequate therapeutic supports during transport was established. Following the results of clinical trials, the system was widely implemented. In particular, at the above-mentioned Medical Centre at Mount Zion, six complexes of this equipment were installed, which made it a national leader in the field of emergency tele-ECG diagnostics (Fig. 2.40).

In 1974, Dr. Herman N. Uhley presented a proprietary telemetry ECG transmitter, distinguished by its economic efficiency (average cost was about USD 20) and easy manufacturing process (ibid; Uhley H., 1976).
In Eastern Europe (USSR), a large-scale formation of telecardiology was associated primarily with the name of Professor Emmanuil Shevakhovich Halfen (Fig. 2.41) (Halfen E. Sh., 1998). As early as 1967, Prof. Halfen and a team, headed by Oleg Mikhailovich Radyuk (Fig. 2.42), engineers B. A. Baturin, G. T. Chevtaevev, Yu. K. Sorokin, N. S. Iofin, designed and manufactured a biological information telemetry device (including ECG) transferring data via telephone and radio. Later the device was named «Volna» («Wave») transtelephonic ECG transmission system. Based on this system, in 1971 in Saratov, at the Introductory Course of Internal Diseases (Propaedeutics) Department of the Saratov State Medical Institute, the first remote consultative and diagnostic center in the USSR was established. At the time of the system development, Prof. E. Halfen was Chairman of the Department mentioned above, and O. Radyuk was Director General of the Scientific Research Institute «Almaz» (State Scientific Industrial Enterprise) in Saratov (Halfen E., 1980; 1985; 1974; 1977; 1980 a; 1980 b; 1980 c; Khramov A. et al., 1996).

The author’s description of the tele-ECG system operation is given below: «... the device - elektrocardiotransducer, by receiving weak heart biosignals, amplifies and transforms them into signals that can be easily transmitted via telephone or radio to the control panel of the attending cardiologist in the consulting and diagnostic center. This control panel is connected with an electronic computing machine, which instantly processes the cardiogram and automatic typewriter ... prints diagnosis outcome... All the control panels of the center have a direct communication with the head of the clinic via intercommunication system, and in the professor's room a monitor is installed on which any information from the control panel is transmitted, if necessary» (Zykov N., 1976).

In 1974 the serial production of «Volna» telemetry system started, which included electric cardio-transmitter (ECT), a consultative and diagnostic control panel (CDCP) and the communication line (telephone or radio one). ECT was a portable device consisting of three units: a transducer, a power supply unit and an acoustic set-top box. Early transmitter models had dimensions of 11x12x4 cm weighing...
1 kg, later on the size was diminished - 3x8x14 cm and weight 400 g. CDCP was intended for the ECG reception by telephone and radio, «ink recording on paper tape», consultations with specialists, the transfer of the ECG opinions and recommendations to the attending doctor. There was an «integral or remote long-term memory» on the panel, which recorded all of the information transmitted and ECG on the magnetic tape. The archive of the performed tele-ECG consultations was created in an ad-hoc way. CDP provided the possibility to transmit ECG to the computer memory for the subsequent automated analysis. It also was equipped with a loud-speaking communication system and an additional telephone to communicate with a third party (for example, a qualified specialist). In general, the system allowed remotely transmitting 12 ECG leads, taking only 3-4 minutes.

Telephone communication was generally for data transmission and when connecting to ambulances, data were transmitted by radio («Cactus» and «Granite» radio stations). Some shortcomings of radio communication equipment, as well as geographical issues (hilly location) required the development and use of special retransmitters for radio signal transmission between the ECT and CDCP. Initially these were operator-controlled equipment sets. The latter were installed in the functional diagnostics offices of district health clinics and nurses, at these offices, were in charge of working with the equipment (there were 7-8 such offices in Saratov). Later on an automated retransmitters appeared (Fig. 2.43-2.45) (Halfen E. 1980; 1985; 1974; 1977; 1980 a; 1980 b; 1980 c; Khramov A. et al., 1996).

Fig. 2.43. Work of Saratov tele-ECG centre in 1976: an attending consultant at the control panel, a doctor holds the elektrocardiotransducer, ECG is transmitted from a factory health centre, computer machine for processing ECG and information about the status of critically ill patients in the in-patient hospital (temperature, contractile function, blood pressure)
Tele-ECG network covered treatment and preventive health care facilities in Saratov, in rural hospitals in 35 districts, as well as outreach brigades of Emergency Health Service formed quickly around the first remote diagnostic center. The network consisted of 125 transmitters in the hospitals, 10 transmitters for outpatients and 6 ECG receiving panels (5 panels operated regularly, and one more was connected additionally during wide-scale preventive examinations). Over time, multi-channel telephony was organized, which simplified and speeded up considerably the communication between health care workers, subscribers and the expert center.

Prof. Halfen determined three main lines for tele-ECG application (Halfen E., 1980; 1985; 1974; 1980 a; 1980 b; 1980 c; Khramov A. et al., 1996):

- Clinical medicine (including rural health care, emergency medical service, large enterprises, sanatoria, etc.);
- Mass preventive onsite screening examinations (combined with automated ECG analysis);
- ECG patient-activated transmission (auto-transmission) during outpatient treatment.

Between 1972 an 1979 about 250 000 ECGs were transmitted in Saratov region via «Volna-1» system (Table 2.1) (ibid).
Table 2.1 Dynamics of tele-ECG consultations of Saratov telecardiological network (1972-1979)

<table>
<thead>
<tr>
<th>ECG received</th>
<th>Consultations</th>
<th>Occupational health examinations</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>1972</td>
<td>12632</td>
<td>8380</td>
<td>21012</td>
</tr>
<tr>
<td>1973</td>
<td>16796</td>
<td>6930</td>
<td>23726</td>
</tr>
<tr>
<td>1974</td>
<td>20457</td>
<td>4832</td>
<td>25289</td>
</tr>
<tr>
<td>1975</td>
<td>21390</td>
<td>5054</td>
<td>26444</td>
</tr>
<tr>
<td>1976</td>
<td>29723</td>
<td>7116</td>
<td>36839</td>
</tr>
<tr>
<td>1977</td>
<td>31148</td>
<td>7026</td>
<td>38174</td>
</tr>
<tr>
<td>1978</td>
<td>30374</td>
<td>7214</td>
<td>37588</td>
</tr>
<tr>
<td>1979</td>
<td>31840</td>
<td>6936</td>
<td>38776</td>
</tr>
<tr>
<td>Total</td>
<td>194360</td>
<td>53488</td>
<td>247848</td>
</tr>
</tbody>
</table>

A large amount of experience was presented in scientific publications and periodicals, both in the USSR and abroad. Tele-ECG system was demonstrated actively to foreign journalists. Between 1974 and 1978 the «Volna» system operated in 74 cities and towns of the USSR, and by 1980 – already in one hundred (Khramov A. et al., 1996). It was demonstrated at the Exhibition of National Economy Achievements and the International Exhibition «Healthcare-74». The «Volna» creators were awarded medals and diplomas. The technical upgrading of the systems continued constantly. In 1980 under the supervision of Prof. E. Sh Halfen tele-ECG systems were developed, where the digital data transfer method was used instead of the analogue one. Also «Jaguar» three-channel tele-ECG system was created enabling direct remote ECG transmission to an early generation computer machine (Fig. 2.46-2.51) (Halfen E., 1980; 1985; 1974; 1977; 1980 a; 1980 b; 1980 c; Khramov A. et al., 1996).

In the late 1970s Prof. E.Sh Halfen suggested the idea of ECG autotransmission by the patient. This is one of the first home telemedicine technologies in Eastern Europe. «In recent years, in some cases, we hand out EPCs to the patients who were discharged from our clinic for outpatient observation... Being at home, the patient, if necessary, quickly calls the remote cardiac centre, transmits the ECG... and gets the relevant recommendations from the centre... Telemetry information allows the consulting physician to diagnose the nature of the attack immediately and to apply the urgent treatment». ECG in one deflection was used for autotransmission. It should be emphasized that as far back as in the 1970s,
through its work, Professor E. Sh. Halfen laid the conceptual foundations of the modern homecare telemedicine (ibid).

Fig. 2.46. In the remote cardiac consultative and diagnostic centre on the basis of Introductory Course of Internal Diseases (Propaedeutics) Department of the Saratov State Medical Institute (1980)

Fig. 2.47. Early modification of electric cardio-transmitter of "Volna" telemetry system with a separate acoustic set-top box

Fig. 2.48. Later modification of electric cardio-transmitter of "Volna" telemetry system with a built-in acoustic device

Fig. 2.49. "Cactus" radio station, retransmitter for ECG radio telemetry, relay panel
By 1980 tele-ECG operational outcomes, technical and diagnostic aspects and potentials had been analyzed carefully. Some statistical analysis and efficiency evaluation had been made. In general, Prof. Halfen carried out considerable scientific work, having analysed and generalized experience of tele-ECG service rules and use. He formulated the general methodological principles of remote diagnostic centers operation, developed a model of territorial tele-ECG network, described the organizational and personnel details, the necessary documentation, etc. In fact for the first time a substantiated concept of telecardiology service was presented.

During the described period another specific development in telecardiology took place in Saratov - a telemetry monitoring of patients under hospital conditions. Approximately in 1980, Professor B. M. Temkin deployed the system for automated interpretation of telemetrically transmitted ECG of patients undergoing rehabilitation treatment after myocardial infarction in the Saratov Medical Institute Clinic. The following equipment was used: «Saratov» computer machine, 21 RTN radio-based transducer and N-338 self-recorder. Intra-hospital telemetry provided great safety of recovery exercises and accurate load dosage in at least 120 patients (Temkin B., 1980).

Long lasting experience and a proven transtelephonic electrocardiography system performance led to the recognition at national level. On May 27, 1977 the Ministry of Health of the USSR issued an Ordinance №495 «On carrying out an experiment for operation of ECG remote transmission systems». Following the results of this work Eugeniy I. Chazov and Rustam I. Utyamyshev (Fig. 2.52) published a methodological guidance under the same name (Chazov E., Utyamyshev R., 1979).
A few years later telecardiology reached a new level. On August 19, 1982, the related resolution of the Central Committee of the CPSU and the USSR Council of Ministers (№773) and on January 20, 1983 the Order of the Ministry of Health (№72) «On the organization of remote diagnostic offices/centres (RDC)» were published with the Regulation for such unit and special forms of medical documentation. Provision was made for the arrangement of remote diagnostic offices (centres) in the state, provincial and regional hospitals and equipping them with the appropriate equipment to improve the quality of diagnosis and treatment of cardiovascular diseases. Within 2 years (1985), there were 180 RDC, implementing tele-ECG consulting, 185 RDC in 1987 and 354 RDC by 1991. Portable instruments for ECG recording and transmission over telephone lines and receiving stations, based on personal computers were widely used (Kosutskyy G. (Ed.), 1987; Sysoeva N. et.al., 1998; Almazov B., Chireikin L., 1985).

Table 2.2 summarizes data on the dates of creation and work of various RDC. Photos of some founders of Remote Diagnostic Centres in the 1970-1980s are presented on Fig. 2.53-2.63. Personal details are provided in section “Short Biographies”.

Fig. 2.53. Saule R. Abseitova  
Fig. 2.54. Galina P. Avdeeva  
Fig. 2.55. Maria V. Akulova

Fig. 2.56. Vasily I. Voynov  
Fig. 2.57. Vladimir L. Gabunskyy  
Fig. 2.58. Igor V. Kobazev
Table 2.2 Summarized data on the USSR telecardiology network (nowadays Russian Federation, Kazakhstan and Ukraine)

<table>
<thead>
<tr>
<th>City</th>
<th>Medical Institution</th>
<th>Year of RDC opening</th>
<th>Activity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Briansk</td>
<td>Regional Hospital No.1</td>
<td>1983</td>
<td>Automated Diagnostics Department was opened under supervision of I. V. Kobazev, Candidate of Medical Sciences, Honoured Doctor Primary medical examination using tele-ECG implied: up to 3 000 telemetric ECGs daily in 1985 - remote electroencephalographic diagnostics</td>
</tr>
<tr>
<td>Location</td>
<td>Healthcare Facility</td>
<td>Year</td>
<td>Additional Information</td>
</tr>
<tr>
<td>-----------------------</td>
<td>---------------------</td>
<td>------</td>
<td>-------------------------</td>
</tr>
<tr>
<td>Vinnitsa</td>
<td>Regional Clinical Hospital</td>
<td>1982 or 1984</td>
<td></td>
</tr>
<tr>
<td>Volgograd</td>
<td>Not established</td>
<td>Middle of the 1970ies</td>
<td>Network: 32 rural district hospitals, 10 hospitals and a number of occupational health facilities of Volgograd industrial enterprises. Equipment: «Kovyl» proprietary system (PTUM 1-3)</td>
</tr>
<tr>
<td>Gorky (Nizhny Novgorod)</td>
<td>Gorky Medical Institute (Nizhny Novgorod State Medical Academy), Municipal Clinical Hospital No.38</td>
<td>1977</td>
<td>Network: up to 60 municipal healthcare facilities (by 1979), separately - 15 outpatient clinics and medical units (in 1986) Total number of tele-ECG consultations was 31 000 (27 384 in 1977-1987). Network clinical teleconsultations for outpatient clinics 12 970 (1977-1986). Development and systemic introduction of cybernetics and automation means into cardiology (under supervision of Prof. A.P. Matusova). During 1997-2004 ECG autotransmission method was introduced (under supervision of Associate Professor A. F. Shestakov)</td>
</tr>
<tr>
<td>Donezk</td>
<td>Regional Clinical Hospital</td>
<td>-</td>
<td>Network: district healthcare facilities of the Region. Equipment: «Volna». Q-ty of tele-ECG consultations: 5 500 - 7 000 per year</td>
</tr>
<tr>
<td>Ivanovo</td>
<td>Regional</td>
<td>1981 or</td>
<td>Network: at least 26 healthcare</td>
</tr>
</tbody>
</table>

Q-ty of tele-ECG consultations: 150 000 over 10 years of active operation (during the first 2 years – 1 324 ECGs)
<table>
<thead>
<tr>
<th>Location</th>
<th>Facility Details</th>
<th>Year</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ivano-Frankovsk</td>
<td>Clinical Hospital earlier facilities with in-hospital departments 204 cases were analysed in the publications</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Kirov</td>
<td>Cardiological Dispensary of the Regional Clinical Hospital</td>
<td>1985</td>
<td></td>
</tr>
<tr>
<td>Krasnoyarsk</td>
<td>Territorial Hospital No.2</td>
<td>1975</td>
<td>Network: 36 districts of the Region In complicated cases tele-ECG consultations were arranged in Moscow and at the leading cardiologists of the 4th Main Directorate Hospital</td>
</tr>
<tr>
<td>Leningrad (Saint-Petersburg)</td>
<td>Scientific Research Institute of Cardiology 1978 (SRI and RCH) testing period</td>
<td></td>
<td>Network: 17 central district hospitals, 4 healthcare facilities (with maximum care delivery distance of 400 km). Quantity:</td>
</tr>
<tr>
<td>Location</td>
<td>Institution</td>
<td>Year</td>
<td>Equipment</td>
</tr>
<tr>
<td>--------------------------------</td>
<td>------------------------------------------------------------------------------</td>
<td>------</td>
<td>-----------</td>
</tr>
<tr>
<td>Moscow</td>
<td>MF Vladimirsky Moscow Regional Research Clinical Institute (MONIKI)</td>
<td>1974</td>
<td>«Volna», «Salyut», «Ultrans» (Finland)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Institute of Experimental and Clinical Therapy/A. L. Myasnikov Institute of Clinical Cardiology</td>
<td>1971</td>
<td></td>
<td>«Tranzicard» (Norway) and “domestic system created by a group of Moscow engineers”. 1st stage - tele-ECG transtelephonic transmission during researches under the myocardial infarction register program (Sokolnicheskyy district) (n=132). Later the network included emergency doctors and the district hospital (Fig. 2.64)</td>
</tr>
<tr>
<td>Location</td>
<td>Institution</td>
<td>Year</td>
<td>Description</td>
</tr>
<tr>
<td>---------------------------</td>
<td>--------------------------------------------------</td>
<td>---------</td>
<td>-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Novosibirsk</td>
<td>Regional Cardiological Dispensary</td>
<td>1976</td>
<td>Around-the-clock consultations for EHS (Fig. 2.65)</td>
</tr>
<tr>
<td>Omsk</td>
<td>Regional Clinical Hospital</td>
<td>1985</td>
<td>-</td>
</tr>
<tr>
<td>Orenburg</td>
<td>Regional Clinical Hospital</td>
<td>1979</td>
<td>Established by Doctor Maria V. Akulova (Fig. 2.55 and 2.66 (Nuzhdina T., 2016))</td>
</tr>
<tr>
<td>Poltava</td>
<td>Cardiological Dispensary</td>
<td>1985 or 1990</td>
<td>Network: Regional Cardiological Dispensary, 25 districts of the Region Equipment: «Volna» (dismantled in 2005) Number of tele-ECG consultations during 1990-2004 totalled to 15,128 (after 1995 it was reduced significantly due to a sharp rise in the cost of long distance telephone services) (Shklyarenko M., Marienko Ya., 2009)</td>
</tr>
<tr>
<td>Saransk</td>
<td>Medical faculty of Mordovia State University</td>
<td>1979</td>
<td>Equipment: «Salyut» Network: district hospitals Centre was founded under supervision of V. Tyavokin, Doctor of Medical Sciences, Professor</td>
</tr>
<tr>
<td>Saratov</td>
<td>SRI of Cardiology, 2nd Municipal Hospital</td>
<td>1971</td>
<td>Network: 20 healthcare facilities of Saratov, 35 districts of the Region, EHS brigades, outpatients (10 transmitters). Equipment: «Volna». Number of tele-ECG consultations during 1972-1979 totalled to 247848; only in 1983 to 11 580</td>
</tr>
<tr>
<td>Sverdlovsk/Ekaterinburg</td>
<td>Regional Cardiac Centre, Municipal Clinical Emergency Care Hospital</td>
<td>1978</td>
<td>Network: 4 receiving stations (panels); 40 transmitters in ambulances and in 15 districts of the Region Equipment: devices developed by All-Union Scientific research Institute «Standartelektron». Lines of activity: EHS; rural districts</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Within a radius of up to 600 km from the regional centre; screening. 610 tele-ECG consultations for EHS brigades and 1 102 telemedicine screening consultations were analysed in the</td>
</tr>
</tbody>
</table>
publications

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Ulan-Ude</td>
<td>First-Aid Station</td>
<td>Middle of the 1980ies</td>
<td>Q-ty of tele-ECG consultations 500</td>
</tr>
<tr>
<td>Kharkov</td>
<td>Central Clinical Hospital No.5</td>
<td>1997</td>
<td>Inter-railway Remote Diagnostic Centre of Cardiovascular Diseases.</td>
</tr>
<tr>
<td>Cheboksary</td>
<td>Chuvash Republican Cardiological Dispensary</td>
<td>1985</td>
<td>-</td>
</tr>
<tr>
<td>Shymkent</td>
<td>EHS Hospital, infarction department (Regional Cardiac Centre)</td>
<td>1985</td>
<td>-</td>
</tr>
</tbody>
</table>

One of the organizers, Associate Professor Konstantin N. Emeshin described the establishment of the Barnaul Centre (Fig. 2.67-68) as follows: «I remember how we managed to get the first Soviet transtelephonic ECG transmission system – «Volna». I brought it into my office and immediately tried to transmit ECG from a nearby office. It was successful. It was shown to Askalonov [at that time, Ascalonov Arthur A. (Fig. 2.69) was the head of the Department of Health of the Altai Territorial Executive Committee - author's note] and he immediately offered to establish a territorial centre. I invited my classmate L. Kochetova

![Fig. 2.64. ECG transmission by phone and transmitting device (tele-ECG network experience in Moscow, 1974 (Mazur N. et al., 1974), «Tranzicard» (Norway) telecardiological equipment is possibly shown in the picture](image)
(maiden name) to work at this new initiative. The centre was established inside the Territorial Hospital, and the late cardiologist Safir was responsible for its introduction. The photo shows this centre in the territorial hospital [Fig. 2.67 - author's note]. At that time there was no Cardiac Centre yet» (Emeshin K., 2013).

In July, 1981 in Kiev, under supervision of Ivan I. Usitchenko (Fig. 2.70) and with the participation of Leonid M. Shlaen, a RDC was started up on the premises of the Municipal First-Aid Station (Usychenko I., Shlaen L., 1987). «Salyut» and «Volna» systems were used. By 1987 the network included 44 cardiotransmitter belts and consultative work was carried out by qualified doctors around-the-clock (Fig. 2.71).

There were some technical problems. The «Salyut» system was recognized as hardly suitable for work conditions in ambulances; the receiving equipment was modified. To optimize the RDC, operation job descriptions were developed; special advanced professional training for tele-ECG was carried out.

There was an increase in number of tele-ECG consultations over
4 years from 240 to 7,293 per year, with an increased level of myocardial infarction detectability. Late hospitalization cases were reduced, and the efficiency of arrhythmias relief by the brigades equipped with tele-ECG devices was 11% more than for brigades without transmitters. It was concluded that it was necessary to increase the number of general ambulance brigades equipped with tele-ECG systems (Fig. 2.72-2.73).

It must be said that in the described period, tele-ECG was used very widely at the prehospital stage. In the USA, in the 1970-1980s, mobile telemedicine systems were actively used in the rescue services (ambulance, paramedics, firefighters), which allowed carrying out 12-channel ECG telemetry and voice communication with a consultant by radio. Biophone (Biophone Company, Fig. 2.74-2.76) and APCOR (from “Advanced
Portable Coronary Observation Radio”, Motorola, Fig. 2.77-2.79) were the most widespread systems. Both carried out multi-channel data transmission, had integral battery power supply and could be connected to the antennas of medical ambulances.

The first Biophone was presented in January 1970, and the first implementation took place around 1974. 2 hospital consoles and 40 Biophone system transmission devices were introduced in the emergency medical service in San Francisco (USA) and in Texas (Fig. 2.80). It must be said that Biophone was a kind of symbol of the age, it even «participated» in the «Emergency» television series dedicated to ambulance routine work. There were also other models of similar telemetry devices (Fig. 2.81).
Fig. 2.75. ECG telemetry simulation (Biophone system prototype) in the conditions of first aid rendering (the photo shows from left to right: Jerry Knolls, unknown person, Harve Hanish, Biophone Company President). Photos by Carl C. Van Cott. (http://behind-the-scene.tripod.com/id5.html)

Fig. 2.76. Biophone 3502 telemetry system (on the right – original device featured in a TV serial) (The Virtual EMS Museum, 2015)

Fig. 2.77. APCOR telemetry system, Motorola (The Virtual EMS Museum, 2015)

Fig. 2.78. APCOR telemetry system, Orange Box model, Motorola
Fig. 2.79. Instruction for voice data transmission via APCOR Orange Box model

Fig. 2.80. Teleconsultation with the help of Biophone (ambulance supervisor Randy Frederick (with a telephone handset in his hands) and paramedic Bill Collins are receiving recommendations from Hood General Hospital (Texas, USA, 1974): «Biophone will save the precious seconds which before were lost» (Holsinger W., Kempner K., 1972)

Fig. 2.81. Bourns Life LS118-1 telemetry system for paramedics (1973)

Fig. 2.82. Pavel Ya. Dovgalevsky
What about «Volna»?

In the late 1970s, the tele-ECG network included health centres of large coal mines and the principal centre at the Donetsk Central Municipal Hospital No.16 (USSR). And in 1990 a team headed by Rimma A. Kopytina used the «Volna» system to control dynamically the health status of miners of Donbass deep coal mines. The method included an «interview, a special questionnaire and transtelephonic transmission of a worker's ECG from the mine health centre to the CDC [Consultative and Diagnostic Centre - author's note] before and after the work shift, at regular intervals determined by the risk level of the disease complications development [ischemic heart disease - author's note]». The positive role of this telecardiological system was established for maintaining working capacity, early diagnosis of ischemic infarction, sudden death prevention. This resulted in a positive social and economic effect (Kopytina R. et al., 1990).

Since 1994 Professor Pavel Dovgalevsky (Fig. 2.82), headed the Saratov Research Institute of Cardiology. Dovgalevsky was a student of E. Sh. Halfen and a Doctor of Medical Sciences. He continued the investigations of his teacher and promoted the development, in priority, of new medical technologies in cardiology using telemetry and local computer systems. Further improvements and changes of the individual telemedicine concept, the «ECG autotransmission by patients», were particularly intensive.

In 1995 the scientific base was developed, the work analysis was performed, the methodical approaches to the organization of the RDC work with patients were offered and standardized. In other words, the scientific and methodological basis of individual telecardiology was developed (Fig. 2.83) (Dovgalevsky P., 1994; 1995).

The following results prove the effectiveness of this concept: «Comparative effectiveness of the ECG autotransmission method at a stage of follow-up of post infarction patients showed that in 57% of the patients using autotransmission, rythm and conduction disturbances were detected as compared with 14% in the control group. The time of patients' return to occupational activities was reduced significantly (on average by 40 days).
Among patients using autotransmission, the total number of recurrent myocardial infarction within 12 months was only 7.8% compared with 13.8% in the control group. Within a year, the mortality in the control group was 13.9%, of which 40% were sudden death cases. Accordingly, mortality of patients, who used autotransmission, was only 10.7%, and sudden death was observed in 27.2% cases (ibid).

However, it should be noted that this work was not the only one in the world. As far back as 1976, in Canada, under the supervision of Kenneth W. Taylor, a tele-ECG network for autotransmission was organized. The expert centre was at the Toronto General Hospital, and every patient with an implanted pacemaker or risk of arrhythmias could transmit an electrical signal by phone. The data were recorded by specially trained nurses, and were interpreted by physicians. For convenience and efficiency, simple and affordable (both technically and financially) transmitters were developed for patients. About 400 patients used this service, which was in fact home telemedicine (Uhley H., 1970).

A special mention in this regard should be made of the tele-ECG experience in the Gorky (today Nizhniy Novgorod) Region, USSR. Since 1962 a group of engineers and doctors in the city of Gorky was actively working on the issue of automation in cardiology. The group of doctors was headed by Professor Aleksandra P. Matusova and the group of engineers was headed by Professor Yury I. Neymark (Fig. 2.84-2.85). The following medical professionals were also involved: Ya. G. Lyubavin, Cand. MS, M. S. Bubel, Cand. MS, K. F. Kravets, L. M. Velikovskaya, N. E. Akhontov, M. B. Shmerelson, R. F. Fedorovskaya, S. N. Sorinson, M. A. Kuznetsova, M. V. Vedenskaya, D. L. Pikovsky, L. G. Chistyakova; and engineering specialists Z. S. Batalova, Yu. G. Vasim, M. D. Breido, N. D. Obraztsova, I. M. Ivanova, V. M. Morozov, L. E. Gokhstein, A. N. Durnovo, S. S. Morin, I. D. Bolshagin, M. Khaimovich, V. Gladkov, V. Borin (Matusova A. et al., 1986; Matusova A., 2010; Gorodetskiy S., 2016).

They developed and implemented unique methods of automated diagnostics of various diseases of the cardiovascular system, based on the proprietary algorithms of medical information detection and analysis, methods of mathematical outcomes predictions, automated pre-medical screening procedure, etc. As a result of the huge theoretical and experimental work they managed to create new methods of initial data processing and additional approaches addressing feature selection and construction of decisive classification rules. They also succeeded to design algorithms of feature recognition, selection and formation, as well as to specify complete systems of machine features of medical curves, cardiograms in particular. With the help of the developed methods, a
number of specific issues of medical diagnosis, prognosis and treatment method selection were successfully solved. The results obtained in this field were published in 1972 under the editorship of Yu. I. Neymark in the book «Pattern recognition and medical diagnostics» (Matusova A. et al., 1986; Matusova A. et al., 1979; Matusova A., 2010; The regional center of remote ECG diagnosis of the Regional Hospital of Novosibirsk, 2016).

In the mid-1970s, at the Internal Diseases Department of Gorky State Medical Institute and Municipal Hospital No.38, the Cardiological Remote Diagnostic Centre was established. Its goal was to receive information from the municipal medical institutions. The centre was founded by Professor Aleksandra P. Matusova. Her students – Nikolay N. Borovkov (Fig. 2.86), Lyubov M. Velikovskaya and M. S Bubel worked actively on the problems of remote ECG diagnostics for 15 years. Their research and applied works were award-winners at the Exhibition of National Economy Achievements (Borovkov N. et al., 1989; Matusova A. et al., 1986; Matusova A. et al., 1979).

Within 15 years of active work, the Gorky tele-ECG centre held over 31000 teleconsultations, including, 27 384 teleconsultations during 1977-1987, where myocardial infarction was diagnosed in 1.3% of patients, angina pectoris in 37.2%. On the basis of the experience gained, a special model was developed for remote ECG diagnostics application on outpatients, and methodology and specific features of RDC establishment based on polyclinic facilities were defined.

By 1986, two Centers performed ECG and clinical data reception from 15 outpatient clinics and medical units in Gorky. Clinical teleconsultations with a mandatory transmission of complete information about the patient were held. In total about 12 970 teleconsultations were given in the outpatient telemedicine network, myocardial infarction was detected in 2.1% (270) patients. Scientific analysis of diagnostic errors was carried out,
the leading role of the tele-ECG was determined for infarction prevention (ibid).

The team headed by prof. A. P. Matusova used the most advanced concepts in their work, combining remote ECG interpretation as such and full-fledged cardiac teleconsultations, accompanied by the transmission of detailed information about the patients. To unify this transmission special coding schemes were developed, which formalised the description of a clinical case. The schemes included complaints, a brief history of life and disease, minimal information on the results of physical examination. However these data were not just transmitted into the RDC, but subjected to computer analysis: «Three linear formulas were developed which helped to perform a mathematical diagnosis of the main forms of ischemic heart disease on the basis of the codified clinical information in the DC [Diagnostic Centre - author's note]». During 1977-1987 13950 teleconsultations were carried out according to this procedure. However, the described scheme was not effective enough due to mandatory medical examination of the remotely consulted patient. That is, medical attendants and nurses could not refer patients for teleconsultation though the need for such services was very high. Therefore, a few years later the schemes were replaced by scientifically substantiated «single program for thoracic pain syndrome diagnostics», which was based on the patient questionnaire. Owing to this innovation «clinical remote consultations... became available to any paramedic centre. The time spent on remote consultation was reduced» (mean time «did not exceed 15 minutes») (ibid). There is an interesting fact: the authors conducted a simple economic calculation and stated that the cost of one tele-ECG consultation was «1 rouble 70 kopecks».

An important methodological moment was the standardization of the variants of the most common RDC recommendations for patient surveillance. In total 7 unified answers remained. The team of Prof. A. P. Matusova also studied the tele-ECG diagnostic value by comparing the «centre and hospital diagnoses in hospitalized patients»; the coincidences were observed in 70-97.6% of the cases. The accumulated experience of the tele-ECG centres was summarized in a number of articles and methodological guidances for the RDC organization on the basis of outpatient clinics. In the mid-1990s the team of Prof. Matusova also studied and mastered the techniques of ECG autotransmission by the patients at the outpatient treatment stage (ibid).

Thus, during the late 1970s-1980s the extensive tele-ECG network was established at the national level in the Soviet Union. The tele-ECG networks operated efficiently: «The average hospital stay... was shortened by 1.5 - 2
hrs., which significantly reduced the number of complications and adverse outcomes ... The number of patients, receiving qualified cardiac care at the prehospital stage increased daily on average by 2.5 times... ECG transmission by phone enabled to reveal a number of patients with periods of brief transient myocardial ischemia» (Fialko V., 2011). Remote Diagnostic Centres worked around-the-clock as well in the interactive mode as asynchronously, reporting the results of ECG interpretation during the second communication session. In some cases teletype machines were used to send the opinions (Antonov Yu. et al., 1979; Vinogradova T. et al., 1977; 1979; Vinogradova T., 1988).

Special mention should be made of the widespread telecardiology use for preventive purposes, i.e. for the implementation of telemedicine screening. Many publications in those times focus precisely on the preventive importance of mass screening, using ECG transmission by telephone. In the late 1980s, the procedure of using remote diagnostic centre for mass screening in groups was developed and implemented under the supervision of Professor Vladimir A. Almazov (Fig. 2.87).

Thanks to tele-ECG screening rather considerable risk groups (14,01-20.7%) were revealed in large cohorts (n = 5 653; n = 1,102) (Almazov B. et al., 1986; Almazov B., Chireikin L., 1985; Fialko V., 2011; Chireikin L. et al., 1977; Chireikin L., Dovgalevskyy P., 1995).

A significant role in the development of scientific and practical aspects of telecardiology and work methodology of remote diagnostic centres was played by Leningrad cardiologists. In 1978 RDC were established in Leningrad Scientific Research Institute of Cardiology, (now Almazov Federal Heart, Blood and Endocrinology Centre, Sankt-Petersburg, Russian Federation) and in the Regional Clinical Hospital. A tele-ECG network was deployed covering 17 central district hospitals and 4 municipal healthcare facilities. Between 1980 and 1985, the Centre carried out over 20 000 tele-ECG consultations and also at least 6400 tele-ECG screening examinations (ibid).

At the Leningrad First-Aid Station, a RDC was also established under the auspices of the Institute of Cardiology. Between 1978 and 1980 the staff carried out preparatory and organizational work and arranged special 4-hour training courses for medical personnel (400 people, mostly doctors) on the tele-ECG usage procedure (Kirilyuk I. et al., 1984). It should be underlined
that this bibliography source contains one of the first references of specialized training on telemedicine. Also, the authors made a simple economic analysis, which showed a quick payback and high efficiency of telecardiological systems. Over the 4 years of operation, the RDC provided more than 4 000 tele-ECG and up to 1 500 clinical remote consultations annually, with a daily average load of 20 teleconsultations.

Telecardiology development from the level of routine tele-ECG use to the level of full-fledged clinical telemedicine consultations, scientific analysis and usage methodology validation resulted from the work of Professor Lev V. Chireykin (Fig. 2.88; Kurapeev D. et al., 2013), who supervised the work of tele-ECG network in the Leningrad Region at that time. Professor Chireykin was the first in the USSR to carry out scientific analysis of clinical telemedicine (Fig. 2.89). The structure of tele-ECG consultation appeal was defined quite clearly: «On the total number of clinical consultations, 79.7% of patients were consulted in urgent indications, including 31.2% of patients with acute macrofocal myocardial infarction (MI); 8.3% with other forms of acute ischemic heart disease; 20.2% of patients with complex arrhythmias and conduction. In 19.6% of cases the «masks» of acute ischemic heart disease» were a reason for consultations (Almazov B. et al., 1986; Almazov B., Chireikin L., 1985; Fialko V., 2011; Chireikin L. et al., 1977; Chireikin L., Dovgalevskyy P., 1995).

Lev V. Chireykin investigated the tele-ECG diagnostic value in the myocardial ischemia syndrome diagnostics, having studied opinion concordance of 5 expert specialists as shown in 300 tele-ECGs. It was determined that a full match of treatments occurred in 69.8% of cases, whereas in 13.4% - responses were completely different. It was found that «more similar results were observed in the evaluation of ECG with macrofocal MI, and evaluations of all specialists matched most during the analysis of the ECG with His Bundle Branch Block» (ibid). Further study referred to clinical efficiency as a result of the tele-ECG consultations (CDH-RCH):

- More than 30% of electrocardiographic findings were corrected and 5.5% were completely revised;
- Treatment regimen was corrected in 60% of cases; the nature of treatment was fundamentally changed in 12% of cases.

In 14.2% of the cases, teleconsultations resulted in conducting urgent actions of health interventions or resuscitation. And «the centre consultants newly diagnosed focal myocardial changes in 12% of patients that had been previously regarded wrong». 
For the first time within the frame of the national Telecardiology, L. V. Chireykin determined that «there are two main lines in RDC work, which, though not excluding each other, are considered by us as equally important to improve cardiac diagnostics, especially in patients with ischemic heart disease: remote ECG analysis and implementation of remote clinical consultations. And both, in the first and in the second case, depending on the tasks assigned to RDC and the list of its «users», consultative assistance can be rendered at the prehospital stage (for polyclinic general practitioners and cardiologists, «emergency care» teams) or in case of sufficiently qualified cardiologists available - consultations of specialists on the functional diagnosis regarding ECG being difficult to interpret or consultations of CDH cardiologists, physicians and resuscitators in the diagnosis of obscure cases» (ibid).

As such, for the first time it was shown that remote ECG interpretation was only one element of a comprehensive cardiac teleconsultation, which should include a full exchange of all available information about the patient's condition to determine not only the diagnosis, but also the therapeutic approach and patient monitoring. Full-fledged «remote clinical consultations» began in the Leningrad RDC no later than in 1978. It is known that annually their number and importance increased and reach at least 6 thousand (annual dynamics looks as follows: 1979 – 582; 1980 – 1 135; 1981 – 1 448; 1982 – 1 352; 1983 – 1 882 consultations) (Kirilyuk I. et al., 1984; Almazov B. et al., 1986; Almazov B., Chireikin L., 1985; Fialko V., 2011; Chireikin L. et al., 1977; Chireikin L., Dovgalevskyy P., 1995). Moreover, Chireykin formulated the «additional conditions for remote
health care with regard to the general ones», i.e. the requirements for clinical cardiac teleconsultation, which are quite relevant up to now. Let’s cite them:

- To provide methodologically correct, systematic, fairly complete collection of information about the patient (data history, physical, laboratory and instrumental examinations);
- To minimize the distortion during the information transmission to the RDC;
- To use the conversational mode to clarify information about the patient;
- To carry out dynamic monitoring of patients by active calls and repeated consultations;
- To record precisely the transmitted information and recommended data, preferably with dictaphone devices;
- To provide peer review of errors committed and accurate diagnosis cases.

Prof. Chireykin emphasized that «compliance with these conditions shall be enhanced by the development of formal documents both to enable the information transmission and to form opinions by the centre, to create a reference system for most common emergency conditions allowing the consultant to immediately obtain information on the amount of aid, the procedure for urgent activities, pharmacodynamic properties of essential medicines» (Chireikin L. et al., 1977; Chireikin L., Dovgalevskyy P., 1995).

Thus, L. V. Chireykin formulated the general methodology of telemedicine consultation: requirements for the quality and quantity of health information interactivity aspects, reporting, resources for evidence-based decision-making, as well as regulatory issues. He proclaimed that «physicians directly supervising the patient are legally responsible for the correct diagnosis and first aid rendering to the fullest extent». This is fully in line with modern telemedicine.

Description of the «human factor» is rather interesting: «The authors encountered a «paradox»: experienced and qualified cardiologists resorted to consultations more often than admitting resident physicians or other medical specialists, mainly due to an incorrect assessment of patients' severity by the latter» (ibid).

An evidence-based methodology of telemedicine in cardiology was presented by L. V. Chireykin in a series of articles, patents, monographs and guidances in collaboration with such leading figures as V. A. Almazov and P. Ya. Dovgalevsky (Fig. 2.90).
Researchers from Leningrad Scientific Research Institute of Cardiology (V. A. Almazov, L. V. Chireykin, Doctor of Medical Sciences Victor F. Chavpetsov (Fig. 2.91), E. M. Fetisova, M. S. Tozhiev, A. I. Koblents-Mishke) prepared special methodological guidance for the establishment and work management of remote cardiac diagnostic centres (Almazov B. et al., 1986). This was a comprehensive document containing general provisions on the RDC, load and mode of operation, organizational structure, tasks and features of the work depending on the health facility served (rural, ambulance, etc.), the deployment procedure, etc. It was assumed that, based on one shift, RDC could hold up to 4 thousand tele-ECG consultations, and in case of around-the-clock operation they could provide 20-25 thousand consultations a year. At least two reception centres with 30-40 transmitters should be established for a district with a population of 250,000 inhabitants.

It was recommended to install computers for automated ECG analysis in the large clinical hospitals. In this case, the organization and operation of the ECG interpretation centre (ECG-RDC), «full-fledged» remote cardiology consultation centre (C-RDC) and wide-scale preventive examination centre (P-RDC) were considered separately (Fig. 2.92) (ibid). Special sections of methodological guidance were devoted to the multifunctional RDC and the creation of

Fig. 2.90. The title page of one of the patents by L. V. Chireykin et al., describing tele-ECG system

Fig. 2.91. Viktor F. Chavpetsov ((07.07.1947-16.11.2011)
telecardiological network. Perhaps for the first time in clinical telecardiology, the requirements for information security provision and the fight against distortion and loss of data during teleconsultation were formulated and also the criteria for evaluating the effectiveness of telecardiological activity were proposed (ibid). In terms of evaluating efficiency, many researchers compared the results of ECG interpretation by physicians of district and regional hospitals where RDC were located (Vinogradova T. et al., 1977; 1979; Vinogradova T., 1988; Chireikin L. et al., 1977; Chireikin L., Dovgalevskyy P., 1995). An interesting positive factor in the tele-ECG use provided by Prof. Tamara S. Vinogradova: «It [remote ECG diagnostics] allows ... psychologically preparing a regional service of functional diagnostics for automatic remote ECG analysis with the use of computers» (Vinogradova T. et al., 1977; 1979).

In the context of this citation it is necessary to make a short deviation. The period of the 1960-1980s can be called a «golden age» of medical cybernetics. Throughout the world, scientific works of grand-strategic importance were carried out and thus predetermined the development of the modern concept of e-health.

Computer analysis of various kinds of medical information was actively developing. Within the course of time it evolved into separate areas called «computer diagnostics» and «automated control systems». Instrumentation for diagnostic and information systems implementation with the help of computer technology were designed. Automated systems for diagnosis of acute distresses of brain, cardiovascular, oncological and other diseases were proposed and implemented. The methods of mathematical prediction and modelling in medicine were particularly studied. Professor Chireykin accurately foresaw the enormous potential of digitally processed medical information. Overcoming the weakness of eternal doubters, he wrote: «The starting point for research problem setting, verification of training groups,
selection of valuable diagnostic signs and testing their efficiency in practice is a Medical Specialist, and therefore any grounds for opposing the methods of traditional medical and computing diagnosis are lacking [italicized by Chireykin]» (Chireikin et al., 1977).

Prof. Halfen, in addition to tele-ECG, also carried out extensive work on the automation of diagnostic and treatment processes in the cardiac institutions. Under his supervision, algorithms and programs were implemented «enabling the computer machine to record and evaluate the electrocardiogram and other basic parameters of the functional state of the cardiovascular system in real time, in the on-line mode» (i.e. the direct patient - computer communication without intermediate carriers). Since 1970 computer-based automated constant supervision system for myocardial infarction patients, cybernetic methods for determining the optimal dosage of medications, mathematical methods for predicting outcomes of pathological processes were developed, operated and continuously improved. In general, Prof. Halfen created and put into practice the concept of automated control over diagnosis and treatment of patients with cardiovascular diseases.

We have already mentioned the large-scale works performed by Prof. A. P. Matusova and Prof. Yu. I. Neymark. In general, in the Soviet Union the works were carried out based on automated collection and processing of medical information. A national automated system for health care planning and management was created. The concept of a medical technical centre of a clinical hospital was formulated, which should include computer centre (with the development of detailed requirements for its location, structure and determination of functioning scheme, solved tasks, etc.). Academician S. A. Gasparyan proposed a model of health servicing network, actively using automation techniques. It was suggested that for the four-stage medical service, medical information and diagnostic centres (1 for 250-300 thousand of inhabitants) should be established. Its task, among other things, would include «servicing of a network of the attached clinics with laboratory diagnostics, including the remote development of some data received over telephone channels from the outpatient clinics» (Gasparyan, 1977). Systemic models of regional and municipal medical automated control systems (ACS), the specific algorithms and programs for use in health care management, automated patient data processing systems, included in the wide-scale preventive examinations, statistical forecasting and modelling, formation and work with medical data banks (including international ones), information management systems for medical check-up, questions of teaching ACS and computer diagnostics in the medical high schools were developed and implemented (Computers in health care and
biomedical research..., 1978). In 1971, in Kiev Nikolay Amosov issued his famous monograph – «Medical Information System»

But let us come back to the main topic: Telemedicine History.

In addition to the «Volna» system, other technical solutions for telemetry of basic physiological parameters, first of all – ECG, were developed and widely used in the USSR. In 1972 a team from Kislovodsk consisting of V. L. Kashin, G. A. Pchelintseva and V. A. Mkrtchyan published a description of the proprietary device for ECG recording over the telephone line: «...there is often a necessity to register electrocardiograms of a recumbent patient... it is suggested to use a communication line over the phone by connecting the appropriate device to the telephone itself». The system for recording and transmission of 12 leads consisted of a bioelectrical amplifier, modulator, communication channel, matching device, demodulator and recorder (the «industrial instrument»). It was reported about the preparation of engineering prototypes for subsequent series production (Kashin V. et al., 1972).

However, the following historical episode deserves special attention. In the mid-1970s a group of employees of the Volgograd Medical Institute - Doctor of Medical Sciences, Professor, Anatoly G. Konevsky, Doctor of Medical Sciences, Professor Konstantin V. Gavrikov, Doctor of Medical Sciences, Professor Yekaterina V. Tsybulina (Fig. 2.93-2.95), engineers A. S. Yudin, M. I. Ryabchenkov, A. V. Buhtin, V. I. Dal - developed their own physiological information and ECG telemetry system «Kovyl» (PTUM 1, 2, 3 devices), approved by the Ministry of Health of the USSR. Data were transmitted over the telephone line. The first version of the system performed consecutive telemetry recording of leads (all 12 leads, one after the other) and was tested by remote consultations on 1 204 patients.
Then, within 2 months, a second version of the system was developed that allowed simultaneous transmission of two leads, which, of course, reduced the time tele-ECG consultation (practical approval involved 120 patients). The diagnostic value of «Kovyl» system was verified by an independent assessment of ECG before and after the transmission by the qualified cardiologists (as tested on 34 patients).

After some time a telemetry centre of functional diagnostics of the cardiovascular system diseases was opened in the region. It collaborated remotely with 32 rural district hospitals and 10 hospitals in Volgograd, and also with the medical units of industrial enterprises. During the first 2 years, about 1 324 patients were remotely consulted; abnormalities were detected in 79.2% of them. For 10 years of active service the centre held about 150000 tele-ECG consultations.

Thematic publications refer to 1977-1978 and major awards for the development of biological radio electronics were received by Prof. K. V. Gavrikov in 1972. Nevertheless, analyzing the available literature we still assume that both the scientific and theoretical basis for the system were carried out in the late 1960s - early 1970s, while the telemetric network as such was developed around 1975. The first important results of scientific and practical conclusions were published in 1977 (Konevskyy A., 2011; Gavrikov K., 1977 a); b); Konevskyy A., 2011 b); Konevskyy A., 1977; Tsybulina E., 1977).

It should be noted that the «Kovyl» system was the result of the long lasting work of the team headed by Prof. K. V. Gavrikov. The team created one of the country's first wireless devices with direct input of medical diagnostic and reflexometering information into the «Ural-1» computer machines, developed and implemented one of the first programs of direct input of physiological data, its machine analysis and automated result readout.

On the basis of summarizing the research findings, a theory of relative informational content of the signal effects on the human body was developed and the foundations of the original theory of systemic organization of human mental activity were laid. Medical multichannel digital telemetry system «Kovyl», which connected almost all district hospitals of the Volgograd Region with the regional diagnostic centre, surpassed not only domestic but also foreign developments by the level of technical and organizational solutions for many years ahead. It was honored with the awards and certificates of the Committee on Science and Technology of the USSR, USSR Ministry of Health, the Chamber of Commerce of the USSR, Exhibition of National Economy Achievements, foreign medical exhibitions, the «Badge of Honor», high praise of the
leading experts in the field of radio engineering and medicine. The Supreme Council of the CMEA countries awarded the authors of the «Kovyl» system with the Diploma of Merit «For active participation and contribution to the scientific and technical integration of the socialist countries in the field of medical technology» (ibid).

The scientific contribution of Professor Yekaterina V. Tsybulina to the «Vovyl» system operation study should be noted separately. Within a few years of active use of clinical telemetry in the Volgograd Region, in 1977, she pioneered the development of clear and well-founded indications for tele-ECG consultations, focusing on the wide-scale preventive examinations. These indications are quoted below (Tsybulina E. et al., 1977):

«1. All patients with suspected acute coronary pathology (myocardial infarction, angina pectoris, preinfarction period) for the purpose of emergency diagnosis, especially if the patient is not hospitalized during the first hours of the disease.

2. Patients with ischemic heart disease, subject to regular medical check-up at CDH. Examinations should be carried out in the dynamics prescribed by a doctor.

3. Patients with essential hypertension.

4. In cases when the electrocardiologist finds difficulty with in the ECG data assessment in the event of discrepancy in the clinical findings and ECG changes, etc.

5. All patients with cardialgias, especially those aged 30-60.

6. Patients with chronic coronary insufficiency of I-III degree for monitoring treatment efficacy of various medicines (outpatient clinic and CDH).

7. All patients with arrhythmias.

8. Patients in the CRH intensive care units, for monitoring the disease evolution and patient’s treatment with the ad-hoc timely medical advice.

9. Dispensary groups of patients with rheumatic heart diseases during a routine examination».

On basis of the experience gained, the team developed the concept of diagnostic service centralization to manage the patients with ischemic heart disease, which consisted of 4 stages.

The first stage included the provision of regular ECG reception by telephone and radio (for ambulance) with the issuance of a qualified opinion. The second stage implied the introduction of so-called «code tables of medical information» consisting of 6 sections: «General information about the patient» (25 positions), «Complaints» (67 positions), «Medical history, clinical picture» (76 positions), «Appealability and quality of health
care», «Objective data» (61 positions), «Laboratory report». The table had 314 positions in total. All questions in the tables were codified and transmitted to RDC by doctor over phone or, after he had marked the relevant positions, by a third party.

The third stage of the concept implied around-the-clock teleconsultation assistance for all in-hospital departments of (non-specialized) municipal hospitals and first aid stations. In this respect the stock of biotelemetry tools was significantly expanded through phonocardiography, sphygmoplethysmography, etc. In the fourth stage, telemetry systems were widely implemented for mass preventive examinations with a computerized preliminary ECG analysis. A significant economic effect was expected immediately upon the introduction of the concept.

In the context of early-stage development of clinical tele-ECG, the «Ultrans» system is worth mentioning. It was developed in Finland by engineer and inventor Veikko Ilmastilla (Fig. 2.96-2.97) in 1972. This system was used quite efficiently in the ambulance service in Helsinki between 1971 and 1975 (Irnich W., 1971). In the USSR, it was tested at the N. V. Sklifosovsky Research Institute of Emergency Medicine in the acute medical unit headed by Prof. A. P. Golikov. Quite encouraging results were obtained.

Engineer Veikko Ilmastilla presented the «Ultrans» in the USSR at the cardiological symposium in Moscow in 1976. Moreover, to demonstrate the unique capabilities of the system in the presence of the USSR Minister of Health, a real time, transtelephonic electrocardiogram transmission of the Finnish President Urho Kekkonen was organized directly into the conference hall. However, it should be said that this story looks somewhat apocryphal.

The «Salyut» system was another technical solution for tele-ECG transmission in the Soviet Union. Since 1970 Izhevsk Motor Plant (now
JSC «Aksion-Holding» has started producing single-channel electrocardiograph ECG-N-«Salyut» (developed by «Salyut» Design Bureau, Moscow). By 1976 more than 10 000 units had been made. It was a self-powered transistor device, using printed-circuit board. It is remarkable that in the 1970-1980s the ECG-H «Salyut» system was constantly used in the orbital space station «Salyut», and also participated in two famous expeditions: the one of Yuri Senkevich with Thor Heyerdahl and the polar expedition of the «Komsomolskaya Pravda» to the North Pole. The tele-ECG networks operated on basis of the «Salyut» system in the cities of Gorky and Saransk.

In 1980, in Gorky, a model was introduced for screening and clinical examination of patients with cardiovascular pathology, developed by a team headed by Professor Evgenia P. Kamysheva (Fig. 2.98). At the so-called «second pre-hospital» level, the model implied ECG recording with further transtelephonic transmission «into the computer system of the clinic through the «Salyut» cardiophone system». Conclusions were transmitted by the doctor or ECG coding was carried out directly by the operator of the computer centre with its subsequent automated analysis and conclusion delivery. The proposed concept of «computing tele-diagnostics» was successfully used in nearly 1 700 examined patients with a diagnostic accuracy of 70-85% (Kamysheva E. et al., 1979; 1981).

In 1979-1980 at the Department of Hospital Therapy of the Medical Faculty of Moldova State University, RDC was organized (on basis of the «Salyut» system) to provide teleconsultations for district hospitals (Department of Hospital Therapy of MSU NO im.Ogareva, 2016).

Between 1971 and 1976, many scientists around the world worked on the problem of automated ECG analysis for mass screening, developing and using «information-diagnostic systems for automated ECG analysis of various complexity». Among them, L. V. Chireykin cited the teams under the supervision of Z. I. Yanushkevichus (1971), Yu. I. Neymark (1972), Yu. G. Vasin (1972, 1976), M. I. Kechker (1976), Ch. Chapodi (1976), Bailey, Caceres, Corday, Pordy, Weihrer (all in 1974). He also made a generalization, indicating that all the «systems have electrocardiological data collection devices that allow... entering the converted ECG into the computer machine or transmit it over the telephone or other communication lines. The presence of such devices enables to subject ECG obtained by ambulance brigades at
home, when examining patients in the outpatient clinic and in-hospital departments... to automated analysis... They are also used for multiphase screening surveys of the population ... The above systems allow serving the entire administrative districts». For example, according Ch. Chapodi, in Hungary a network was established covering peripheral devices (medical terminals) in 16 localities that provided telephone connection of a nurse with the centre and the automatic ECG transmission (Chapodi Ch., 1981; Chireikin L. V et al., 1977).

Professor Chireykin (or rather, the team under his supervision, including Professor Dorofei Y. Shurigin (Fig. 2.99), engineer Vadim K. Labutin, A. R. Keyver, I. D. Pupko and others) also proposed a proprietary system based on a specialized device for mass cardiological examination of the population (in modern terminology - telemedicine station) - AEKS-1 (Fig.2.100-2.101) (Chireikin L.V et al., 1977). With its help a «real-time ECS [electrocardiosignals] are analyzed and all the examined persons are divided into two classes: persons who are recognized as «healthy» on the basis of the ECS analysis (Class A) and those found «sick» and being in need of physical examination (Class B)». System capacity was up to 20 (on average 14-15) patients per hour (ibid). Telecardiological screening sensitivity was 85-90%, specificity being 85-87% (Almazov B. et al., 1986).

In this case, the element of ECG remote transmission was the key one – «research conducted during ECG transmission to a distance via telephone communication channels provides an opportunity to create multi-path information and diagnostic systems that will enable to achieve a significant improvement in the operating quality of ambulance stations, outpatient network, industrial health centres» (Chireikin L. V et al., 1977). In this paper L. V. Chireikin also described the line of activity in the telecardiology, which could be called the computing one. It is precisely this line that was the main path of tele-ECG technology development in North America at the same period of time.
So, in the 1960s-1970s tele-computing was actively developing in the United States, which represented telemetry ECG transmission over the phone or radio for automated analysis with a computer and submission of a conclusion by the teletype. It is noteworthy that in the 1970s representative demonstrations of the computing tele-ECG capabilities were held. «Competitions» between the medical experts and computers equipped with special software were organized for this purpose. For example, five doctors were physically located in Los Angeles, and the computer was in Washington. On another occasion, in April 1968 ECG was transmitted from Lima (Peru) to Washington, DC (USA), where Dr. C. A. Caceres' system was placed (see further) (Kaseres Ts., Dreifus L., 1974). The ECGs were interpreted in parallel by six doctors from several countries (Alfonso Anselmi (Venezuela), A. Castellanos Jr. (USA), Danto Penaloza (Peru), Mauricio Rosenbaum (Argentina), Demetrio Sodi-Pallares (Mexico), Joao Transhesi (Brazil)), who took part in the VIII Interamerican Congress of Cardiology. The doctors won the duel, as their interpretations were more detailed and comprehensive and revealed a number of important clinical nuances. However, the computer analyzed it much faster and the possibility to use computer tele-ECG diagnosis by general practitioners was underlined.

In 1961, one of the most advanced and powerful computer-aided ECG analysis was developed under the supervision of Dr. Cesar Augusto Caceres (Fig. 2.102) in Washington, DC, at the Medical Systems Development Laboratory (MSDL) of the U.S. Department of Health and Education (Kaseres Ts., Dreifus L., 1974). Physically, the system was running on the CDC-1700 computer, located in Washington DC. Telemetric and direct data entry for machine processing was provided. Later, the software itself was repeatedly updated, rewritten in different languages and for different
computer platforms. Here is a description of the system: «... The telephone system is used for sending signals in analogue form to the computer. The signal is received by a dataphone, entered into the analog-to-digital converter unit and sent to a digital computer system for analysis. The signals are processed, interpreted and prepared for back transmission to the physician within some seconds after they have been received at the processing centre. Measurement and interpretation data are teletyped or printed out» (ibid). 12 leads ECG was used. Dr. John Stauffer (Hagerstown, Maryland) was the first family doctor to start using this service. And in 1963, when practical experience reached 5 000 automated tele-ECG consultations all hospitals around Washington, DC, were connected to this network. Later the medical centres of San Francisco and Columbia joined it, too.

Special demonstration of the system was carried out in 1965: 1500 «ordinary» ECG were transmitted telemetrically from Las Vegas to Washington and immediately interpreted. In many cases the results were obtained prior to the electrodes being taken off the patients. A demonstrative remote computer interpretation of the ECG transmitted from New York to Washington in September of the same year, took less than a minute (transmission, decoding, reply feedback).

In 1966, on basis of the MSDL system, the unified archive for telemetry data and centralized computer analysis was created, i.e. The Unified Archive of ECG data of the Federal Health Office. In other words, the national network of computational telecardiology was created (ibid).

It should be noted that the idea of creating similar unified, though international centre of accumulation and interpretation of electrocardiography data, was proposed in Eastern Europe by Academician Z. I. Yanushkevichus in the 1970s. Unfortunately, it was not implemented in full scale (Yanushkevichus Z., 1980). In North America, however, for the creation of such a powerful structure, the requirements for standardization and unification of medical information, terminology and reporting were developed. The technical and legal aspects were coordinated. Up to 50 000 surveys were analyzed annually (including 70% ECG, 10% spirograms and 20% of sequentially recorded ECG and spirograms). Yet, only 40% of the data were transmitted telemetrically (via analogue dataphones), and the rest were delivered by messenger or mail on magnetic media. Data from 14 inhabited locations
were constantly transmitted telemetrically: «in three settlements, dataphone teletype is used, in eight, the usual teletype, and in another three, portable teletype machines with two-way voice communication and conventional talk lines to immediately receive the interpretation results».

Conclusions were presented by «graphs, reconstructed according to the digital data», by reduced output list of diagnoses and results of basic measurements, or records in terms of the Minnesota code. It is interesting that 25% of the data transmitted telemetrically were received from eight clinics located in the vicinity of the unified archive (neighbouring block of flats) as well as at a distance of 5 000 km. In all cases, duration of automated tele-ECG consultation took at least 24 hours.

Electrocardiograms were recorded using specific «carts» (Fig. 2.103), i.e. ECG machines mounted on the chassis and equipped with additional data input devices (to enter passport, anthropological, and other data), and by telemetry: «data enter the communication control device from teletype via the telephone channel and are introduced into the computer» (Kasertes Ts. and Dreifus L., 1974).

In the same way, but in reverse direction, the computer was linked to the teletype». Tel-EK 6703 analogue device (Computer Instruments Corp.) and DRS 100 Digicorder digital device (Beckman Unstruments Corp.) were used for telemetry data transmission, which allowed transmitting ECG over the phone or cable channel to transmit directly to the computer (ibid).

Table 2.3 provides information about the basic projects within this line of activity.
Table 2.3 Basic projects in the field of computational telecardiology (USA and Canada, 1960s-1970s) (Kaseres Ts. and Dreifus L., 1974; Dobrow R. et al., 1968; Hill S. A., 1964)

<table>
<thead>
<tr>
<th>City</th>
<th>Institution</th>
<th>Activity</th>
</tr>
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<tbody>
<tr>
<td>Halifax, Canada</td>
<td>Dalhousie University, Medical School</td>
<td>Network: IBM 1800 central computer (Fig. 2.104), 16 peripheral units, Intra-hospital and external (telephone) communication channel. Processing rate: 30 ECG per hour. Financial and technical aspects were studied. Cost of the system use was USD 5 000 per year. The requirements for the characteristics of the computer performance quality.</td>
</tr>
<tr>
<td>Manitoba, Winnipeg, Canada</td>
<td>Winnipeg General Hospital, Portage la Prairie hospital</td>
<td>Transphone tele-ECG network</td>
</tr>
<tr>
<td>Alexandria, Virginia</td>
<td>Department of Health, Honeywell Inc.</td>
<td>MSDL system. Development of a special portable electrocardiograph with storage battery power supply for ECG recording and transmission to the MSDL system. Active use of tele-ECG in the regional screening program</td>
</tr>
<tr>
<td>Hartford, Connecticut</td>
<td>Hartford Hospital, since October 1967</td>
<td>MSDL system with data transmission by teletype and phone Later author's software for CDC1700 computer was developed later. Quantity of tele-ECG consultations made 20 000 per year. ECS were transmitted via «dataphone line», conclusions were teletyped. The system practical approval: 5 300 outpatients, 1 000 emergency room patients, 6 700 inpatients. The overall quality of diagnosis was found to be satisfactory, but needed technical improvements for emergency teleconsultations</td>
</tr>
<tr>
<td>Knoxville, Tennessee</td>
<td>Healthcare program of the Department of Agricultural and Resource Economics, St.</td>
<td>Network: expert centre in Knoxville; hospitals in Oneida, Oak Ridge, Sevierville, White Pine, Johnson City; mobile laboratory for screening examinations in remote districts. ECG was transmitted by the phone, opinions - by teletype.</td>
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<tr>
<th>Location</th>
<th>Institution</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lisbon, North Dakota</td>
<td>Community Memorial Hospital</td>
<td>Dataphone tele-ECG network between Lisbon and Fargo</td>
</tr>
<tr>
<td>New York</td>
<td>The Mount Sinai Hospital, IBM Company</td>
<td>Network: IBM 1401 central computer, later - IBM 1800 and 360; intra-hospital and external telephone lines (special three-channel acoustic transducer was developed for the latter) Q-ty of tele-ECG consultations was about 50 000 Machine diagnostics accuracy was about 90%</td>
</tr>
<tr>
<td>Omaha, Nebraska, Iowa and South Dakota</td>
<td>Cardiac laboratory of the Creighton University, Northwest Bell Telephone Inc. 1966.</td>
<td>Network: expert centre in the Creighton University (physician's consultations), MSDL system in Washington, about 30 hospitals, clinics and offices of rural doctors. Data transmission was made by Bell datapones. Quantity of tele-ECG consultations made up to 100 000 per year</td>
</tr>
<tr>
<td>Rochester, Minnesota</td>
<td>Mayo Clinics</td>
<td>Own computer machine, electrocardiograph carts, telephone communication lines</td>
</tr>
<tr>
<td>Saint Paul, Minnesota</td>
<td>Biomedical Associates Private Company</td>
<td>MSDL system with data transmission by teletype and phone Average duration of tele-ECG consultations was 5 minutes Forms of medical information transmission and storage were optimized</td>
</tr>
<tr>
<td>Washington</td>
<td>Veterans Affairs Medical Center</td>
<td>Network: CDC 3200 central computer, ECG data collection carts Materials of 16 000 patients were used to create expert system</td>
</tr>
</tbody>
</table>
Fig. 2.104. Telecardiology computing system based on IBM-1800 (USA, 1960)

Fig. 2.105. General layout of tele-ECG network in Knoxville (USA, 1960s): T - telephone, TT - teletype

Fig. 2.106. Robert J. Dobrow organized the work of telecardiology computing network in Hartford, Connecticut, USA

Fig. 2.107. General layout of tele-ECG network in Hartford (USA, 1960s)

Fig. 2.108. Tele-ECG consultation as a part of the wide-scale preventive examinations using Bell dataphone (the patient is at home, the survey is conducted by a nurse) (Rahm W. et al., 1953)

Fig. 2.109. Expert centre of the tele-ECG network in Cardiac laboratory of the Creighton University (Omaha, USA, 1966). Dr William Anthony Carnazzo is studying ECG transmitted telemetrically, technician Ingrid Peters is receiving additional information about the patient over the phone
Hartford telecardiology computing system, mentioned in the table, was one of the most actively operated and provided daily tele-ECG consultations for outpatients (Fig. 2.106-2.109). Scientific and practical analysis of the Hartford network was summarized and presented in a number of publications. The work was carried out under the supervision of Dr. Robert J. Dobrow (1968).

An interesting episode of computer telecardiology was the use of the MSDL system for continuous ECG analysis of patients, during surgical operations, performed in the clinic of the George Washington University. Data were transmitted from the operating room with a portable acoustic dataphone (Bell System X 603C).

So, C. Caseres created an original system of automated ECG analysis with telemetry data transmission, in fact one of the basic computer telecardiology systems in the USA, in the 1960s-1970s. It is noteworthy that he was the first to automate ECG analyses, which were recorded in the conventional system of leads for the needs of everyday clinical practice. The national telemedicine network was constructed on the basis of this system.

Yet it is too early to put already a hold at this point. The system of Dr. C. A. Caceres attracted the attention of NASA. A special version was created for the biotelemetry of astronauts' cardiac function during space flight. «Automatic diagnostics were carried out online and in real time, when for the first time electrocardiographic data of each examined person were fully controlled and interpreted by a digital computer system». During the flight of «Gemini 7>, ECG of astronauts Frank Borman and James Lovell were recorded in analogue form in real time and periodically monitored at intervals of 30-60 minutes during the entire flight, which lasted 2 weeks. In total 215 discrete recording areas were transmitted and analyzed. In the subsequent flights (from «Gemini 8» to «Gemini 12») automated ECG analyses were carried out continuously. At first, data were transmitted from the spacecraft to the nearest tracking station and then they were sent via the telemetry system to Goddard Space Flight Center (Maryland), and from there «over the phone in multiplex mode as analogue signals to the computer center in Washington». Signals of four leads (2 of each astronaut) entered over there, but due to limitations of technical capabilities, signals were real-time analyzed only for one deflection of each examined astronaut. «Remaining» data were recorded on the magnetic tape for delayed in-depth study (Kaseres Ts., Dreifus L., 1974).

In 1965, at the Massachusetts Institute of Technology under the supervision of Dr. Lawrence Stark and James F. Dickson a computer system for remote analysis of medical information, including ECG (Fig. 2.110-111)
was created. Duration of tele-ECG consultation with the Massachusetts Memorial Hospital was about 5 minutes (Fig. 2.112) (Swihart F., 1974).

Fig. 2.110. Dr Richard Booth (arranged the work of telecardiology computing network in Creighton University, USA). He told about telecardiology activity: “Even on a weekend, we might get 50 ECGs to read at home... In our best years we were taking in 100 000... We extended all the way from Wyoming to Illinois, from the Canadian border well into Kansas”

Fig. 2.111. Scheme of the computer telecardiology system of the Massachusetts Institute of Technology (USA, 1965)

Fig. 2.112. Computing tele-ECG consultation - receiving of computer interpretation of electrocardiosignals by teletype

Fig. 2.113. Operation of tele-ECG network in the state of Missouri. The Nurse Ann Hoefelman (top picture), in Burge Protestant Hospital, Springfield, sends ECG data, while Dr. P. R. Amlinger (sitting) and Dr. Donald Linberg carry out remote interpretation of the electrocardiosignal at Columbia (USA, 1968)
One of the most powerful and famous computer telecardiology projects was implemented in the state of Missouri (USA). There, in April 1968, a tele-ECG network was organized under the supervision of Assistant Professor Donald A. B. Lindberg and Dr. Phillip Rudolph Amlinger (Fig. 2.113-2.114). Initially, the network was designed specifically for telemedicine servicing of the rural area (a special state grant was obtained) (Lindberg DAB, 1965 a), b); Lindberg DAB., 1967; 1968; Lukuisten keksintöjen mies, 2011; MacFarlane P. et al., 1977; Heartbeat over phone, 1958; Amlinger P., 1969 a), b)). The receiving station was placed at the University of Missouri Medical Center (Columbia). At first, transtelephonic ECG transmission was carried out from the offices of six doctors in Springfield (Dr. Cecil Auner), Trenton (Dr. C. L. Clark), Cordwell (Dr. Wallace D. English), Kansas City (Dr. P. Hill), Columbia (Dr. J. M. Mart) and Boonville (Dr. B. M. Stuart). Ten the network expanded to 25 subscribers in 1976, within a radius of up to 600 km from the expert centre. ECG computer processing was made using MSDL software on CDC8090 computer machine CIC «DatEK» «carts for data collection» - mobile electrocardiographs - allowing transmitting ECG over the phone. They were placed at the subscriber stations. Remote ECG transmission and computer-aided automated analysis was performed, followed by teletyping conclusion to the subscribing physician. Duration of the tele-consultation was 10-20 minutes.

P. Amlinger and D. Lindberg conducted a thorough study of the technical aspects of the automated tele-ECG analysis and prevention of disturbances and faults, and also defined the diagnostic value. They determined the way to further improve the method in general and the specific hardware and software packages (Fig. 2.115) (ibid).

In the 1970s a number of commercial computer telecardiology services were in operation in the United States, among which the most successful providers were CEIS (Denver, Colorado), which served 35 hospitals within a radius of several hundred kilometres, and «Telemed» which served 480 hospitals, transmitting up to 4500 ECG per day for automated teleconsultations (Mount Zion Memories, 2015).

In the context of «computer telecardiology» in the Soviet Union, in 1979, a team headed by Yu. R. Kremer proposed a system providing «synchronous three-channel recording of electrocardiosignals (ECS) using an ordinary tape recorder, transmitting these data over a telephone line, as
well as their reproduction and input into the processing apparatus». The system passed clinical trials (Kremer Yu. et al., 1979).

Later, at the beginning of the 1980s a joint Soviet-Hungarian project was established: «SAS-1» - an automated multi-channel system for ECG transmission and analysis on the basis of an EC1010 small computer. The system was developed by the Communications Research Institute (Hungary) and the Institute for Information Transmission Problems (USSR). Possibility was provided to transmit ECG via direct lines or over the telephone for further automated analysis by specially developed algorithms. Particular attention was paid to the issue of digital ECG transmission using the original methods of data compression. The system was practically approved on data of 400 examined patients (Pokrovskaya M. at el., 1981; Chapodi Ch., 1981).

In the late 1970s some final steps for computer telecardiology implementation were taken in Izhevsk by a team headed by I. B. Ellinskyy. An automated expert system was developed and remote transtelephonic ECG transmission was tested (Ellinskyy et al., 1979; Ellinskyy I., 1979).

The development of tele-ECG technology in some other countries will be described separately.

In Europe in the 1960s a number of scientists dealt with the problems of ECG transmission over long distances (Honkavaara P., 1980; Omiya Z. et al., 1975). Then the first works were published reporting on the activities of the first centres of transtelephonic ECG and the research results of its effectiveness (Geddes L. et al., 2000). In 1971, in Germany remote monitoring of pacemaker functions started (Late rush to football tilts cited as prime cause of stadium heart attacks, 1972). Development works were performed aimed at miniaturizing technical solutions and developing devices for personal use (Hrdlicka S, Osmera P., 1979).

By 1975 the main areas of concern for transtelephonic electrocardiography had been identified:

1. Surveillance of pacemaker operation;
2. ECG interpretation by specialists and consultation service;
3. Automated ECG analysis in the diagnostic centres;
4. Data transmission by ambulance brigades to the clinics.

At the same time appeared the first works on the development of an integrated European biomedical telemetry system.

In the 1980s extensive research was carried out to study the clinical effectiveness of transtelephonic ECG transmission for individual nosologies and in comparison with conventional methods of healthcare provision. Reduced mortality and lethality rate due to the use of this type of telemedicine systems was convincingly demonstrated (Chadda K. et al., 1986; Fletcher G. et al., 1984; Watts M., Macfarlane P., 1977).

Table 2.4 and Fig. 2.116-2.117 provide information on the use of telecardiology within the territory of some European countries (Lindberg D. A., Amlinger P. 1968; Sakurai Y. et al., 1978; Stanić R, Cvetkov R., 1980; Stark L., Dickson J., 1965; Yan V, Sloman G., 1973).

In 1979 in Prague (Czechoslovakia / Czech Republic) S. Hrdlička and P. Ošmera were working in the field of transtelephonic ECG diagnosis, but the most significant achievements in the area of telecardiology in the country are associated with the name of Dr. Petr Bartůněk (Fig. 2.118). Not later than in 1982 TELSAR transtelephonic ECG diagnosis system was developed in Czechoslovakia in the hospital of the Faculty of Medicine of Charles University.
<table>
<thead>
<tr>
<th>Country</th>
<th>Supervisor</th>
<th>System</th>
</tr>
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<tbody>
<tr>
<td>Denmark</td>
<td>P. Christoffersen</td>
<td>Single-channel tele-ECG telemetry; tele-ECG at the prehospital stage. Optimal configurations and specifications for tele-ECG systems were developed to solve each individual telemetry task (see above). By 1977 there were approximately 10 telemetry systems operating in Denmark, they were used for single-channel transmission from doctors' offices to large hospitals or between hospitals and attending doctors at home. A pacemaker tele-check was carried out with a transmission from Greenland to Copenhagen. Radio telemetry was used at two ambulance transmission systems.</td>
</tr>
<tr>
<td>Germany</td>
<td>Weber H., Kiss H., Joskowicz G., Pfundner P., Müller C., Auinger C., Steinbach K., Kaindl F.</td>
<td>Transtelephonic ECG diagnostics for the detection of paroxysmal arrhythmias. By 1984 not less than 196 patients benefited from the system.</td>
</tr>
<tr>
<td>Milan</td>
<td>G. Valentini</td>
<td>Tele-ECG transmission with computer control (an original automatic calling system, leased telephone network was used).</td>
</tr>
<tr>
<td>Location</td>
<td>Author(s)</td>
<td>Description</td>
</tr>
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<tr>
<td>Pisa</td>
<td>P.Mancini, R.Bedini, G.Palagi, C.Contini</td>
<td>Transtelephonic control of pacemakers</td>
</tr>
<tr>
<td>The Netherlands</td>
<td>T.P. de Jongh, Neher</td>
<td>Experimental computerized tele-ECG system (PDP-8E minicomputer and IBM-1800 process computer, transmission via telephone network) since 1972 or earlier to provide teleconsultations for general practitioners. Single- or three-channel ECG was used. 3 receiving centres and at least 400 transmitters have been installed by 1975</td>
</tr>
<tr>
<td>Leiden (The Netherlands)</td>
<td>F.A. Rodrigo</td>
<td>Transtelephonic acoustic pacemaker check-up, more precisely pulse frequency control using the Pacertest system of Biotronik During 1973-1975 – about 100 patients</td>
</tr>
<tr>
<td>France (Paris)</td>
<td>Renaud Koechlin, Jacques Mugica</td>
<td>1) Daily Transtelephonic single-channel tele-ECG transmission in patients with transplanted hearts (about 10 patients). 2) Transtelephonic control of pacemakers. Within a range of 250 km around Paris a number of pacemaker check-up centres were established. Patients were attended by a cardiologist according a schedule. ECG telemetry was carried out from each check-up centre to consultation centre in the Clinique VAL-D’OR of Saint Cloud near Paris. SUSICALL system was used for data transmission and discussion. 3) Development of numerous technological aspects of ECG telemetry</td>
</tr>
<tr>
<td>Sweden</td>
<td>Stålberg E, Wallin G.</td>
<td>Experimental transtelephonic ECG and EEG transmission for interpretation at the Uppsala University Hospital</td>
</tr>
<tr>
<td>Yugoslavia (Croatia)</td>
<td>Stanić R, Cvetkov R.</td>
<td>Transtelephonic ECG transmission</td>
</tr>
</tbody>
</table>
The idea belonged to the clinic staff assistant Svjatoslav Vinogradov, and practical implementation was carried out by a team headed by assistant Petr Bartůněk with the participation of experts from the Czech Technical University (Jiří Skořepa, Ladislav Mikysa et al.). The system was used primarily to diagnose arrhythmias: detecting early signs of arrhythmias, monitoring the effectiveness of treatment and diagnosing emergency, etc (Bartůněk P. et al., 1982; 1989; 1996; Bartůněk P. 1987 a, b)). The system was tested in the network of five cardiac departments in the Czech Republic and in Bratislava. Transtelephonic one-lead ECG transmission was performed to assess the clinical effectiveness of antiarrhythmic therapy. The method simplicity and low cost was flagrant, compared with Holter monitoring and laboratory examinations. The results of practical trials were good, and the Ministry of Health of Czechoslovakia decided to start serial production of the equipment under the name TELSAR. However various problems with the national medical equipment industry in 1989 did not let this happen. In 1996, in the article summarizing 10 years of experience in using the system, Dr. Bartůněk announced the successful transtelephonic transmission and interpretation of 3 727 ECG of 251 patients, and the high efficiency of the TELSAR system for arrhythmia detection (including sporadic ones) and their treatment control (ibid).

In the UK, the computer tele-ECG diagnosis was associated with the work of the team consisting of Dr. Peter W. MacFarlane (Fig. 2.119-120), Professor T. D. V. Lawrie, physicist M. P. Watts and Dr. R. S. Walker (Medical data transmission by public telephone systems, 1977). An original algorithm was developed for data analysis and a computer with the appropriate software was installed in the Cardiology Department of the University of Glasgow. The equipment was installed in Law Hospital, a Carluke district general hospital. It allowed recording ECG and «digital information» and transmitting them over two separate public telephone lines to the city of Glasgow for computer-assisted analysis. The 3-lead ECG was used for transmission. The system could record 12-lead ECG using the same cable, but the authors asserted that «this was not necessary for the computer interpretation».

As mentioned above, the input information entered via two telephone lines. «Digital information» (passport, anthropological and other data) was introduced using a special terminal with a keyboard linked to the telephone line via a modem. The same line could also be used to send conclusions (immediate interpretation results) in the opposite direction and print them out. The second telephone link was used for tele-transmitting the 3-lead ECS (ibid).
The diagnostic value of the materials was analyzed for 100 TV ECG interpretations. This dataset was originally transmitted via telephone communication lines for computer analysis, and then the same ECG was recorded on the magnetic media and transmitted to the University of Glasgow by mail for repeated analysis.

It is noteworthy that in this study, the scientists were rather interested in the opportunities and/or potential loss of quality, than the quality of the algorithm and program operation, when transmitting the data over telephone lines. As a result 4% of errors were registered. Following the results of clinical trials, the algorithm and program were upgraded and improved. The authors stated that they had created a kind of computer telecardiology centre for the entire region, able to remotely interpret up to 65 000 ECGs per year. It should be noted that the authors focused on routine examination and screening surveys and not on emergency situations (ibid).
In 1968, the single-channel ECG telemetry line was organized between Lincoln and London (Colbeck W., 1968). In 1970 - two-channel line of «distant» connection between the Netherlands (Nijmegen) and the UK (London) was also organized. Both projects were implemented with the participation of Dr. Dennis Walter Hill. Later he developed a telemetry system of intraoperative monitoring (this will be explained in the chapter on telemetry). Dr. Hill introduced a system of computer diagnostics for remote ECG analysis, which functioned quite actively. It is interesting that in 1969, a 12-lead ECG was transmitted from France (Nancy) for computer analysis by the system of Dr. Hill to the Royal College of Surgeons (London). Diagnostic conclusion arrived at the subscriber terminal and was printed out within 2 minutes. On the French side, this tele-ECG consultation was organized by Dr. Koechlin, Dr. Courtois and Dr. Janouch (the latter was a representative of the Czech Republic).

This shows how the idea of resource sharing computer telecardiology started to take shape: «if one computer fails, which did happen in Paris, then another one having the same program in London was called» (Colbeck W., 1968; Mount Zion Memories, 2015).

In Canada, in the early 1960s, on the initiative of Dr. Constantine T. Cerkez (Fig. 2.121) and the most active participation of Professor George W. Manning (Fig. 2.122), who at that time headed the Cardiac Center, University of Western Ontario, the development of a transtelephonic ECG transmission system was started up. Chief technology officer of the Cardiology Center, University of Western Ontario Gordon C. Steward developed its own original tele-ECG system and carried out its laboratory trial (Cerkez C. et al., 1964; 1965). In the period of January 1 - March 31, 1964, the clinical «field» testing of the system was held. Tele-ECG consultations were carried out between the hospital in London (Ontario) and the cardiac center in Wingham. Dataphones of Bell Telephone Company of Canada were used to transmit data (Fig. 2.123) (ibid).
Over a period of 3 months, 102 teleconsultations were held on 71 patients (12-lead ECG). Abnormal ECGs were revealed in 70% of cases and in 7% remote interpretation was extremely valuable for timely diagnosis and treatment. Technical aspects were studied and the system was optimized in terms of engineering design. A significant clinical and logistical value of tele-ECG diagnosis was established (for example, prior to its introduction, interpretation of ECG recorded in London, Ontario, took 3 days). Later the authors began to develop individual telemetry systems for assessing cardiac function in the normal life conditions using satellite communications for data transmission. A special transmitting transistor set with autonomous power supply (Spacelabs model 130 Biotel Telemetry System), was made up as a jacket. There was a remarkable detail - the system allowed direct voice communication between the patient and the physician. If necessary, an audio microphone clipped to the clothing was provided for this purpose. Data telemetry was implemented via satellite communication channel over a distance of 20 km (Fig. 2.124-2.125) (ibid).
In the course of testing, 94 remote examinations of 63 patients were carried out. They studied the diagnostic value and technical aspects (including the specific use of the electrodes). The method of prolonged individual satellite telemetry ECG was acknowledged to be very effective and meaningful for monitoring heart activity in daily life, and for special surveys (Fig. 2.126).

Meanwhile the usefulness of telecardiology networks for military and scientific research became evident. The cardiological centre headed by Prof. G. W. Manning acted as an expert centre. In 1986 about 350 000 tele-ECG consultations were given (ibid).

Also in Canada (Toronto) in 1976 Dr Neil D. Berman arranged ECG autotransmission service by telephone for patients with non-diagnosed arrhythmias or with implanted pacemakers. The receiving centre was organized in Toronto Western Hospital. Data were transferred on the patients' initiative. Thus, when symptoms of the disease occurred, a patient called the consultation centre, stated his name and location, and then placed the ECG transmitter against the chest and placed the telephone mouthpiece against the transmitter. ECG was recorded on the magnetic carrier and interpreted by the physician. It should be noted that real-time ECG overview was not performed practically. In most cases the cardiologist worked with the patients' recordings over a certain period (for example, over a day). So this system was extremely useful for the detection of recurrent paroxysmal arrhythmias, though it did not work in emergency situations (Fig. 2.127-2.128, Berman N., 1979). From January 1976 to January 1979 this service was used by at least 31 patients. The author stated that patient-activated transtelphonic ECG transmissions had been carried out even earlier in the hospital, but due to scarce detailed documentation from the earlier years their results were unavailable for research and publication. This service was acknowledged as a very efficient clinical tool,
since it provided good detection of arrhythmias, in particular paroxysmal ones (ibid).

In Japan in 1969, radio telemetry ECG transmission systems were developed under the supervision of Dr. Hirokazu Niitani from the Medical School of Showa University (Tokio). In 1975, the construction of regional medical networks for transtelephonic ECG transmission at the outpatient treatment stage was already considered (Peter T. et al., 1973).

Work of the teams headed by Dr. Jun-ichi Hattori (Kanto Teishin Hospital, Tokyo) and Dr. Y. Sakurai (Niigata Hospital) should be mentioned separately. In September 1973 in Tokyo and Niigata (Japan), an experiment was conducted on transtelephonic pacemaker operation data transmission. ECG telemetry was so successful that the system was implemented in practice and its constant use began since October 1974. The equipment allowed two-channel transmission, but it was extremely difficult for the patients (60% failed for technical reasons), so the authors limited the practical use to one channel (Fig. 2.129). Following the results of this work, it received the name of «pacemaker telephone clinic» and it treated at least 60 patients during 2 years (Hattori J. et al, 1975; Sakurai Y. et al. 1975; 1978).
By 1978 results on 15 patients with implanted pacemakers, who carried out transtelephonic telemetry of 1-lead ECG, pacemaker pulse frequency and heart rate, were published. The system was identical to personal visits of patients by the quality of diagnosis and medical care, significantly lowering the logistics costs (ibid).

In 1980 the issue of possible wide-scale tele-ECG application based on common national telephone line was studied in Japan. Under the supervision of Professor Yoshiaki Nose (Faculty of Medicine, Kyushu University) the study of their technical suitability was conducted by multiple repetitive transmission of 100 ECG (34 normal ECG and 66 ECG with pathological signs) between Tokyo and Fukuoka (at a distance of about 1000 km) (Fig. 2.130). Identical results of remote interpretation were registered for 97% of standard ECGs and 92% of ECGs with pathological deviations (Nose Y. et al., 1980; 1982; 1986).

On basis of the results obtained, the computer telecardiology network was implemented (IBM computer and software developed by Bonner et al., 1972 were used), where 1 236 tele-ECG consultations were carried out only during the first month. The quality of this data transmission was completely satisfactory in 98.6% of cases. Nevertheless, the authors modified the software so that the determination of the quality level of the transmitted information and the subscriber notification (in case of a transmitting an ECG unsuitable for interpretation) occurred within a few
Such approach significantly improved the operating quality of the computer telecardiology network, due to momentary ECG re-transmission in case of defective primary transmission. In the next 4-5 years about 35000 tele-ECG consultations were performed (ibid).

In Greece in 1976 or by 1980 E. Skordialakis and Professor George Papakonstantinou (Fig. 2.131) from the National Technical University of Athens developed and implemented their own transtelephonic ECG diagnosis system. The issues of computer analysis of electrocardiosignals were studied as well. The equipment was so efficient that its use lasted at least 15 years (Ferrer-Roca O., Sosa-Iudicissa M., 1998; Skordialakis E., Papakonstantinou G., 1981).

In the context of telecardiology development in the middle of the 20th century, it is worth noting that in this period, telemetry systems were proposed for use in perinatal medicine and paediatrics. In the USA in April 1963 W. K. Hagan and S. D. Larks published the description of a transtelephonic foetal ECG transmission method over long distances (Hagan W., Larks S., 1963).

In Germany in 1967 K. Baumgarten and K. Sokol also transmitted ECG and foetal heart rate using radio telemetry system, both during pregnancy and childbirth. Much later, in 1981, in France, telemetry of foetal cardiac function in pregnant women at high risk was performed and assessed in terms of quality. Completely sufficient diagnostic value of the transmitted data, the possibility of rapid and early diagnosis of threatening pathological conditions, total simplicity and availability of the system were stated (Baumgarten K., Sokol K., 1967; Crépin G. et al., 1981).

In paediatric practice, transtelephonic outpatient tele-ECG transmission was actively used in the United States in 1984 at least on 41 patients with symptoms suggesting arrhythmia. As a result, in 22% of the observed patients, paroxysmal arrhythmias were revealed, which allowed starting a reasonable drug treatment (Fyfe D. et al., 1984).
To summarize: In the mid-late 1970s, clinical tele-ECG, in conjunction with automated remote analysis of electrocardiosignals, was widely spread throughout the world.

«Computer telecardiology» can be considered a separate line of research. National tele-ECG systems were created and actively operated in the USSR, USA, Canada, Japan, Australia, The Netherlands, Finland, East Germany (GDR) and Hungary.

Words written by Prof. Halfen, a few decades ago, remain completely relevant today: «ECG telemetric recording and evaluation should be performed where there is no possibility for a specialist to record and decode it at the given moment. If such a possibility exists, it should not be neglected in any case. Telemetry should not substitute the direct contact with the patient, wherever possible …» (Halfen E., 1974; 1977; 1980; 1980 a, b, c; 1985; 1998).

The above statement is supported by L. V. Chireikin: «It goes without saying that remote consultations will never be able to replace real communication of an experienced physician with patients ... RDC contribute to the approximation of specialized cardiac care to the population, especially in the rural areas. Remote clinical consultations on their own are effective not only in the hospital itself, but, most importantly, at the prehospital stage» (Chireikin L. et al., 1977; Chireikin L., Dovgalevskyy P., 1995). How close are these statements to the famous declaration of Kenneth T. Bird, one of the founders of the American telemedicine: «Telemedicine can be defined as the practice of medicine by means of an interactive audio-video communications system without the usual physician-patient physical confrontation. Telemedicine depends on the physician and his special abilities. It does not replace him or alter his role. In fact telemedicine multiplies the usefulness of the specialist and enlarges his horizons while simultaneously maintaining his position at the focal point of all health care activities». These citations express the entire essence of modern telemedicine!

In the 20th century, the most widespread form of telemedicine was telecardiology - a comprehensive use of telemedicine procedures (biotelemetry and telemonitoring, remote interpretation of diagnostic data, teleconsultation, home telemedicine) for the prevention, emergency and routine medical care for patients with disorders of cardiovascular system. During that period the main component of telecardiology was precisely the tele-ECG, the process of transferring of the electrocardiography data over telecommunication lines for the purpose of remote interpretation, telemedicine consultation and distance learning. The significance of this technology is confirmed by the fact that it still is a common and widely
spread practice since its creation in 1905. During the 1940s-1970s in Europe, Asia and North America, numerous engineering solutions for tele-ECG were developed in parallel, and the relevant networks were successfully implemented. The concepts of telemedicine use for emergency support at primary-level health care was fully developed, and also the foundation for an individual (home) telemedicine was established to provide long-term medical care for patients in everyday life.

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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.

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 (Vladzimirskiy 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
International Federation for Medical Electronics and Biological Engineering. Another significant medical and biological invention of professor Zvorykin is the electronic microscope (Vladimirskiy 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, 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. 3.3. Medical black and white video conferences in Israel Zion Hospital (New York, USA), 1939

Fig. 3.4. Rosewell C. Williams
The method was first used for transmission of stomach carcinomectomy 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.

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 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

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

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
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).

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.

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).
It is presumed that the term “medical television” was first used in 1949 (Carroll W., 1949) in the meaning of medical videoconferences for educational and medical purposes. In less than a year, on October 15, 1950 during the 100th annual meeting of the Pennsylvanian Medical Society several telebridges were held for remote demonstration of caesarean section, thoracic and orthopedic operations, skin transplantation, as well as for telelectures on oncology, vascular surgery, radiology, traumatology (Elsom K., Roll G., 1951).

Since that time a lot of national conferences in the USA have been attended by videoconferences. As examples, at the annual AMA conference in San Francisco in June 1950, 91% of respondents confirmed the advantages of color videoconferences in teaching surgery. In Saint Louis, in 1953, at the congress of the American Association for Cancer Research, a color telebridge was held, devoted to malignant neoplasms in the prostate. In November 1950, Wayne University held a 2-day distance learning course for general practitioners. 85% to 92% of the participants gave positive evaluation to different aspects of color videoconferences in medical education (ibid).

For two and a half years after these first experiments, Kendall Elsom and PR Director of Smith, Kline and French Laboratories, G. Frederick Roll, actively used videoconferencing and reported about 28 sessions in the USA and Europe (Paris, September 24-29, 1951) with over 200 000 participants. Organizational and methodological approaches to the application of medical videoconferences were suggested for the first time and the peculiarities of interactive transmission of surgical interventions were also presented (Fig. 3.17-3.19) (ibid).
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 world, remotely demonstrated endarterectomy and Dr Owen Wangensteen 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 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)).
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).

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.

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).


It should be underined 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 (Aksyiniv 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.

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
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 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.

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 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.
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).

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).
“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).

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).

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).
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 radiotherapy, 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).

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](image)

![Fig. 3.49. Reba Ann Benschoter](image)

![Fig. 3.50. Frank J. Menolascino](image)

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).
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 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.
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).
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).

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.
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. 3.74. 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 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”.

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

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.

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

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
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).

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).

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 hydatic 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 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.

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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).


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)

<table>
<thead>
<tr>
<th>Physiological index</th>
<th>Author(s)</th>
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<tbody>
<tr>
<td>Arterial tension</td>
<td>Bradfute G. et al. (1968)</td>
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<tr>
<td>Intra-oral tension</td>
<td>Kydd W. L. et al. (1963)</td>
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<td>Pedometry</td>
<td>Herron R. E. et al. (1967)</td>
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<td>Photoplethysmogram</td>
<td>Jones J. W. et al. (1989)</td>
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<td>Pulse</td>
<td>Seliger V. et al. (1965), Pircher L. (during workload and sport load, 1964), Bauer H. et al.</td>
</tr>
<tr>
<td>Instrument</td>
<td>Reference</td>
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<td>Rheogram</td>
<td>Bolshov V. M. et al. (1974)</td>
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<tr>
<td>Temperature</td>
<td>Morhardt J. E. (1972)</td>
</tr>
<tr>
<td>Respiratory function and criteria</td>
<td>Lewillie L. et al. (1968), Lota M. J. (1967)</td>
</tr>
<tr>
<td>Electromyography</td>
<td>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)</td>
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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).
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.
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).

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
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).

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 Vasiliy 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 Vasiliy 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. Vasiliy V. Parin
Fig. 4.17. Vladimir I. Yazdovskyy
Fig. 4.18. Oleg G. Gazenko
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. Yazdovskyy (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, sphygmmograms 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; Yazdovskyy V., 1966; 2015; Yazdovskyy, Bayevskyy, 1962).

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. Prutskoy checking on-board physiological equipment](image1)

![Fig 4.23. Medical examination of Yuri Gagarin by I. T. Akulinichev, A. R. Kotovskaya and F. D. Gorbov, April 11, 1961](image2)

![Fig 4.24. Y. Gagarin (1934-1968), the first cosmonaut before first manned-space flight April 12, 1961](image3)

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...

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).
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 EGC, SCG, PG and heart rate throughout the flight. The heart rate and body temperature during spacecraft-to-spacecraft transfer were recorded too. All date 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 in1964) 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 fotografiyakh, 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), tachooscillography (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 fare 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 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. Lovdzhiiev (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., Lovdzhiiev 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 15×12×4 cm, weight 900 g and a big one - transmitting distance up to 60 km, dimensions 26×18×16 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)](image)

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).
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).
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 telecardiograph (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).

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).

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. Pelenskyy, T. I. Sinyavskyy, G. B. Safronova created the
"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 weight 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>
<thead>
<tr>
<th>Authors &amp; city</th>
<th>Findings</th>
<th>System</th>
</tr>
</thead>
<tbody>
<tr>
<td>V. A. Varlamov, A. V. Slyusarev, V. I. Karyukin (Moscow)</td>
<td>Alteration in the angle of speed and acceleration state in joints</td>
<td>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</td>
</tr>
<tr>
<td>A. K. Volkov (Leningrad/St. Petersburg)</td>
<td>Electromyogram (simultaneous recording from two leads)</td>
<td>Transistor receivers and receiving devices. Radius 500 m</td>
</tr>
<tr>
<td>Yu. L. Spiridonov (Ivanovo)</td>
<td>Cardiovascular rate</td>
<td>1-channel system with optimized receiving set</td>
</tr>
</tbody>
</table>
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.unt.edu/northtexan/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).
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.

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

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).

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. 4.54. Vladimir V. Rosenblat
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 Vladimir Viktovicha Rosenblata, 2000; Parin V., 1963; Rimskikh E. et al., 1974; Rosenblat V., 1967; 1974; 1976; 1989; 2015; Rosenblat V. et al., 1979).

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

<table>
<thead>
<tr>
<th>Device</th>
<th>Physiological parameters</th>
<th>Patient's device</th>
<th>Researcher's device</th>
</tr>
</thead>
<tbody>
<tr>
<td>Radio pulsephone (first model developed in 1955-1957)</td>
<td>Pulse rate</td>
<td>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</td>
<td>VHF-receiver of amplitudeodulated signals; the aurally information receiving with pulse counting over a timer or graphic recording</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Device Type</th>
<th>Parameter(s)</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Radio pneumograph (1957-1959)</td>
<td>Pneumogram</td>
<td>RPG-1, RPG-2, Resistance coal pulverulent transducer, total weight - 100 g, radius 70-100 m</td>
</tr>
<tr>
<td>VHF-receiver of moderate sensitivity with connected frequency counter; graphic recording</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Radio pneumometer (1960)*</td>
<td>Respiratory rate</td>
<td>RPM-1, RPM-2, A face mask with valves-lockers, weight of transmitter unit 60 g</td>
</tr>
<tr>
<td>Radio receiver set</td>
<td></td>
<td>Aural information receiving with respiratory rate count by a timer</td>
</tr>
<tr>
<td>Combined radiotelemetry devices (CRD)</td>
<td>Pulse rate, pneumogram and others</td>
<td>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</td>
</tr>
<tr>
<td>VHF-amplitude-modulation receiver</td>
<td></td>
<td>Later - specially designed portable transistor semiconducting radio receiver sets (*&quot;RL device&quot; (Fig. 4.58), weight 200 g</td>
</tr>
<tr>
<td>Radio pulsephone-electrocardiograph (REC) (February 1962)</td>
<td>Pulse rate, ECG</td>
<td>Several models, in practice REC-1, 3 were used. Total weight -120 g, operating radius 30-50 m</td>
</tr>
<tr>
<td>On the basis of APC-2, a modified vehicle radio set, graphic recording</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Multi-purpose radiotelemetry device (MRD-1K10)</td>
<td>10 parameters</td>
<td>Dimensions 170x100x50 mm, total weight 700 g</td>
</tr>
<tr>
<td>Similar to the previous; frequency counter-decoder</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* 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):
- Observation on sportsmen during trainings: skating – 50, skiyng – 2, ski-jumping – 6, track and field events – 3;
- Observation on sportsmen during competitions: skating – 28, track and field events – 7, table tennis – 5;

The investigations in weightlifting (A. T. Vorobyov, M. B. Kazakov, N. M. Khodakov, V. P. Khudorozhkov), in rhythmic-sportive gymnastics (R. N. Karelna) 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).

![Valentina S. Stenina](image1.png)

**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**

![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](image2.png)

**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 (radiopulsoometry, 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).

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 radiopulsoometry 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).

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 radiobitelemetry 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 biotelemery 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)
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
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 cardiotocography 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).

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 cardiotocograms recorded on paper. In 1989 in the USA, Dr. S. L. Clark established a teledisgnosis 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).

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. Mkrtunchan during therapeutic physical training of patients with cardiological pathology; by V. N. Velkin during insolutions (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. Stålberg (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);

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 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 than 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).

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).

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).

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)*

<table>
<thead>
<tr>
<th>Lines of research</th>
<th>Authors</th>
</tr>
</thead>
<tbody>
<tr>
<td>General methodological, technical and basic physiological aspects</td>
<td>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</td>
</tr>
<tr>
<td>Tele-EEG and telemetry EEG monitoring under clinical conditions for topical and differential diagnostics, determination of seizure frequency and possible trigger factors</td>
<td>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)</td>
</tr>
<tr>
<td>Electrophysiological and clinical aspects of epilepsy according to the tele-EEG results</td>
<td>Tomka I. (1974); Vidart L. et al. (1967, 1968; 1969 a), b)</td>
</tr>
</tbody>
</table>

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).
Thanks to the works of A. Kamp in the 1960-1980s, a model for independent EEG recording by the patients themselves under everyday 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).

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.

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)
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.

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Chapter 5
Computational Telediagnosis and Development of Clinical Telemedicine

5.1. Main Achievements of Computational Telediagnosis in the Middle of the 20th Century

In the late 1970s, a new line of research was formed that can be called conventionally as "computational telediagnosis". It was supposed to use the remote transmission of certain medical information for its automated analysis by a computer machine for the purpose of diagnosis, screening and monitoring. This idea was successfully realized in the field of telecardiology and partly in tele-EEG (as specifically described in the relevant sections), but there were some achievements in other disciplines as well.

In the USSR, a number of research teams developed computer systems with data entry over telephone communication channels, and feedback (formalized conclusion) sent by teletype. Such tools of "computing telediagnosis" were developed by Yu. I. Barashnev, I. M. Beskrovnyy, M. P. Vilyanskyy, R. I. Dubov, B. D. Zhigarev, M. V. Zhilinskaya, N. I. Moiseeva, N. V. Fentsov and others in the fields of clinical genetics, traumatology, emergency, surgery, paediatrics, neurosurgery and laboratory diagnostics (Barashnev Yu., et al. 1979; Beskrovnyy I. et al., 1979; Vilyanskyy M. et al., 1979; Dubov R. et al., 1979; Zhigarev B., 1979; Zhigarev B. et al., 1979; Moiseeva N. et al., 1979; Fentsov N. et al., 1979) (Fig. 5.1-5.2).
The extent of implementation varied from conceptual ideas to entirely working systems with fully proven efficiency. The most striking practical implementation of the "computing telediagnosis" concept was recorded in Yaroslavl. In 1979, the team of Yaroslavl Medical Institute, consisting of Mark P. Vilyanskyy, Aleksandr A. Chumakov and Aleksandr N. Khorev, developed the remote acute abdomen diagnosis system based on the automated analysis of data transmitted from remote hospitals (Fig. 5.3-5.5). The system was approved successfully by treating of 470 patients. An around-the-clock "consultative remote diagnosis centre" was established at the Institute clinic (Vilyanskyy M. et al., 1979). The "Nairi-K" computer was used applying software for recognition of acute abdomen diagnosis in patients with unclear clinical picture. The system was operated by nurses.

The above mentioned system supported a telemedicine network that included municipal and rural hospitals connected by telephone lines. The number of successful teleconsultations increased to 874, including 122 consultations on patients admitted in the rural hospitals. The diagnostics accuracy was about 89%. The system was found to be effective and promising. It was planned to equip the network additionally with teletypes and implement similar networks in the remote areas (including along the route of the Baikal-Amur Mainline construction) (ibid).

In the early 1980s, a Medical Automated System Centre was established at Altai Territorial Medical Information Computer Centre (Barnaul, USSR/Russia). "Computer diagnostics" were used in cardiology and surgery too (Fig. 5.6-5.7) (Emeshin K., 2012).
Electrocardiosignals were received from the territorial tele-ECG network (described in the appropriate chapter), and remote diagnostics of surgical pathology were conducted on the basis of special algorithms. At least 9,500 computing teleconsultations were provided for patients with surgical pathology. The work was headed by Dr. Nikolai F. Gerasimenko (Fig. 5.8) (ibid).

In the USSR, between 1978-1982 and 1983-1990 the targeted comprehensive program "Development and introduction of automated systems for consultative diagnosis, prognosis and treatment policy selection in case of medical emergencies" was implemented. The program applied the main achievements in the field of clinical telemedicine at that time. Professor Suren A. Gasparyan (2002) (Fig. 5.9) describes this as follows: "By the end of the 1970s, computer equipment and developments of mathematical methods for medical diagnosis and prognosis have created the conditions
for implementation of practical diagnostic systems, accumulating the experience of clinical medicine. Technical facilities allowed conferring a remote character for such systems in order to enable medical institutions to address remote diagnostic centres for consultation”.

Program researchers determined the development of construction principles, the structure of medical information, mathematical, technical and organizational support of such systems. They performed research trying to create a standard system on the basis of domestic computer equipment, which at that time was especially important. They carried out the construction and implementation of standard automated systems for diagnosis, prognosis and treatment policy selection in case of emergency for local health services. At the same time the scientists solved a wide range of clinical, organizational, social and economic problems. The description of the program and system is quoted as it stands in Gasparyan (2002) and Pashkina and Zarubina (2010): "The program brought together 12 research institutes, 3 universities and 3 computer and information centres. It was monitored by V. S. Saveliev, the USSR Academy of Medical Sciences, Academician, Professor, and L. G. Erokhina, head of the section, a member of the coordinating council, Professor. The leading institution was the Republican Information Computer Centre of the RSFSR Ministry of Health (S. A. Gasparyan, Professor, Research Program Manager, Chairman of the Coordination Council; M. L. Bykhovsky, Professor, deputy chairman of the Coordination Council, scientific consultant). The main institution for project documentation development was the Information Computer Centre of Primorsky Territorial Public Health Department (A. A. Rybchenko, PhD., deputy chairman of the Coordination Council, head of the section; A. A. Savchuk, academic secretary of the program section).

The main institutions participating in the program were:

- The Saratov branch of the Leningrad Scientific Research Institute of Cardiology (team leaders: E. Sh. Halfen, Honoured Worker of Science of the Russian Federation, Professor, deputy chairman of the Coordination Council, head of the section; and V. N. Shemetenkov, academic secretary of the program section);
- Yaroslavl Medical Institute (team leaders: M. P. Vilyanskyy, Professor, head of the section, a member of the Coordination Council

Fig. 5.9 Suren A. Gasparyan
Council; A. A. Chumakov, Ph.D., Associate Professor and A. N. Khorev, academic secretary of the program section);

- Russian National Research Medical University (RNRMU) named after N. I. Pirogov (team leaders: S. M. Prigozhina, Ph.D., senior staff scientist, academic secretary of the program section, a member of the Coordination Council; V. A. Boyadzhyan, Doctor of Medical Science; E. S. Pashkina, academic secretary of the program section);

- Leningrad Scientific Research Institute of Neurosurgery named after A. L. Polenov (team leaders: Yu. V. Zotov, Professor, head of the section, a member of the Coordination Council; B. G. Budashevskyy, Ph.D., senior staff scientist, and A. F. Lepekhin, Ph.D., academic secretaries of the program section);

- Leningrad Paediatric Medical Institute (team leaders: I. M. Vorontsov, Professor, head of the section, a member of the Coordination Council; E. V. Gubler, Professor, academic secretary of the program section, a member of the Coordination Council);

- Moscow Scientific Research Institute of Paediatrics and Paediatric Surgery (team leaders: Yu. E Veltishchev, Honoured Worker of Science of the Russian Federation, Corresponding Member of the USSR AMS, Professor, head of the section, a member of the Coordination Council; and B. A. Kobrinskyy, Ph.D., academic secretary of the program section, a member of the Coordination Council).

Participating institutions included also:

- MONIKI named after M. F. Vladimirskyy (team leaders: T. S. Vinogradova, Professor, a member of the Coordination Council; M. P. Pachin, Ph.D., a member of the Coordination Council);

- Altai Territorial Medical Information Computer Centre (team leader: K. N. Emeshin, Ph.D., Associate Professor, a member of the Coordination Council);

- Information Computer Centre of Sverdlovsk Regional Public Health Department (team leader: V. L. Gurevich, Ph.D., academic secretary of the program section, a member of the Coordination Council);
• Gorky Medical Institute (V. D. Troshin, Professor, a member of the Coordination Council; E. P. Troshin, Professor, a member of the Coordination Council; E. P. Strongin, principal investigator);
• Gorky Scientific and Research Institute of Traumatology and Orthopaedics (the team consist of L. B. Likhterman, Professor, head of the section, a member of the Coordination Council; Yu. I. Neimark, Professor, academic secretary of the program section; V. M. Troshin, Ph.D., senior staff scientist, principal investigator);
• Information Computer Centre of Directorate General for Health Services of Leningrad Municipal Executive Council (E. R. Useinov, a member of the Coordination Council; M. M. Zimnev, academic secretary of the program section),
• Leningrad Municipal Hostital No.3 (team leader G. A. Khay, PhD, head of the section; a member of the Coordination Council);
• Sverdlovsk Medical Institute (team including E. N. Krupin, Professor and M. Ya. Charnis, principal investigator).

In addition, the members of the Coordination Council of the national targeted comprehensive program were V. A. Alekseev, Ph.D., Associate Professor, Deputy Head of Directorate General for healthcare assistance to children and mothers of the RSFSR Ministry of Health and S. M. Kulagin, Ph.D., Head of Directorate General for healthcare assistance to children and mothers of the RSFSR Ministry of Health. The Information Computer Centre of Primorsky Territorial Public Health Department became the design centre of a standard replicated system of remote computing emergency diagnostics based on the algorithms and programs developed in research institutes and high schools. It director was A. A. Rybchenko, Ph.D.

The system of remote computing emergency diagnostics functioned on the basis of formalized cards. Consultative diagnostic centres were established at the medical aviation service stations of regional, territorial and national hospitals. Their work was carried out continuously 24 hours a day. A user dictated the numbers of diagnostic signs, specified in the clinical standardized card, over a direct telephone line. The numbers were uploaded to the computer by an attending physician. Within 20-30 seconds, a possible diagnosis was issued. Sometimes clinical or laboratory data were offered that had to be added for more precise differential diagnoses".

The amount of the accumulated data and study of the effectiveness conducted by S. A. Gasparyan is impressive (Gasparyan S., 2002; Pashkina E., Zarubina T., 2010): "Analysis of the results of 39 000 consultations in the course of two-year work of three consultative centres showed that the overall quality of diagnosis by doctors in rural and district hospitals is 63%. When addressing the computing consultative diagnosis centre for
consultation, accuracy rises up to 86%. Repeated consultation, including additional data for computer accuracy, increased the diagnostic accuracy up to 96%. Thus, the early diagnosis quality for critical health conditions was enhanced at the prehospital stage and in the in-hospital departments without an increase of resources for emergency assistance. This reduced mortality in children's hospitals of Leningrad by more than 15% during the period between 1976-77 to 1981-82 and to some extent infant mortality in general. The accuracy of statistical information on critical health conditions and their outcomes increased as well, and it was possible to obtain data on the defects in the health services operation that caused the increase of critical conditions. The developed system of remote computing emergency diagnostics was implemented in more than 40 territories of the Russian Federation. It was also used by the Far East fishing fleet. The system solved a critical economic problem by improving the quality of diagnosis in case of emergency conditions in the countryside, in remote areas and on ships at sea."

In the USA in 1965, Professor Lawrence W. Stark and Dr. James F. Dickson described computing telemedicine system for scientific research in the field of neurology in Massachusetts (USA). Physiological information was transmitted from four laboratories located in three medical institutions (National Institutes of Health, the Memorial and General hospitals) over telephone lines and teletype to the computer centre at the Massachusetts Institute of Technology for automated analysis. A series of studies was carried out with this telemedicine system in the field of physiology of the vision organ and the nervous regulation (Fig. 5.10-5.11) (Stark L., Dickson J., 1965).

Also in 1965, a computerized laboratory telediagnosis system was installed in the Missouri Medical Centre (USA) headed by Dr. Donald A. B. Lindberg (for more details refer to the chapter on telecardiology). This was a kind of "superstructure" over the prototype of the medical information system which was already in use since 1955 (Fig. 5.12). At the time of publication “Automated laboratory data handling” (1965), the system had accumulated a significant number of radiological images and more than 60000 ECGs with explanations and interpretations. It was assumed that the laboratory telediagnosis would be used in half a million examinations per year (ibid).
In the early and mid 1960s, many hospitals in the USA were equipped with teletypes for external document workflow, exchange of information about the movement of patients and statistical data. In particular, in 1961, this equipment was installed in Philadelphia at the Blue Cross organization (Teletypes installed at hospitals, 1961).

In 1964, the common teletype network covered 102 Veteran Hospitals in 21 states (40 new stations join local VA hospital hookup, 1964). This equipment was also used successfully in the computerized diagnosis complexes (Fig. 5.13) (40 new stations join local VA hospital hookup,
5.2. Clinical Telemedicine Formation

In the 1970s, a wide range of clinical telemedicine projects was implemented in the United States based on video communication and on biotelemetry. For example, in Puerto Rico in 1974, a telemedicine network was established, consisting of three bilateral microwave channels for video, audio and telemetry information exchange between Guayama and Ponce at a distance of about 70 km. The network was implemented by local specialists Dr Victor Carlo of the Ponce District Hospital and electrical engineer Luis Rivas Calderon.

It was remarkable that they used tele-auscultation. As Dr. Carlo stated: "The system has worked so well in preliminary tests that the sounds picked up by the stethoscope come out as clear as if you had the patient right next to you". The telemedicine network demonstrated efficient approach of qualified medical assistance to the place of necessity and logistics optimization (Puerto Rico takes to “telemedicine”, 1974). Most of the above mentioned projects had rather local value, so we shall give only summarized information (Table 5.1) (Bennett M., 1978).

Table 5.1 Clinical telemedicine projects in the USA during 1969-1979

<table>
<thead>
<tr>
<th>State</th>
<th>Applied</th>
<th>Activity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alabama</td>
<td>1969-1979</td>
<td>Computerization of work of nurses and general practitioners' offices, transtelephonic telemetry, telephone teaching conferences for nurses</td>
</tr>
<tr>
<td>Appalachian Mountains</td>
<td>1974-1975</td>
<td>Clinical medicine and distant learning by means of satellite audio communication (ATS-6), network of 10 VA hospitals</td>
</tr>
<tr>
<td>California</td>
<td>1977-1978</td>
<td>Telemedicine network between rural localities (without hospitals) and general practitioners' offices; communications by telephone and one-side slow-scan video</td>
</tr>
<tr>
<td>Colorado</td>
<td>1976-1979</td>
<td>Telemedicine network for rural area based on computerized telediagnosis</td>
</tr>
<tr>
<td>Location</td>
<td>Years</td>
<td>Description</td>
</tr>
<tr>
<td>-------------------------</td>
<td>----------</td>
<td>---------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Connecticut</td>
<td>1971-1978</td>
<td>Telemedicine and distant learning by means of VCC*; a network between the University clinic and 2 hospitals</td>
</tr>
<tr>
<td>Hawaii and Pacific Islands</td>
<td>1971-1978</td>
<td>Clinical medicine and distant learning by means of satellite audio and facsimile communication (ATS-1)</td>
</tr>
<tr>
<td>Indiana</td>
<td>1967-1978</td>
<td>Distant learning by means of audio and video conference communication; a network of 7 University centres and over 40 hospitals</td>
</tr>
<tr>
<td>Maine</td>
<td>1971-1978</td>
<td>Networks based on VCC between 3 private hospitals, a Memorial hospital and nursing ambulance station</td>
</tr>
<tr>
<td>Minnesota</td>
<td>1972-1974</td>
<td>Clinical telemedicine by means of VCC with medical data transmission (ECG, X-ray patterns, laboratory analyses results); a network between 2 hospitals</td>
</tr>
<tr>
<td>Nebraska</td>
<td>1976-1979</td>
<td>Telemedicine for the primary level of health care on the basis of facsimile, radio and telephone communication</td>
</tr>
<tr>
<td>New Mexico</td>
<td>1973-1979</td>
<td>A network between 7 isolated hospitals in the low inhabited area on the basis of radio and telephone communication (teleconsultations, briefing, distant learning). Telemedicine based on VCC for industrial and mining settlements</td>
</tr>
<tr>
<td>Ohio</td>
<td>1974-1979</td>
<td>Clinical telemedicine and distant learning by means of VCC between the University clinics and 6 hospitals</td>
</tr>
<tr>
<td>Oregon</td>
<td>1976-1979</td>
<td>Telemedicine for the primary level of health care on the basis of slow-scan video</td>
</tr>
<tr>
<td>Rhode Island</td>
<td>1976-1979</td>
<td>Telemedicine for the primary level of health care on the basis of slow-scan video and medical data transmission (ECG, X-ray patterns, laboratory analyses results)</td>
</tr>
</tbody>
</table>
Texas 1974-1979

Telemedicine (teleconsultations, management, distant learning) for the primary level of health care based on VCC

*VCC - video conference communication*

An important feature in this period was the evident emphasis on the educational opportunities for health care offered by telecommunications.

Starting from the 1970s, an important development of clinical telemedicine, i.e. its integration into the routine health care, was made in Canada. This process was based on two projects.

Between October 1976 and February 1977, the *Hermes* communications satellite was used for telemedicine purposes in London, Ontario, Canada. The telemedicine project was managed by Dr. Lewis Stafford de Sausmarez Carey, Chairman of diagnostic radiology and nuclear medicine at the University of Western Ontario. Communication between the University clinic and the remote hospital, rendering first aid, was established. Telemedicine tools included: satellite communication line, a one-way video and data transmission, two-way exchange of audio information and facsimile communication (Fig. 5.14) (Carey L. et al., 1979).

A video camera mounted in the hospital was controlled remotely by consultants in the clinic; interactivity was provided by facsimile and voice communication. The teleconsultations were held mainly for nurses, and general practitioners received advisory support on radiology, anaesthesiology, cardiology, pathology, haematology, physiotherapy, dentistry, pharmacy, infection control, respiratory therapy, administration (ibid).

During the period between September 1977 and December 1979, the telemedicine network was organized between 20 health care units, 7 nursing ambulance stations, a hospital in the town of Sioux Lookout and 2 consultative centres in Toronto. The network was managed by Earl V. Dunn (Family Medicine Chair, University of Toronto) and David W. Conrath (Department of Science, University of Waterloo) (Fig. 5.15-5.16) (Dunn E. et al., 1977). Radio, telephone (cable and wireless) and satellite channels were used as communication lines. Slow-scan video communication was the major telemedicine tool. The video information was transmitted via the cable telephone lines.

Fig. 5.14 Lewis Stafford de Sausmarez Carey
The project compared the quality of primary health with and without the use of telemedicine. The economic effects were also evaluated. The project demonstrated the technical availability and reliability of the telemedicine decisions, as well as the economic efficiency by optimizing the logistics (ibid). In 1977, Earl Dunn, David Conrath, William G. Bloor and Barbara Tranquada published an article reporting the experience of telemedicine consultations on more than 1 000 patients. A thorough comparison of the diagnostic accuracy and clinical value of various telemedicine tools (two-way black-and-white and color video conferencing, hands-free phones, slow-scan video communication) was also provided. Teleconsultations were held between the hospital in Flemington and the University Hospital in Sunnybrook. The authors pointed out that there were no major differences in the diagnostic value between various telemedicine tools. Also they studied diagnostic and treatment programs offered by doctors-subscribers and consultants, in terms of their complexity, duration, safety. The authors compared the logistics solutions, too. They found insignificant statistical difference between the telemedicine tools, which is quite strange considering the comparison of different technologies such as telephony and video communication. The results surprised the researchers and they recommended to make decisions based on clinical issues and economic feasibility (ibid).

In 1976, at the Memorial University of Newfoundland (Canada) a telemedicine project was implemented. The project was dedicated to clinical teleconsultation and distant learning. It was carried out under the supervision of Dr. Arthur Maxwell House (Fig. 5.17), with the participation of W. C. McNamara, Judy M. Roberts and others. By 1977, a full-fledged telemedicine centre was established. Four remote hospitals, in Stephenville, Goose Bay, St. Anthony and in Labrador City, interacted with the University via satellite communications and video conferencing (Distance Education and Learning Technologies, 2015; M.U.N.’s Telemedicine
Experiment, 2015; Roberts J. et al., 1993; Tele-Health and Tele-Education at Memorial University of Newfoundland 1977-1981, 2015; The Faculty of Medicine Founders’ Archive, Memorial University of Newfoundland, 2015; The early days of the medical school at Memorial University of Newfoundland. Administrative History: Telemedicine, 2015).

Initially, only one-way audio and video transmission via Hermes satellite was carried out. The telephony was used for interactive communication. These technologies allowed implementing distant learning. A few months later, slow-scan television communication and biotelemetry, with data transmission over cable channels, was tested. In general, this demonstrated the importance and effectiveness of health care telecommunications and enabled to continue the program.

With the use of the Anik B satellite, telemedicine collaboration was established between the University and the oil platforms. The operating methods were adjusted and special terminals were developed. Based on the latter, the University telemedicine network was established between 170 institutions in 80 different locations. In addition to the active distant learning telemedicine, consultations were also constantly held such as (Fig. 5.18-5.26, source http://telehealth.gcatt.gatech.edu) (ibid):

- Teleradiology (X-ray patterns, sonograms, simultaneous fluoroscopy) by means of slow-scan television communication to at least 3 hospitals;
- Neurological and cardiac teleconsultations by means of biotelemetry to at least 6 hospitals. About 1 200 tele-EEG consultations annually; urgent tele-ECG service for most hospitals were organized;
- Clinical video conferences with the demonstration of the disease place, micropreparations, interactive discussion of patients, as well as - for telepsychiatry.

Later teletype communications and e-mail were also used. Monthly a significant amount of clinical sessions was held. For example, in 1977, 216 teleconsultations were organized between the University Centre and the Hospital in Moose Factory. This telemedicine program was headed by Dr. Lewis Stafford de Sausmarez Carey.

During 15 years of active service the network grew significantly. By the early 1990s it covered 190 teleconferencing points at 100 institutions, including rural hospitals, district administration, university campuses, rural
schools (50), and nursing ambulance stations in the provinces of Newfoundland and Labrador. Up to 5 500 hours of distant learning were provided annually. Numerous telemedicine consultations were given with the use of teleradiology, video conferencing (slow-scan television communication) and biotelemetry facilities.

Fig. 5.18. Tele-EEG (Newfoundland, Canada, 1977-1982)

Fig. 5.19. Teletype transmission of medical data (Newfoundland, Canada, 1977-1982)

Fig. 5.20. Distant learning in the health care (Newfoundland, Canada, 1977-1982)
Fig. 5.21. Video conferences in teleradiology (Newfoundland, Canada, 1977-1982)

Fig. 5.22. Video conferences (slow-scan television communication) for teleradiology purposes (telebridge between Canada and Austria - presentation of Dr. A. M. House at the Unispace’82 conference)
In 1982, the technological base of the telemedicine center at the Memorial University of Newfoundland was used to create a national telemedicine network that covered 16 medical educational institutions.

In 1988, the University telemedicine center was transformed into the Telemedicine and Educational Technology Resources Agency (TETRA). On basis of the experience gained, the Memorial University of Newfoundland implemented a number of educational projects for the islands of the Atlantic and Pacific oceans, as well as for African countries. Satellite links and more seldom radio communication were mainly used (ibid).
In 1987, at the research center of telecommunications administration in Tromsø (Norway), a Department of telemedicine was organized, which in future became the Norwegian Centre for Telemedicine, one of the world's leading specialized scientific and clinical organizations (Fig. 5.27) (20 years of telemedicine in Tromsø: a historical retrospective, 2015).

5.3. Formation of Separate Lines of Clinical Telemedicine

Specialities of clinical telemedicine that were developed before the 1990s were teleradiology and telepathology.

5.3.1. Teleradiology

Since 1957, at the University of Montreal (Canada), Professor Albert Jutras began supervising the development of teleradiology for the diagnosis of the respiratory system diseases, gastrointestinal tract and oncological gastric pathology. A. Jutras introduced such terms as "remote radiodiagnosis", "video-tele-radiodiagnosis", "teleradiology diagnosis", "telefluoroscopy" (Jutras A., 1957; 1959 a), b); 1960; Jutras A., Duckett G., 1957). Under the supervision of A. Jutras and the participation of Dr. Guy Dukett, a cable (coaxial) telemedicine system, connecting two hospitals in Montreal, Hotel Dieu and St. Jean Talon, separated by 10 km, was established. Successful fluoroscopic imaging exchange was implemented in order to improve diagnostic decision. Yet, the concept of A. Jutras found only "intra-hospital" applications. In most cases, radiological images were not transmitted between health care facilities, but within them. Nevertheless, higher safety and quality of radiologic examinations were achieved (Fig. 5.28-5.30) (ibid).
In the USA in 1947, G. Austin developed a system for X-ray imaging transmission via telephone cable and radio (Bashshur R. et al., 2014). In the same year, a team of radiologists and engineers headed by Professor Jacob Gershon-Cohen and with the participation of A. G. Cooley established a system for radiological imaging transmission by facsimile communication, called "telognosis", between the cities of Philadelphia and Westchester. The transmission of one image took up to 5 minutes (Fig. 5.31) (Gershon-Cohen J., 1951; Gershon-Cohen J. et al., 1957; Gershon-Cohen J., Cooley A., 1949, 1950, 1956).

According to the official definition, telognosis was an interpretation of facsimile roentgenograms received remotely with the help of telephone or radio communication (New developments in cancer, 1952). Gershon-Cohen introduced also the term "videognosis" to provide roentgenogram teleconsultation via television link (Gershon-Cohen J., 1951; Gershon-Cohen J. et al., 1957; Gershon-Cohen J., Cooley A., 1950, 1956).
1949, 1950, 1956). In 1951, he considered remote diagnostics of X-ray imaging the most essential tool for improving health care quality in rural hospitals (ibid). "Videognosis" technology was performed between Philadelphia and New York. In the mid-1950s, together with Dr. Harry Shay, Professor Gershon-Cohen transmitted full-color radiological images.

![Fig. 5.32. Application of videoconferencing (telenegatoscope) as an instrument for teleradiology (1950s, photo of Paul Almasy for WHO), a photo from the collection of History of Medicine (NLM), record UI 101437327 http://ihm.nlm.nih.gov/images/A14072](image)

Professor Jacob Gershon-Cohen, recognized as the creator of the concept of telo- and videognosis, is one of the founders of mammography and thermography, too. This energetic man and talented scientist devoted all his life to radiology. Few weeks before his death he demonstrated the possibilities of roentgenogram teleconsultation using one of the world's first videotelephones (Bell Picturephone®).

![Fig. 5.33. Clinical teleradiology by means of videoconferencing based on the closed cable television systems, on the left - Dr. Wolf, on the right - Dr. Hunt (USA, 1969)](image)
In the 1970s, teleradiology systems, using television communication, were used in USA, France, Japan and Sweden (Fig. 5.32-5.33). In parallel with the television communication, systems for transtelephonic data transmission - facsimile and teletype, were used particularly in France. The subscriber reported the patient's parameters by phone, computer mapping and dose calculation were performed in the expert centre, and the results were "returned" by facsimile.

In 1972, doctors W. S. Andrus and T. K. Bird introduced the term "teleradiology" (Andrus W., Bird T., 1972). Their activities in this field were described in details in the chapter devoted to video conferencing).

In the late 1970s, a teleradiological network was organized in Canada, using the *Hermes* satellite. Diagnostic imaging exchange was established between the nursing ambulance stations, district hospitals and university medical centres. The project was headed by doctors Lewis S. Carey and Earl Stuart Russell. According to the project authors, teleradiography and telefluoroscopy consultations were effective in 90% of cases (Fig. 5.34-5.35) (Carey L. et al., 1979; TV X-Rays in Hull Hospital, 1961; Gitlin J., 1986; Thomas A., 2015).

Fig. 5.35. Teleradiology: a radiologist works remotely at the expert centre, roentgenogram digitalization by video camera (USA, 1986)

In 1973-1975 a teleradiological network, based on wireless slow-scan television communication, was operating in Omaha (Nebraska, USA). The system interactivity was provided by two-way voice communication. Teleconsultations were carried out between a rural hospital in Broken Bow and the University clinic. In 1976 a teleradiological network was started up in St. Louis (Missouri, USA) between the VA Medical Centre and several rural hospitals.
One of the project supervisors was Dr. Robert Donati. At the end of each working day the technical staff transmitted the results of all conducted examinations to the expert centre for computer processing (by Bell Dataphone). Interpretations and conclusions were sent by teletype during the next day (Bennett M., 1978).

5.3.2. Telepathology

It is remarkable that the first experiments on the transmission of cytological images dated back to the 1950s-1970s (Fig. 5.36, http://www.earlytelevision.org/skf_color.html; National Museum of Health and Medicine, AFIP, SC 521401 - http://www.smecc.org/walter_reed_rca_color_television.htm). Powerful digital tools of telepathology are used in modern health care, but for the described period (up to the 1990s) special attention should be paid to the following facts:

![Telepathology by means of television communication. Lt. colonel H. Sprinz, Surgical Pathologist operates the completely new color TV microscope), Walter Read Hospital (USA, 14 November 1957), a photo of Steve Dichter](image)

In 1986, the first robotic telemicroscopic system was created and successfully implemented in the United States, which marked the start of an entirely new generation of telepathology instruments (Fig. 5.37) (Park S. et al., 2013).

Also in 1986, Professor Ronald S. Weinstein introduced the term "telepathology" (Fig. 5.38) (Weinstein R., 1986; Weinstein R. et al., 1987). Telepathology, according to Weinstein, is the practice of pathology at a distance by visualizing an indirect image on a video monitor screen rather than viewing a specimen directly through a microscope (ibid).
So, the dominant line of telemedicine in the 20th century was undoubtedly computing telediagnosis, based on computer analysis of formalized medical information. Despite the rapid growth and development of various programs and systems, currently this tool is practically not used anymore.  
On the other hand, the 1970s-1980s were marked by the formation of clinical telemedicine models and principles, which became the basis of modern e-Health.

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Chapter 6
Telemedicine Satellite Technologies

6.1. Transatlantic Telemedicine

On May 26 and July 3 1958, Dr Arthur Briskier (New York, USA) performed experiments on medical information transmission via shortwave radio and telephoto transmitter. As early as 1953, Briskier developed the system of electromagnetic cardiac auscultation recording. On those dates, a volunteer’s heart tones were recorded by using his equipment in New York (USA). Then the record was transmitted to Paris (France) via radio and translated back by the author himself to test the diagnostic quality of the record (Fig. 6.1) (Briskier A., 1958, 1959).

Fig. 6.1. Dr A. Brisker (in a black jacket) testing his telemedicine system (New York, USA, 1958)

Thereafter, some anthropological and clinical data as temperature, blood pressure, ECG, thoracic cage X-ray, lab results, etc. were sequentially translated by applying "radiophotos" (Fig. 6.2) (ibid). Experiments continued with records from several volunteers:

- A healthy volunteer;
- Patients suffering from mitral or aortic stenosis or incompetence;
- Pre- and post-operation data of patients who had undergone heart surgery for bacterial endocarditis and heart disease;
- Cardiac auscultation records of a pregnant woman and a fetus immediately prior to the delivery.
Arthur Briskier established the high diagnostic value of the method. He underlined that the system was overcoming the language barrier, as the data did not “contain words”, but only visual and graphic images. The conclusions highlighted the universality and importance of such technologies for urgent situations, transport medicine, and also for caustic cases (ibid).

In the 1960s, NASA placed the first telecommunication satellites into geostationary orbit, enabling super-fast data transmission, including biomedical ones, between Europe and America. In 1963, one of the first transatlantic biotelemetry projects was implemented (Larks S., 1964; Marquette Scientist, 1962; Ray C. et al. 1965). The participants included (Fig. 6.3-6.7):

- **In USA:**
  - The Mayo Clinic staff in Rochester, Minnesota. (Doctors Reginald G. Bickford, Wayne Russert, Christie Ray, Don Carroll);
  - The NASA representatives (Leonard Jaffee, Joseph M. Gerret), the Federal Commission for Communication (E. William), telephone companies (John Brunnette, Dill Burke);
  - Experts from the medical electronic sphere of Magnavox company (William K. Hagan, George Nichter);
  - Mount Sinai hospitals staff (Milwaukee, Wisconsin,) and Parkview (Fort Wayne, Indiana);

- **In France:**

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Fig. 6.2. Medical data transmitted by A. Briskier from North America to Europe via shortwave radio and radiophoto: the original to the left, the information received – to the right (1958)
- Professor Antoine Remond and his neurophysiological laboratory staff L.E.N.A, Salpetriere Hospital (Paris), and Dr Charles Dean Ray (USA);
- Dr Claude Suru, University of Paris;

- **In Great Britain:**
  - Neurological Institute of Barden staff in Bristol, Great Britain (Doctor William Grey Walter, Doctor Ray Cooper, W. J. Warren);

- **In Belgium:**
  - Dr Saul D. Larks (Marquette University, USA).
The transatlantic transmission project was implemented in several phases. First local preliminary tests of biotelemetry system at Mayo clinic were carried out with data exchange through Rochester-Minneapolis-Omaha cable telephone lines and backwards (Fig. 6.8) (Hagan W., Larks S., 1963; Ray C. et al., 1965). Engineering improvement of the system was performed, noise immunity was reinforced, and the artefacts were eliminated. The possibility of multichannel data transmission was provided. Telemetry rheoencephalography data approach was worked out, too (Fig. 6.9) (Ray C. et al., 1965).

The first transatlantic biotelemetric experiment took place on April 25, 1963 at 22.45 (GMT). A normal encephalogram was transmitted via satellite from the Neurologistic Barden Institute (Bristol, Great Britain). First the signal was directed through the cable channel from Bristol to Goonhilly Downs, then transmitted to the satellite, translated to North America, Nutley (New Jersey) and again sent to Rochester through cable with Bell dataphone. The encephalogram was successfully recorded in ECM and instantly transmitted back (Fig. 6.10). Earlier, Dr William Grey Walter in cooperation with A. Kamp and W. Storm van Leeuwen (Institute of

![Fig. 6.8. General pattern of transtelephonic biotelemetry system at Mayo clinic, USA (a – receiving station, b – transmitting station); at the heart of the system Hagen-Larks implementation, USA, 1960s](image)
Medical Physics, Utrecht, The Netherlands) developed and successfully tested the equipment for 8- and 16-chanel EEG telemetry at short distance (Walter W., 1969) (Fig. 6.11-6.12).

After the experiment on 25.04.1963, the results of computing telediagnosis with data transmission through the underwater cable and via satellite were compared. For this purpose the same biological data were gradually transmitted. No differences in diagnostic value of both methods were recorded.

In May, sessions of transatlantic telemetry of fetal ECG were held. Prioriy to these sessions, an experimental transmission of fetal ECG between hospitals in Milwaukee (Wisconsin) and Fort Wayne (Indiana) was performed under Professor Saul D. Larks’ supervision.

![Fig. 6.9. General pattern of computing biotelemetry (rheoencephalographic) system at Mayo clinic, 1960s](image1)

![Fig. 6.10. Transatlantic computerized tele-EEG consultation, USA, Mayo clinic, Dr R. G. Bickford (behind) and technical experts W. Russert (in the centre) and Don Carroll (Medical milestone, 1963)](image2)
On May 7, 1963, “the international cable telemetry” took place: a fetal ECG was transmitted on-line from a mother, being at Mount Sinai Hospital (Milwaukee, USA), to Dr Antoine Remond’s laboratory (Paris, France). On May 28, 1963, at 14.15 (GMT) “the international satellite telemetry” took place – via the Relay I satellite. A fetal ECG was transmitted from Milwaukee to Paris where it was successfully received and recorded for the
further interpretation. On the basis of these findings the concept of international fetal cardiology network was developed. The latter could receive fetal ECG in function of the timetable via cable or satellite communication channels and interpret the data to improve medical aid in perinatology. It was envisaged to establish not less than 12 similar international centres (Larks S., 1965; Ray C. et al., 1965).

On June 25, 1963, a biotelemetry session was held between Mayo clinic (Rochester, USA) and the International conference on medical electronics (Liege, Belgium). The information was transmitted through the underwater cable. Simultaneously, the same data recorded on the cassette were sent to the laboratory of Prof. Antoine Remond (Paris, France) for a comparative interpretation. The results of the distant and delayed immediate analysis coincided entirely (Fig. 6.13) (Ray C. et al., 1965).

The results of all the sessions were thoroughly analysed. The technical requirements of the equipment were defined. The methods of transmitted data integrity provision were developed and the path for practical implementation of transatlantic telemetry was opened.

![Fig. 6.13. General schematic diagram of biotelemetry system used for the session between the USA and Belgium 25.07.1963](image)
On July 14, 1965, a successful transatlantic telemetric transmission of electric cardiosignal was fulfilled. Dr James Charles Hirschman in cooperation with Thomas J. Baker and Arthur F. Schiff performed ECG transmission at a distance of 7,500 km from Conakry (Guinea, Western Africa) to Miami (Florida, North America). Physically the data transmission was performed from aboard the *S. S. Hope*, a hospital ship (Fig. 6.14-6.15).

![J. C. Hirschman](image1.png)  
![The S. S. Hope, a hospital ship (1965)](image2.png)

To pick up and record the signal, a “standard, financially affordable and ready for use” equipment of Cambridge Instrument Company, Hallicrafters and Hammerlund radiostations, was used. The entire consulting process of 12-channel ECG took several minutes. The additional data and distant result interpretation were communicated via voice service. During the next week, transatlantic telemetric consultations were held on two more patients, in which case even a tropical storm could not prevent qualitative data transmission.

Some tests preceded the Transatlantic transmission: ECS radio transmission (via amateur radio station) at a distance of 15 km, followed by transmission between Detroit - Miami and Mexico City - Miami (USA). Interferences were determined and successfully eliminated, once the the transatlantic session was held (Fig. 6.16-6.17).

The gained experience was confirmed some months later. ECG radio consultations were held between the states of New York and Florida (distance of 2,100 km) via amateur radio stations. The importance of the method was obvious for medical care on ships at sea, isolated hospitals and emergency situations. The possibility of distant computerized treatment of all possible types of electrophysiological data was discussed. Later on, Dr Hirschman participated in the development of a telemetry system for paramedics (ref. to Chapter “Telecardiology”).

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It is worth adding that in 1973 another experiment was held on board of the *SS Hope*. The ship was anchored on a Brazilian shore. A telemedicine consultation for a patient suffering from lymphosarcoma was received from experts in Washington (USA) via satellite. The conclusion was drawn concerning the possibility to use compact receiving and transmitting equipment for voice and teletype messages exchange, facsimile, patient’s fixed video, X-ray patterns and microscopic pictures and journal articles on ships at sea (Walsh W. et al., 1974).

On May 2, 1965, the first transatlantic medical videoconference was held during which Professor Michael Ellis DeBakey performed an open-heart operative replacement of the aortic valve with an artificial prosthesis on a patient from Chile named Saba Jadue (Fig. 6.18) (DeBakey M., 1995).

The surgery was performed at the Methodist Hospital in Houston (USA). The audience was in the lecture hall of the Medical Department at the University of Geneva, Switzerland. Interactive transmission was performed via the *Early Bird* satellite. During the surgery, Professor DeBakey answered the questions asked by doctors in the audience. Many distinguished doctors (Professor Jean-Claude Rudler, Professor Charles
Mentha and others) and WHO’s Director General, Dr M. G. Candau took part in this remarkable event. The patient in a satisfactory condition was dismissed from hospital after 2 weeks. He told journalists: “Now I can marry because my heart will be strong” (Fig. 6.19).

On July 5, 1967, a transatlantic ECG teleconsultation was held using the computing cardiology system of Dr C. Caceres (ref. to Chapter “Telecardiology”). An electrocardiogram was recorded at the University Hospital, Tours, (France), and then transmitted via satellite telephone channel to Washington (USA) for computerized interpretation. The results of the analysis were transmitted back by telex. The analysis itself took 15 seconds, and the result was received in France within 30 seconds on completion of data transmission in the USA. In fact, the transatlantic computing teleconsultation took as much time as the similar procedure carried out between New York and Washington. In France, this event was organized by Professor Renaud Koechlin (Hospital Foch and National Institute of Healthcare Service and Medical Researches), Dr Gaudeau and biomedical engineering expert Jozef Cywinski (Fig. 6.20). The latter developed a special interface for satellite telediagnostic vectorcardiogram. After successful tests the system was presented to General Charles de Gaulle and members of the French government.
But it was not only the Atlantic which was served by telecommunication. In 1971, the first telemedicine session between countries on both sides of the Pacific Ocean took place. Cooperation between the Mayo clinic (Rochester, USA) and a hospital in Sidney (Australia) was established. At first, a transmission and distant interpretation of ECG from Australia to North America using telephone and satellite connection was performed. And on April 12, 1978, a 45-minute videoconference between the medical centres via two satellites and with the help of microwave data transmission was held (Telemedicine at Mayo, 2015).

On December 7, 1988, a disastrous earthquake happened in Armenia. 21 cities and 350 villages were hit, 25 thousand people died, hundred thousand people were injured. Within 2 weeks after the catastrophe, the USA and the USSR launched the joint project to carry out telemedicine consultations for survivors via satellite communication. Four medical centres provided experts to participate in telemedical sessions with the national diagnostic centre in Yerevan. It is worth mentioning that in the USA there was already experience of using ordinary telecommunication tools in disaster areas as in 1985 NASA implemented for the first time systems based on voice satellite communication for teleconsultation of survivors of the earthquake in Mexico (NASA satellite aids in Mexico City resue effort, 1985). It is remarkable that the system was launched within 24 hours (Fig. 6.21-6.23) (Grigoriev A., Baevsky R., 2007; Telemeditsina Bashkortostana 2014; Hasbiev S. et al., 2011; NASA Lewis …, 2014; Nicogossian A. 2001, 2014, 2015).

An unexpected follow-up took place after the industrial disaster in Bashkiria. On June 4, 1989, in the region Asha-Ulu-Telyak two passenger trains collided and a powerful explosion of light hydrocarbons gazes occurred in the nearby oil pipeline. 575 persons were killed; more than 600 persons were injured. Immediately, another telemedicine terminal was added to the Ufa medical centre (Fig. 6.24) (ibid). During 3 months, 51 telemedicine sessions were held, in which more than 400 doctors and nurses from both hemispheres took part. 253 patients were consulted at a distance. The sessions were organized as bilateral audio-, video and facsimile information exchange (Fig. 6.25) (ibid).
Fig. 6.21. The head and organizer of telemedicine “spacebridges” on behalf of the USSR – Oleg G. Gazenko

Fig. 6.22. The head and organizer of telemedicine “spacebridges” on behalf of the USA – Arnauld Nicogossian

Fig. 6.23. The head and organizer of telemedicine “space bridges” on behalf of the USA – Ronald C. Merrell

Fig. 6.24. Episodes of transatlantic “spacebridge” Armenia/USSR – USA (1988)
Fig. 6.25. Medical transatlantic (slow scan) videoconference: transmission of static images and sound (Bashkiria, USSR, 1989)

Fig. 6.26. Screenshot of telemedicine consultation project “Telemedicine Spacebridge to Russia”
Later on, the project was named “Telemedicine Spacebridge to Russia”.

Before 1993 as part of its strategic framework, store-and-forward teleconsultations via the Internet were performed. Specially developed dynamic web-applications were tested and various types of medical multimedia information channels were employed (Fig. 6.26) (Grigoriev A., Baevsky R., 2007).

The potential offered by desktop-videoconferences also enabled the usage of this technology for real-time teleconsultations and distant lectures. At the end of the 1980s, transatlantic telemedicine for the first time ever allowed to bridge not only the geographical distance but political barriers as well.

6.2. Polar Telemedicine

Over decades of Arctic and Antarctic exploration, radio teleconsultations were the only means of distant medical support.

It should be noted that radio in Antarctica was used for the first time in the expeditions of Sir Douglas Mawson in 1911-1914 (Australian Antarctic Division, 2015).

In the USSR in 1970, during the 15th Antarctic expedition, a remarkable event took place – the first experimental transmission of a range of electrocardiograms from Mirny observatory in Leningrad was carried out (Gorbunov G. et al., 2008; Deryapa N. et al., 1975; Senkevich Yu., 2004). This can be considered as the beginning of telemedicine application for healthcare support of the Antarctica polar explorations.

A year later (during the 16th expedition) doctors at Molodezhnaya station established a connection through phototelegraph with the polar medicine department of the Arctic and Antarctic Research Institute in Leningrad. On three occasions, expedition doctors received efficient radio consultations based on the electrocardiograms of a patient with acute myocardial infarction sent from Antarctica (ibid). It should be noted that the quality of the transmitted phototelegraphic ECG and messages was rather low due to less sophisticated technical devices available at that time, and also due to the long lasting transmission time. The time of data transmission ranged to from 20 to 40 minutes. But these were the first technical and organizational attempts of monitoring of polar explorers’ health and to organize distant medical consultations to the poles.

In 1974, an article about telemedicine implementation linked to the Australian Antarctic expeditions was published (Lugg D., 1974). It revealed the application of facsimile connection for diagnosing and treatment selection. The expedition doctor sent black and white X-rays prints to the polar medicine centre via fax. The answer came as a text, but when
necessary, a voice message was sent via radio (Australian Antarctic Division, www.aad.gov.au 2015).

More widely, telemedicine started to be used as a support of polar explorers in different countries from the mid-1990s and later. Over decades radio connections remained the key telemedicine tool in Polar Regions of Europe and North America (Fig. 6.27).

The telemedicine network created on the territory of the state of Alaska (USA) is worth mentioning too. There is an earlier fact about radio consultation in this territory. A newspaper article from 2 September 1933 (An Epic of the Air …, 1933) describes a radio telemedicine support in the following way: «In Seattle, early that Thursday morning, Ed Stevens, operator of amateur station W7BB, received a call for help. He was engaged in a conversation with the operator at Alitak, more than 1000 miles away. At lonely Lazy Bay on Kodiak Island, five-year-old Henry Loof lay near death with appendicitis. Stevens described the little boy's symptoms to Dr. A. H. Seering of Harbor View Hospital, Seattle. The physician diagnosed the case, warned of the danger of peritonitis, urged that the boy be taken to a hospital at once…Stevens called the United States Army Alaska Telegraph, which used both wireless and cable, and the message was relayed through to Anchorage, a circuit of 2000 miles. Pilot Harry Blunt took off at once through the storm, together with Dr. Walkowsky. Twice the seaplane was forced down. Twice the intrepid duo again roared into the gale. Late that afternoon they reached Lazy Bay, 400 miles from Anchorage. They were just in time to save the little boy's life» (Fig. 6.28).

![Fig. 6.27. Radio consultation supervised by WHO, a communications service provider helps a patient (Canada, ~1952). Photo of Paul Almasy, NLM History of Medicine collection, record ID 101436842 http://ihm.nlm.nih.gov/images/A13758](http://ihm.nlm.nih.gov/images/A13758)
So, there is written evidence that on August 31, 1933 the amateur radio consultation was conducted between extremely isolated areas in Alaska with participation of ham operator Ed Stevens on one side, and medical doctor A. H. Seering assisted by Cyril Pemberton, the operator at Alitak, at the other. Both wireless and cable lines were used for this communication. After the teleconsultation the famous Alaskan pioneer pilot Harry Blunt (aka «Bristol Bay Sea Hawk», 1889-1985) brought Dr Walkowsky to the patient side for an urgent surgery (An Epic of the Air …, 1933; DeSoto C. Calling C., 1941).
After a systematic start in the 1950s, the Alaska radio communication was actively used for medical purposes. Residents of small villages had the possibility to connect with the hospital for ordinary voice consultations. In 1955, a range of technical standards was issued, which helped substantially upgrading radio stations network and improving their work. In 1964, a training program on emergency medical aid for volunteers from small villages and rural settlements was launched. These persons also used radio communication for regular meetings and consultations with doctors responsible for certain areas. During 3 years, the volunteer network significantly increased, despite of the fact that new hospitals were built. In 1968, official timetables and radio consultations schedules were adopted. The attending doctors were bound to connect with the supervised settlements and to guide volunteers’ consultations. A specific term, “radio-medical-traffic” appeared, pointing at the significant amount of medicine information transmitted via radio channels. The presence of at least voice communication with medical staff had already seriously impacted on the fact that assistance was available and timely. However, because of atmosphere ionization, radio communication suffered constant interruptions and interferences (Fig. 6.29) (Alaska Federal Health Care Access Network Telemedicine Project, 2004; Brady C., 2015; Foote D., 1977; Spain P. et al., 1977; Foote D. et al., 1976).

In the same year on Senator Mike Gravel's initiative, several stations with satellite communication were launched in Alaska (ATS-I satellite, launched on 7.12.1966). Initially the new communication tool was mainly used for distant teaching of doctors and volunteers. In 1971, a health care system started in Alaska under the auspices of the Bureau of Indian Affairs (BIA). During a short period of time, hospitals in seven settlements were opened and from their creation onward they were equipped with shortwave radio-devices. BIA sent special standardized medical kits to the small settlements and the same radio stations for connection with hospitals. Simultaneously a program of telemedicine consultations via “Doctor Call” satellite communication was officially opened. In the summer of 1971, nineteen settlements received satellite communication sets and managed to activate this telemedicine network, which was officially launched with the involvement of Governor Egan and Senator Stevens in September (ibid).

Satellite links were used at scheduled times in the morning, and in emergency cases – out of schedule. Expert centers were created in Tanana and Anchorage hospitals, and also at the University of Alaska. Satellite communication was protected from the ionization interference. This triggered a quadruple increase of “radio-medical-traffic” as compared to the ordinary radio. On average about 250 telemedicine consultations were held
annually (as a rule, 2 consultations per a patient). Approximately 280 meetings took place to address organizational and logistics problems. Distant educational consultations were actively carried out. They resulted in improvement and simplification of decision taking related to transportation, patients’ transfer, decrease in number and period of hospital admissions, etc. (ibid).

On May 30, 1974, the ATS-6 satellite was launched. Thanks to it the health care system in Alaska received more advanced, stable and accessible system of audio and video communication. A special project, the Alaska ATS-6 Washington-Alaska-Montana-Idaho (WAMI) Telemedicine/Education experiment was launched. The goal of the project was to study technical and clinical suitability of broadband satellite technologies to address health care issues. The new equipment was installed at hospitals. Available videoconferencing allowed a better interaction between hospitals and nurse outpatient clinics, in far distant and hard-to-reach settlements. The Alaska telemedicine network functioned under the supervision of Dr Martha R. Wilson (head of the medical centre for indigenous population), Professors Heather E. Hudson, Charles D. Brady. Dr Dennis R. Foote (The Academy of Education Development, Washington, USA), held the technical consultations and assessed the telemedicine usage efficiency of the ATS-1 and ATS-6 satellites for Alaska (Fig. 6.30-6.31) (ibid). All points of the new telemedicine network used interactive videoconferencing. Tele-ECG and stethoscopes were also employed for tele-auscultation (“stethophone”) in Fort Yukon and Galena. Simultaneously the first medical information systems began to be formed (Fig. 6.32-6.34) (Bradly C., 2015).

A specific schedule for clinical telemedicine sessions was set up for every settlement (60 minutes, 3 times a week). During 104 days, 325 teleconsultations were held on paediatrics, internal medicine, orthopaedics, surgery, ophthalmology, gynaecology, dentistry, otorhinolaryngology, radiology, dietology and recovery treatment. There were emergency teleconsultations in cases of acute injuries and coronary syndrome. In addition to videoconferencing, tele-ECG, teleradiology and tele-auscultation were implemented. The average length of video-teleconsultations was about 12-15 minutes, while radio consultations lasted for 3-6 minutes. A specific line of activities was distant learning, interactive telelectures, sometimes supported by video record transmission (Alaska Federal Health Care Access Network Telemedicine Project, 2004; Brady C., 2015; Foote D., 1977; Spain P. et al., 1977; Foote D. et al., 1976).
Fig. 6.30. Martha R. Wilson

Fig. 6.31. Geography and Alaska ATS-6 telemedicine experiment resource base

Fig. 6.32. Telemedicine consultations in 1974 (Anchorage, Alaska)
Technical sustainability, sufficient diagnostic quality of physical examination and X-ray images transmission, standard security level, an important positive clinical effect were determined in terms of efficiency. On basis of the data collected, the model of regional multilevel telemedicine aid system was developed. It is worth noting that black and white as well as colour videoconferences were held via the ATS-6 satellite in 1974-1975 and 1977-1978, respectively. Unfortunately, because of the irregular functioning of the satellite, the experiment was terminated at some point, and the search for alternative means of telecommunication was started.

In 1972-1976, in Alaska, various telephone lines were laid, which also improved communication between hospitals and patients. Round-the-clock duties for emergency consultations through telephone were organized. By 1984, the installation of the telecommunication network was completed and radio communication became a much better alternative. In 1985, slow-scan TV systems were installed at three hospitals, which again helped holding videoconferences for clinical and learning purposes. At the end of the 1980s, faxes and digitizers were in use for distant document management, i.e. to transmit X-ray images through telephone lines. The quality of data transmission was bad and doctors immediately abandoned this application. Later on, modern digital telemedicine tools began to be actively used in Alaska.
In conclusion: just a couple of additional facts about the use of ATS-3 satellite. After the earthquake in Mexico (20.09.1985) radio amateurs (refer to chapter 1.2.4) contributed to the rescue operations within a day. The National Aeronautics and Space Administration (NASA) used telecommunication technology to provide disaster aid. The ATS-3 communications satellite provided critical voice communication support for the international rescue and relief efforts of a few medical organisations. Within 24 hours of the disaster, ATS-3 gave priority to satellite communication traffic involving disaster assessment and emergency rescue operations (Aeronautics and Space Report of the President 1985 Activities, 1985). «ATS-3… was instrumental in relaying communications of relief organizations after the earthquake in Mexico and the volcanic eruption in Columbia… ATS-3 is a useful communications tool in support of relief efforts, such as those that occurred after the earthquake in Mexico City and the volcano eruption in Columbia». ATS-3 also provided emergency communications links (including medical issues) after another Mexican earthquake in 1987 and during St. Helens volcano eruption in 1980 (ibid).

6.3. Mobile Telemedicine

In 1967, NASA started the project “Integrated Medical and Behavioural Laboratory Measurement System (MBLMS)” on creation of systems for medical aid, health care, carrying out biomedical analyses and bioscientific experiments for spacecraft crews and distant settlements on Earth. In 1971-72, for the first time operating telemedicine systems including audio- and video communications, broadcasting of vital functions (cardiovascular and respiratory systems), transmission of data, X-ray images, biochemical and microscopic findings were implemented as a part of the project (Lockheed to develop IMBLMS ground test unit, 1972; Rfp on IMBLMS, 1972). The research on potentials to use such systems in remote and rural areas was carried out. This preliminary resulted in a unique project, named “STARPAHC” (Space Technology Applied to Rural Papago Advanced Health Care). The project was aimed at providing medical assistance to the residents from segregated and remote areas via mobile telemedicine system (Freiburger G. et al., 2007; Fuchs M., 1979; Starpahc Systems Report, 1977 a) b)) (Fig. 6.35-6.36).

The project was implemented in the Indian reservation of the Papago tribe, situated in Southern Arizona. For the first time, mobile medical cabs (cars), equipped with telemedicine systems, apart from standard diagnostic and therapeutic equipment, were developed. The project covered approximately 14 thousand residents of 75 settlements. Every mobile health unit (MHU) gave the possibility for color and black-and-white
videoconferences (television connection format, including micro medication and X-ray patterns demonstration), voice connection, computerized information exchange channel. Satellite communication channels were used alongside with land telephone lines (Fig. 6.37) (ibid).

Fig. 6.35. General view of the mobile telemedicine complex (mobile health unit – MHU) of the STARPAHC project (1970s, USA)

Fig. 6.36. The concept of STARPAHC telemedicine system
Over a period of two years, 3 648 persons sought for medical care in MHU. Telemedicine sessions were held for 439 cases (12%), videoconferences were held only in 3.5% cases. Telemedicine sessions included teleconsulting, tele X-raying, real time patient examination, video microscoping. The most frequent reasons for teleconsultations were traumas (38%), skin diseases (27.9%), metabolic and hemodynamic disorders (21.4%). Most efficient was the usage of telemedicine to treat fractures, injuries, throat diseases, skin ulcers, snake bites, respiratory infections and gastroenteritis as well as for minor surgery. It was established that telemedicine consultations were either urgent or important and useful for patients’ treatment in 86.3-97% cases (for videoconferences – 78.3%). The technical efficiency was characterized as acceptable in 85% cases (Fig. 6.38) (ibid). As a whole, the project resulted in clearly defined high organizational, moral and clinical efficiency of telemedicine system usage for health care in segregated and rural areas.

In 1974, the NASA supervised the first in-depth investigation into diagnostic and technical efficiency of a telemedicine system to define standardized requirements for remote medical diagnosis applications (Davis J., 1974). For the first time, the engineering requirements for telemedicine systems were scientifically substantiated and harmonized.

In 1973-1979, in Alabama, a project on the usage of two minibuses, equipped with telemedicine appliances to provide medical care in 17 sparsely populated districts was implemented. Every minivan team included a highly qualified nurse, a laborant and technician-driver. Facsimile and computerized tele-ECG system were used for data transmission.
In the early 1980s, in USSR/Russia, the *Avtosan-82* mobile computerized laboratory was developed under supervision of Professor Roman M. Bayevskyy. The work was performed by experts from the Institute for Biomedical Problems, Russian Academy of Sciences and Moscow Regional Research Institute (Russia) (Fig. 6.39) (Adamovich B. et al., 1990; Baevskyy R., 1970; 1979; Baevskyy R. et al., 1978, 2008; Grigoriev A., Baevskyy R., 2007; Deryapa N. et a., 1975; Parin V. et al., 1967).

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Fig. 6.38. STARPAHC telemedicine session project, USA, 1970s

Fig. 6.39. *Avtosan-82* mobile system and its main developers: Azaliya P. Berseneva, Roman M. Bayevskyy, Irina I. Funtova, Vadim A. Stepanov
The *Avtosan*-82 was a diagnostic laboratory, mounted on a bus and to a certain degree copying the structure of systems of medical and physiological researches on board of the *Salut*-7 space station. It was equipped with the range of instruments similar to the system for medical monitoring of cosmonauts. Besides it included a computer which was similar to prototype of the on-board medical computers, mounted on the *Mir* space station just 5-8 years before (Fig. 6.40) (ibid). The *Avtosan*-82 mobile laboratory marked an important step forward not only in space equipment and methods usage in the “Earth” medicine. First and foremost a new health assessment methodology, the pre-nosology diagnostics, was developed. It is directed at studying individual stages in-between norm and pathology. This new scientific and practical approach was created to assess cosmonauts’ functional state. This nosological approach, based on the diagnosing of known diseases, appeared to be unsuitable for space medicine. The reason is that cosmonauts were selected among the healthiest candidates and did not represent the most appropriate experimental subject group.

The most prominent features of the pre-nosology approach were cardiovascular system assessment methods as indicators of personal adaptive reactions as well as the examination of vegetative regulatory mechanisms. The above allowed disorders to be registered far ahead of the appearance of clinical symptoms. In fact, this system was a powerful tool for telemedicine screening. *Avtosan*-82 was used in factories and rural areas for a preventive examination of the population, with the usage of both, standard medical methods and the newest space technologies. The results received were transmitted to the analytical centre in Moscow through different communication channels, i.e. radiotelemetry, teletype, telephone. Operational conclusions were given to the subject via the computing unit of the mobile laboratory. This was the first experience of space technologies application in the health care practice (Fig. 6.41) (ibid).
Regular research with the *Avtosan*-82 mobile laboratory and units of the Vita-87 type, that followed, allowed determining that approximately 70% of population was in relatively good health. The introduction of space technologies and the pre-nosology approach allowed to assess the pathology development pattern and to take timely the necessary preventive actions (ibid).

So, satellite communication technologies have been a unique telemedicine communicative tool enabling to quickly pass from ordinary experiments on biological data transoceanic transmission to the fully-featured distant medical care of entire regions. The mobile telemedicine concept formed at that time, proved quickly its efficiency and it is in use till now.

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Afterword

One can emphasize that the present achievements of telemedicine reflects what once was science fiction.

For example, in 1955, the film "Flight to the Moon" by K. Artseulov and L. Zhigariov showed a quite interesting prediction of cosmic biotelemetry systems (Fig. 1).

Doctors from the Earth are monitoring space travellers via special radiochannel. Cosmonauts have small electric devices inside of space suits.

Crew’s health is perfect, but doctor Akopyan makes regular examinations. Doctors from the Earth can give advice, if necessary.

Fig. 1. "Flight to the Moon" USSR, D-372-55, "Diafilm" Factory, 1955

And in 1962, in the Soviet Union, Viktor S. Saparin, science fiction writer and journalist, described in his book "The First Watch" a global telemedicine system and telesurgery (Fig. 2) (Saparin V., 1962).

In the 1920s, in the USA, writer Neil Ardley, in his book "Health and Medicine (World of Tomorrow)" , asserted that in future all patients would "communicate" only with a computer, transmitting their complaints to the expert systems and undergoing self-examination. The physicians would examine patients only in extreme cases and surgery would be "put on the shoulders" of robots (Fig. 3) (Ardley N., 1982).
However, the most significant and well-known prediction regarding telemedicine was a series of publications by the writer and editor Hugo Gernsback, who is considered as the father of science fiction. In the 1920s in the United States, he described multiple devices and technologies in his novels and short stories, including those that we now call telemedicine tools - videoconferencing, telesurgery, telemetry, electronic prescriptions, etc. (Fig. 4) (Fips. Radio Doctor – Maybe, 1924; How telemedicine has already surpassed our earliest predictions, 2013).

Fig. 2. Telesurgery predicted by Viktor Saparin in 1962 (illustration author I. Ushakov)

Fig. 3. Computing diagnosis of the future and telesurgery according to Neil Ardley
Fig. 4. Hugo Gernsback / Gernsbacher

Fig. 5. Gernsback’s systems for remote handling and telesurgery, illustrations from the journal "Science and Invention", 1920s

Fig. 6. Illustration of Gernsback’s prediction of biotelemetry and telediagnosis, "Science and Invention", 1920s
In particular, the possibilities of modern telesurgery were also predicted by Hugo Gernsback. He described an instrument called «teledactyl» (from Greek "tele" meaning “at a distance” and "dactyl" - finger), which allowed the physician to remotely carry out inspection and palpation of the patient, and perform medical manipulations (Fig. 5-7) (ibid).

An illustration to the article "Radio Doctor - Maybe", published on the cover of "Radio News" in April, 1924 became quite famous. It showed an amazing telemedicine system, which was a brilliant prediction of medical videoconferencing, remote diagnosis and e-prescribing.

It must be mentioned that Fips, the author of the article "Radio Doctor – Maybe", was a "Head office boy" (Fig. 8) (How telemedicine has already surpassed our earliest predictions, 2013). This article is a kind of semi-fiction work dedicated to the invention of the system, though its value is questionable. But the "Radio Doctor" image itself on the cover of the magazine became a historic symbol of telemedicine.
Fig. 8. Cover of Radio News magazine (1924) with the image of the "Radio Doctor" system, which became a historic symbol of telemedicine (left) and scheme of telemedicine system from the original article (right). (The magazine is part of Dr. A. Vladzymyrs'ky's personal collection)

References

Abseitova Saule R. Candidate of Medical Sciences, Assistant Professor, founder and chief doctor of Shymkent Regional Cardiac Centre, Kazakhstan. In 1985 consultative trans-telephonic tele-ECG RDC was established upon her initiative on the basis of Shymkent EHS Hospital.

Adey William Ross (31.01.1922, Australia – 20.05.2004, USA); an outstanding neurophysiologist, Professor of Physiology and anatomy, designed the first electroencephalograph in Australia, used general-purpose computers for automated EEG analysis. He was the author of more than 300 research works in the field of brain electrical activity.

Akhutin Vladimir M. (26.03.1924-09.11.2005; Russia), engineer-captain 1 rank, Candidate and Doctor of Engineering (1971), Professor (1972), the chief and primary constructor of State Scientific Institution "The Scientific and Research Technological Institute of Bioengineering Systems" in St. Petersburg. Award "Honored Science Worker of Russia" (1995). In June 1941 after the graduation from Leningrad Naval Special School he entered F. E. Dzerzhinskiy Higher Naval Engineering College. In October of the same year joint the battlefield and was injured several times. In 1942-1946 he continued his studies. From 1948 to May 1968 was engaged in scientific research, constructive and military activity in the field of designing the new equipment for the Navy. In 1964 organized and headed the first research laboratory of biomedical cybernetics in the country, which since 1968 was transformed into a Specialist design department of biological and medical cybernetics and even later became "The Scientific and Research Technological Institute of Bioengineering Systems". Akhutin was Director of this Institute till the end of his life. V. Akhutin is the founder of a new scientific field - the theory of bioengineering systems, in which biological elements and systems of different complicacy can integrate in appropriate way with technical facilities. Akhutin’s team developed the mathematical techniques of current diagnostics and living organism forecasting on the basis of automatic data processing from bio subjects in real time. Based on the above research, unique systems of automated control and management of a human health under extreme conditions (i.e. prolonged deep diving, long duration space stays, etc.) were developed. Under the supervision of Akhutin and with his direct participation the space flight support systems were performed. He is an author of 12 monographs and manuals, 157 articles, 48 inventions; under his guidance more than 30 governmental research, design and engineering developments were carried out. Akhutin was awarded 21 state grades, including the Academician S. P. Korolyov medal and Yu. A. Gagarin commemorative medal, laureate of the Lenin Prize (1959) and state prize of Russia (1991).

Akulinichev Ivan T. (02.07.1915-02.01.2000; Russia), Candidate of Medical Sciences and Doctor of Medical Sciences, Professor, Associate Member of International Astronautic Academy, the inventor of vector-cardioscope, one of the founders of medical radio-electronics, the main developer of telemetric medical
control systems of (MCS) for space flights. He maintained personally Yury A. Gagarin's MCS functioning. Akulinichev received technical education, in 1941 graduated from Omsk Medical Institute and volunteered to the war; served as a head of a hospital train, ended the war in Berlin, held the rank of Colonel of Medical Service. In the 1960-1970s he took part in the development of the methods and devices, which were used at cosmonauts training and maintained the control over their health conditions during the flight, medical supply of space flights on the Vostok spaceship. He was an employee of the Institute of Biomedical Problems, a famous public person, schematic-based analyzer and author of numerous scientific works, 20 inventions; honored with awards and medals such as Distinguished Service Medal (Order of the Red Star), for labor and scientific achievements (Order of the Red Banner of Labor); a holder of golden medal of Christopher Columbus, etc.

Akulova Maria V. Honoured Doctor of the RSFSR, Chief Physician of Orenburg Region, one of the RDC founders and active workers in the Regional Clinical Hospital in 1979.

Almazov Vladimir A. (27.05.1931-04.01.2001; Russia) went to a primary village school, then to the secondary school 1 of Toropetsk. In 1948 entered the first Leningrad Medical Institute n.a. Academician I. P. Pavlov. Doctor of Medical Sciences, Professor, Academician of Russian Academy of Medical Sciences (1995), during 47 years of his work at the St. Petersburg State Medical Almazov contributed greatly to the training of high quality medical doctors. The clinic of the Faculty Therapy department, which he headed from 1971 to 1997, developed as a multifunctional medical establishment. Almazov laid the basis of the cardiology scientific school, which served as a foundation for the Scientific Research Institute of Cardiology of the Ministry of Health of the Russian Federation in 1980. A remote diagnostic centre was arranged at the Institute, where specialists analysed ECG transmitted over telephone communication lines. In the late 1980s, the procedure of using remote diagnostic centre for mass screening in groups was developed and implemented under the supervision of Professor V. Almazov. He is the author of 300 scientific works, including 25 monographs and internal diseases training manuals. 60 candidate and 25 doctor theses were defended under his supervision. In 1998 V. A. Almazov was appointed to the grade of Honoured Science Worker of the Russian Federation. In 1996 the International biographic centre (Cambridge) awarded him a medal and certificate "For outstanding achievements in medicine of the XX century".

Amlinger Phillip R. (10.08.1911-21.11.2002; USA), a physician, an employee of the University of Missouri Medical Center, the author of a number of conceptual and practical articles on telecardiology, one of the founders of the tele-ECG network in Missouri.

Andrus Scott W. (10.08.1938-19.05.2013; USA) graduated from college, and then from the New York University, received a doctorate in physics. In the 1970s he was a consultant to the Massachusetts General Hospital on telecommunications. He is the author of a series of pioneering works in the field of teleradiology. Andrus
studied the issues of optics, image transmission, and developed a number of medical devices. He was the author of the book on religion and science “Being, Meaning, and Breath”, and also a spiritual and religious leader.

Ascalonov Arthur A. ((born on 04.11.1940), Doctor of Medical Sciences, Professor, in 1981-1990 - Head of the Department of Health of the Altai Territorial Executive Committee (Barnaul), the territorial tele-ECG network was organized under his supervision.

Avdeeva Galina P. (born on 1.10.1941, Honored Doctor of the Russian Federation, Chief Doctor of the State Cardiological Dispensary, Cheboksary; consultative tele-ECG RDC was established in the dispensary under her supervision.

Barashnev Yuri I. (born on 21.09.1929), Doctor of Medical Sciences, Professor, Honoured Worker of Science of the Russian Federation; after graduation from the department of pediatrics he studied at clinical residency; then worked at the Institute of Pediatrics of the AMS of the USSR*. In 1970 he headed the country's first Department of Clinical Genetics, later was a Deputy Director for Science of Moscow SRI of Pediatrics and Pediatric Surgery. Barashnev was dissertation advisor of 40 doctoral and candidate theses, author of more than 300 scientific publications and 9 monographs.

Barr Norman Lee (31.08.1908-26.04.1979; USA), Captain, Head of the Aero Medical Space Research Laboratory of the US Navy. In 1929 he graduated from flight school, served 2 years in the Air Force, and then worked as a civilian pilot. In 1933-1937 he was trained at the Georgetown University School of Medicine, and then - at the naval postgraduate medical school, where he received the qualification of a flight surgeon (1939). In 1942 he graduated from the naval aviation school. N. Barr was a veteran of World War II. Since 1950 he headed the Aero Medical Space Research Laboratory of the US Navy, where a number of important scientific and practical projects were implemented during 9 subsequent years. Captain Barr was one of the founders of biotelemetry in the United States. Under his leadership, a biotelemetry system for space flight was designed, built and proved in practice. The system was successfully tested during the stratospheric flights. In 1960 Navy awarded him a Certificate of Exceptional Service in recognition of his extraordinary achievements, as well as for his numerous other significant contributions to aviation medicine.

Bartůněk Petr (born on 23.8.1939; Czech Republic), Candidate (1989) and Doctor of Medical Sciences, Associate Professor. He graduated from the Faculty of Medicine of Charles University (Prague, Czechoslovakia/Czech Republic) in 1969, undertook a postgraduate residency in internal medicine and cardiology. His professional activity was related with the 4th Clinic of Internal Medicine of the Medical Faculty of Charles University. He was a doctor, a senior registrar, head of the departments of cardiology, internal medicine, intensive care unit. Also he repeatedly served as deputy dean and dean of the Faculty of Medicine. In the 1980s together with colleagues from the Czech Technical University developed and implemented TELSAR, a system of trans-telephonic ECG diagnostics. He was the
founder and editor of a number of scientific journals in the field of public health; public figure. He is author of 90 scientific publications, 4 monographs and 5 textbooks, a writer of science fiction on medical subjects as well.

Bayevskyy Roman M. (born in 03.08.1928; Russia/USSR), Candidate and Doctor of Medicine Sciences, Professor, Honored Science Worker of Russia, Academician of International Academy of Astronautics, Academician of International Informatics Academy; one of the founders of aerospace cardiology and creator of systems of automated prenosological diagnostics. In 1953 he graduated from military medical faculty at the Saratov Medical Institute and was posted to serve in the Far East and Sakhalin. During that time a portable ballistocardiograph was invented. In 1959 Roman M. Bayevskyy received an appointment to the Institute of Space Medicine. Since March 1964 he has worked at the Institute of Biomedical Problems. Roman M. Bayevskyy personally carried out the development of the medical control system, performed the selection of the diagnostic techniques and the construction of airborne hardware of Yu. A. Gagarin's space flight. Due to his inventions number of cardiological methods were applied in the space for the first time ever, in particular ballistocardiography and seismocardiography, to study myocardial contractile function, Holter recording for the assessment of ECG changes during a day, etc. He contributed significantly to the fulfilment of the first research of spacemen's coordinating motions via hand-operated dynamography. At the beginning of the 1960s the first centre for medical telemetric information reception was arranged by R. M. Bayevskyy. Over the last years under his guidance the study of autonomic regulation of heart and respiratory system of the crew members of the International Space Station was carried out. He implemented the achievements of space medicine to the Health care system. As early as in the 1960s he offered the technique of heart rate variability analysis to study autonomic regulation of blood circulation under the condition of a space flight. In the subsequent years this method was used widely in different fields of clinical practice and applied physiology. Using the experience of cosmonaut research, he worked out the absolutely new approach to the health level assessment, which got the name "prenosological diagnostics". Bayevskyy is a member of editorial boards of research-to-practice journals; the dissertation advisor of 30 Candidate and 5 Doctor theses; the author of 20 monographs and manuals, 400 scientific works, 12 certificates of authorship; was awarded medals and 12 Distinguished Service Medals (Order of the Red Star), for labour and scientific achievements (the Badge of Honour Order, Yu.A. Gagarin commemorative medal), etc.

Belknap James Walter (11.05.1858-06.04.1927, USA) began to practice in New York in 1886 in the Medical College of Columbia University and the New York Academy of Medicine. He was an attending physician in Presbyterian Hospitals; in Columbia University Medical School; in 1892 he passed from Clinical Lecturer to Professor of Clinical Medicine; he was an active member and leader of national and regional medical and health societies and committees.

Bennett Donald (1929-29.01.1996, USA); graduated from Military Institute and Medical faculty, in 1961-1965 served in the army. For 9 years headed the EEG-lab
Benschoter Reba Ann (1930), Doctor of Medical Science (1978), Professor, worked in the University Medical Centre in Omaha, Nebraska for 40 years; held the position of the Director for Biomedical Communications.

Beskrovnyy Ivan M. (born in 1930, Russia), Doctor of Engineering, Professor, since 1957 worked in the institutes for Nuclear Research and Physics, since 1973 he was a Director of computer centre of Directorate General for Health Services in Moscow, worked on the methodological basis development for creation of automated control systems (ACS) for metropolis health care. In the period 1977-1970 he was a Deputy Director of ACS Scientific Research Institute, later worked in the ACS Scientific Research Centre of the Ministry of Radio Industry. Since 1985 he was Professor of Medical Cybernetics in the Department of Russian National Research Medical University (RNRMU) named after N. I. Pirogov; author of 220 articles and 6 books.

Bird Kenneth Timothy (1918-13.02.1991; USA) graduated from Harvard University and Medical School. He passed the Korean War as a captain, and then more than 40 years worked at the Massachusetts General Hospital, at the beginning as a consultant, doctor-pulmonologist, Project Coordinator, then - as Director for Telecommunications. He was also a teacher and an associate clinical professor at Harvard University, headed the medical service of Logan Airport. Bird initiated the creation of the Boston - Logan - Bedford telemedicine network in 1968-1970. He is the founder of the methodology for the videoconferencing use in medicine, author and co-author of the first scientific evidence-based research on the effectiveness of telemedicine. Bird also developed other information technologies, for example - colour photography of disease symptoms and signs for medical records as an alternative to hand-written history.

Borovkov Nikolay N. ((born on 26.01.1940, Russia) Doctor of Medical Sciences, Professor, Honored Doctor of the Russian Federation, held the Chair of Hospital Therapy of Nizhny Novgorod State Medical Academy, Chief Physician of Volga Federal District; rose through the ranks from an attending doctor to the head of the Therapeutic Clinic of Nizhny Novgorod Regional Hospital named after N.A. Semashko. In the 1980s actively studied the problems of automated remote cardiac diagnostics, formulated the principles of organization and operation tele-ECG centres at the outpatient level of health care; author of over 600 scientific publications, 3 monographs, 33 manuals, 6 patents; dissertation advisor of 6 doctoral and 33 candidate theses; holder of medals and commemorative tokens).

Bosscha Johannes (18.11.1831-15.04.1911;The Netherlands), Doctor of Sciences (1854) Professor, Academician (1863), physicist; graduated from the Latin School in Amsterdam, was enrolled at the University of Leiden, in 1854 received his doctorate for research in the field of the galvanometry. After internship in Germany,
he returned to work at the Department of Physics at Leiden. In 1860 he headed the Department of Natural Sciences at the Military Academy of Breda and 3 years later became a full member of the Royal Academy of Sciences. He dedicated lots of efforts to the development of higher education system. In 1873 he was appointed the head of the department of physics at the Delft Polytechnic Institute, and from 1878 to 1885 was the Director of this Institute. In 1905 he invented the tele-ECG method (together with Wilhelm Einthoven). In his later years he held the post of secretary of the Dutch Society of Sciences, and contributed a lot to the development of international scientific relations. He is the author of many scientific papers on acoustics, galvanic polarization, electrolytic reduction, thermodynamics as well as of a three-volume textbook on physics (1875).

Brisker Arthur (15.07.1902-01.07.1976; USA), a physician, almost all his life worked in New York, an inventor of a number of auscultation devices. He is known as a talented musician, who had adapted some of I.S. Bach's musical pieces for piano.

Caceres Cesar Augusto (USA), MD., one of the founders of computer telecardiology, executive director of the Institute of Technology in Health. In 1953, Dr. Caceres obtained his pre-medical and medical degrees from Georgetown University, for 3 years worked in internal medicine, specializing in cardiology. He was engaged for the Public Health Services, where he developed the U.S. first functional computer-electrocardiographic interpretive system. Later Caceres joined George Washington University where he was Professor of Clinical Engineering. As a clinical professor he taught at the Georgetown University. He was one of the first doctors who dealt with AIDS patients in 1982. He coined the term "clinical engineering" in 1969. Caceres published over 100 scientific articles, textbooks and inventions and patented an electronic stethoscope. He won numerous awards and prizes, including two "Superior Service Awards".

Carnazzo William Anthony (23.05.1915-19.06.2003), worked as a practitioner from 1938 to 1990. He was a Director of training of paramedics in Trauma Center, Omaha, since 1975. Dr Carnazzo was a prominent physician, social activist and educator.

Chavpetsov Viktor F. ((07.07.1947-16.11.2011), Doctor of Medical Sciences, Professor, Honorary Figure of Russian Higher Education, headed the medical business administration research department of St. Petersburg Research Institute of Cardiology Since the beginning of the 1980s. He actively participated in the creation, operation and analysis of the effectiveness of tele-ECG RDC, was the founder of the original scientific school, the developer of the automated technology of healthcare quality expertise; author of more than 150 scientific publications, including 4 monographs, dissertation advisor of 6 doctoral and 33 candidate theses.

Chireykin Lev V. (1931-2002; USSR-Russia), Doctor of Medical Science, Senior Researcher, Head of Laboratory / Department of heart rhythm disorders of the Leningrad Institute of Cardiology, scientific consultant of the Northwest Centre of diagnosis and treatment of arrhythmias (St. Petersburg). He was the founder of
scientific telecardiology, organized and studied the work of network television ECG in the Leningrad Region, developed a methodology for telemedicine consultation in cardiology in the 1970-1980s.

Chumakov Aleksandr A. (born on 04.05.1941, Kazakhstan / USSR), Candidate (1972) and Doctor (1989) of Medical Sciences, Professor, Honored Doctor of the Russian Federation. In 1958, after graduating from high school, he entered the medical faculty of the Orenburg State Medical Institute. After graduation in 1964, he worked as a surgeon in public health practice. In 1968 was enrolled in graduate school at the department of general surgery of the Yaroslavl Medical Institute, which he successfully finished in 1971 and defended his thesis on "Diagnosis of acute peritonitis with the help of a computer" (1972). From 1971 to 1973 Alexander Chumakov worked as the head of the department of remote diagnostics at emergency hospital in Yaroslavl. Later he joined the Yaroslavl State Medical Academy, being promoted from a teaching assistant to Professor and the head of the Department of surgery (since 1991). He is the author of over 300 scientific papers, under his guidance 3 doctoral and 18 master's theses were defended. For long-term and conscientious work he was awarded with honorable mention at the Academy, of Yaroslavl Region "For Merits in Science".

Conrath David W. - Professor, holds a doctorate in business administration; for 25 years working at the Faculty of Engineering at the University of Waterloo. He also had permanent positions at the faculties of engineering and business at other universities of Canada; was the Dean of the College of Business at San Jose State University (USA); a businessman and public figure.

Cooley Austin G. (1900 - 07.09.1993, USA); a telecommunications expert who helped developing the fax machine. He held more than 75 patents on methods and equipment for the transmission of weather maps, medical X-rays and facsimile text and pictures.

Corbin Charles - professor, headed the department in Kansas City University, then for over 20 years worked in Arizona University, a creator of the Physical Education conception, globally appreciated; the author of more than 200 publications, 70 books, numerous video films, devoted to fitness, received numerous awards.

Cywinski Jozef (born on 13.03.1936), a Pole by ethnicity, emigrated to the USA in 1967, waiting for emigration documents, was in France for 6 months, where he took part in the transatlantic ECG tele-session performance. Later on he participated in the development of numerous biomedical tools, pacemakers, various electrical stimulators of body tissues, etc.; lived in the USA, Switzerland, then in France; IEEE member and the author of more than 100 articles, 2 books and 12 patents.

DeBakey Michael Ellis (07.09.1908-11.07.2008), modern cardiosurgery founder, a physician, scientist and lecturer, developed coronary artery bypass methodologies, prosthetics of valves and artificial heart implanting. He received the doctor’s diploma in 1932, undertook an internship in Europe, had military and medical service. From 1948 till 1993 worked at Baylor Medical College, rose
through the ranks from the Surgery Department Head to the President and Chancellor of the college. DeBakey was the author of numerous scientific articles and inventions, honoured with the national and international awards.

**Dimond Edmunds Grey** (8.12.1918-3.11.2013; USA), MD., Professor, founder of the the University of Kansas School of Medicine. After leaving school in 1937, he started working at the factory and at the same time entered the college in Indiana. Being a very good football player, he received an offer of admission to Purdue University and in 1941 he was transferred to the University of Indiana. In 1944 E.G. Dimond received his medical degree, served in the army (troops of the U.S. Army in Japan), where he headed the cardiology service. During 10 years he headed the Department of Cardiology of the Kansas University Medical Centre. In 1950, he headed the cardiology laboratory of the Medical Centre of the Kansas University, where under his leadership; the original tele-ECG system was developed and successfully put into serial production. Nine years later Dr. Dimond founded and headed the Institute for Cardiopulmonary Diseases at the Scripps Clinic (California) and was a special consultant on medical education to the Department of Health, Education and Welfare, Washington, DC. In 1961-1962 Dr. Dimond was elected a President of the American College of Cardiology. He conducted great public work in the establishment of friendly relations between the US and China and was an outstanding educator in the public health care system. Dr. Dimond was the author of over 1000 scientific articles, essays and audio recordings, including 18 books.

**Dovgalevskyy Pavel Ya.** (born on 26.11.1947; USSR), director of the Saratov Research and Development Institute of Cardiology of the Ministry of Health and Social Development of the Russian Federation, Professor, Candidate (1983) and Doctor (1997) of Medical Sciences, Vice-president of Society of cardiology of the Russian Federation, honored cardiologist of Russia (2005). After the graduation from the Saratov State Medical Institute in 1971 he embarked upon a career at the emergency hospital, then - at the Saratov Municipal Hospital (in 1978 he headed the cardiological department). In 1981 Dovgalevskyy started a simultaneous work at the Saratov State Medical Institute Clinic. In 1994 he headed Saratov Scientific Research Institute of Cardiology. A lot of techniques of telemedicine information technologies for prevention and treatment of cardiovascular diseases were developed by Dovgalevskyy. He was one of the initiators of the arrangement of remote telemedicine cardiological centres in Russia, established the transmitions of ECG. He promoted the application of ECG auto transmission method (domestic monitoring) in order to monitor patients, who suffered from acute myocardial infarction. P. Ya. Dovgolevskyy developed the methods of myocardial infarction forecasting and heart rate variability during exercise testing. Dovgolevskyy is an editorial board member of many research and practice journals. He is the author of more than 300 scientific works and 12 invention patents. Under supervision of Prof. Dovgolevskyy 21 candidate and 7 doctor theses were defended.

**Dreyfuss Jack R.** (1923-25.01.1985) – Professor of Radiology in Harvard Medical School; employee of Massachusetts General Hospital; graduated from Harvard School and the Taft University School of Medical; worked at Massachusetts
General Hospital for 25 years; author of over 50 scientific papers (including those on the history of radiology) and a traditional educational book on radiology, community leader.

**Dunn Earl V.** - Professor, received his medical degree in 1960, completed his residency training on family medicine in the USA, then he practiced medicine in rural area in Canada. For over 30 years he has been employed at the University of Toronto, Canada.

**Einthoven Wilhelm** (21.05.1860-29.09.1927; The Netherlands), Doctor of Medicine (1885), Professor, psychologist, founder of electrocardiography, Nobel Prize Winner in Physiology and Medicine (1924). He received his medical education at the University of Utrecht; then worked in the Eye Care Clinic, where he actively conducted research on the physiology of vision organ and locomotor system. In 1886, at the age of 25, he was appointed a Professor at the Leiden University, which he held for all his life. In 1889, Einthoven began to work in the field of electrocardiography. By 1901 he had designed a string galvanometer, introduced "P-Q-R-S-T-U" nomenclature, described the three standard leads, was the first to prove that the ECGs of various forms of heart disease have characteristic differences; and in 1905 he invented the tele-ECG method (together with Johannes Bosscha). For a number of years Einthoven actively improved his electrocardiograph, tried to establish its sales, and at the same time conducted electro-physiological studies. In 1924 he was awarded the Nobel Prize "for his discovery of the art of the electrocardiogram." He was the author of 127 scientific papers; his research was referred to the ten greatest discoveries in the field of cardiology of the 20th century.

**Elsom Kendall A.** (1904-1978; US), MD, one of the initiators of the medical equipment for colour medicine television, "TV coordinator" of the University of Pennsylvania, the organizer of many medical video conferences; received his medical degree in 1927 in Pennsylvania, joined the Army, where he served in the rank of major, and then as a Medical Colonel until 1945; he headed a number of departments in the Medical Centre of the University of Pennsylvania. In 1961 was appointed medical director of Scott Paper Company. He is author of scientific papers in the field of endocrinology, gastroenterology, nephrology, infectious diseases, public health.

**Emeshin Konstantin N.** (Barnaul, Russia) one of the RDC founders in the Territorial Clinical Hospital in 1982.

**Farooq Jaffer** (14.09.1942; India-31.07.1991, USA) – graduated from the Medical University in Pune, India in 1966; from 1969 to 1977 was an employee of the Radiology Department of Massachusetts General Hospital where he got promoted from the resident to the doctor and the teacher; later worked in Arizona at different medical establishments.

**Fialko Vladimir A.** (born on 17.07.1931; USSR), Candidate of Medical Sciences, Doctor of the highest category. In 1956 he graduated from the Sverdlovsk State Medical Institute (therapeutic and preventive faculty), and then started working for the city ambulance station. In 1962-1969 he became the first head of the
specialized "thromboembolic" substation of the emergency hospital; the chief cardiologist of the city health service department in 1969-1971. He was twice a deputy chief physician at the medical wing (in 1957-1960 and 1978-1988). Since 1971 he worked part-time at the therapeutic departments and later as a doctor methodologist at Emergency hospital, a teacher and one of the organizers of the course "ambulance" in the Ural State Medical Academy of Ekaterinburg. He is one of the initiators and active participants in the organization of specialized Ambulance service in Ekaterinburg (1959-1967) and Tomsk (1972-1978). He created the system of examination of medical errors as part of the Voluntary Group of Experts. In 1978 he organized a remote diagnostic centre and a network of tele-ECG (with V. L. Gabinski). He is the author of more than 190 publications, including 5 monographs, 40 manuals, 1 glossary of Ambulance service and was awarded the badge "Excellent Health" and the Ekaterinburg professional recognition award "Medical Olympus".

**Flynn John** (25.10.1880-05.05.1951; Australia), Presbyterian minister, founder of Royal Flying Doctor service, one of the telemedicine pioneers. He received religious education at the University of Melbourne in 1907-1910, and was ordained in 1911. He worked in remote and isolated parishes, paying much attention to health care and the creation of rural hospitals. In 1917 he held correspondence with an Australian pilot Clifford Peel, who served in Europe and described the evacuation of the wounded with the help of aircraft in his letters; in the same year Rev. Flynn witnessed history of Jimmy Darcy. Both events, apparently prompted J. Flynn the idea to create an air ambulance service equipped with telecommunication means for medical servicing of isolated and remote settlements. After a long period of searching for funding and support the service was established in 1928 in Cloncurry (Queensland, Australia). It acquired national status in 1934, thanks to intensive work and lobbying J. Flynn. The following years he worked extensively on the development of the network of air ambulance, rapidly moved up the ecclesiastical ladder. He was an award-winner of the British Empire.

**Franke Marian** (21.03.1877-12.09.1944; Poland-Ukraine), Associate Professor (1908), Professor (1916), Academician of the Academy of Medical Sciences of Poland, a cardiologist and physiologist, founder of the first clinical tele-ECG system. He received his medical degree from the University of Vienna in 1900, after which he worked at the Department of Internal Medicine of the Medical Faculty of the University of Lvov, specialized in Germany and France. In 1914-1921 as a military doctor he served in the Austrian and Polish armies and took part in the military operations in Lvov. From 1921 to 1939 (according to other sources, from 1916 to 1942) he headed the Department of General and Experimental Pathology of the Medical Faculty of the University of Lvov; twice he was also the dean of the Faculty (1928-1929, 1936-1937). In the period 1935-1937 Franke Marian implemented and used the first clinical tele-ECG system (with W. Lipinskiy). He was the author of several scientific papers and textbooks; public figure, the head of professional communities. During the Nazi occupation of Prof. M. Franke was removed from the management of the department, in 1942 he was arrested by the Gestapo; after his release from detention he was for a time restored the rank of professor, and then forcibly sent into retirement.
Gabinskyy Vladimir L. (24.12.1943; USSR), Candidate (1970) and Doctor (1992) of Medical Sciences, Professor, Academician. He graduated from Sverdlovsk Medical Institute, department of general medicine, after that was enlisted to the research work, became one of the first hospital physicians of the new Heart Attack Department. Then he headed the laboratory of functional diagnostics at the Sverdlovsk Medical Institute. After 1975 he headed the Cardiac Centre. In 1978 Vladimir L. Gabinskyy arranged a remote diagnostic centre and tele-ECG network (together with V. A. Fialko). He took part in the development of medical devices and techniques, which were used during the flight of a pilot astronaut Oleg Atkov (was awarded the S. P. Korolyov medal). Since 1980 he worked in Krasnodar as a head of a cardiac centre and at the same time - as a chief of the laboratory of new methods of diagnostics and treatment of Scientific Development and Production Association "Kvant". Since 1994 he has worked in the USA, where he created and headed Russian and American University, Russian medical centre - the Institute of Medicine and Rehabilitation in Atlanta. Vladimir L. Gabinskyy is the author of 4 monographs, and more than 200 published scientific works. He was awarded honourable badges, prizes, medals for excellence in health protection, medals of the International Academy of Education, Big Star of Peace, with international medal "Knight's White Cross".

Gabunskyy Vladimir L. (Sverdlovsk/Ekaterinburg, Russia), RDC founder at the Regional Cardiac Centre in 1978.

Gardner Reed M. (USA); got the degree of electronic engineer (1960) and the Doctor's degree on biophysics and bioengineering (1968) at the Utah University; worked in hospitals, university clinics and private companies, addressed the issues of health informatics, medical information and expert systems. He was one of the developers of "HELP", hospital data analyzing and decisions support system. Between 1996 and 2005 headed the department of health informatics of Utah University. He is the author of more than 350 scientific works, an award-holder, a public person, a member of the editorial boards of various scientific journals.

Gasparyan Suren Ash. (10.02.1932 – 4.11.2005; Russia), Candidate (1963) and Doctor (1967) of Medical Science, Professor, Honored Science Worker of the Russian Federation, the founder of the first in the world department of medical and biological cybernetics in medical university and in a range of establishments of the field of medical cybernetics; got a degree of a medical doctor in 1957, worked as a head doctor and surgeon. Since 1960 he worked at N. I. Pirogov 2nd Moscow State Medical University. Starting as a post-graduate student he reached the position of a Professor, then a head of department and a vice-rector for education. Since 1974 he was the chairman of the Medical Cybernetics and Computing Technology Board at Academic Medical Council of the Ministry of Health of the Union of Soviet Socialist Republics. In 1977-1985 he was the director of Republic-wide Computer Information Centre; since 1994 - the president of the Health informatics department of the International Informatics Academy; the organizer of 19 Russian and 9 international conferences and forums. Under his scientific editorship 34 collections of research papers were published. He hismeslf was the author of 300 works;
dissertation advisor of 7 doctoral and 36 candidate theses; was awarded medals and orders.

**Gavrikov Konstantin V.** (23.08.1928-21.10.2010; Russia), Candidate (1960) and Doctor of Medical Sciences, Professor. In 1953 he graduated with distinction from the Stalingrad Medical Institute and started to work at the department of morbid physiology at first as a paramedic and then as a teaching assistant. From 1958 to 1968 he worked as an Associate Professor at the department of anatomy and physiology. After that during 28 years he headed the department of Human Physiology. During three years (200-2004) Gavrikov headed the department of anatomy and biomechanics at the Volgograd State Academy of Physical Education. The range of scientific interests of Konstantin V. Gavrikov was rather wide. In the 1960s he developed and realized on practice the original technique of porto-caval shunt with movable ligatures. His master's thesis was devoted to the influence of analeptic and sleeping medicine on immune responsiveness to intestinal and typhic bacteria. Next years of his life were devoted to the study of Advanced Mathematics and to gaining the design engineering skills in original radio aids for medical application. The result was a unique concept and the whole range of biotelemetry radio aids (facilities enabling to enter diagnostic data directly to ECM, programs for computer analysis of medical information, biotelemetry). For many years Gavrikov was engaged in design of special electronic medical and physiological devices. Per totality he was appointed a grade "Master of sport of the USSR on special radio design" in 1972. The practical result of this research was the creation of "Kovyl", medical multichannel digital telemetry system, which united almost all district hospitals of Volgograd Region into one Regional Diagnostic Centre. The system was honored with numerous state awards. In the 1980s Gavrikov supervised the creation of the project of International Congress arrangement "Ecology, life, health" in the Russian Federation, and in the 1990s he worked over the project "Health passport of a human", developed the theory of organization of the united health care and educational informational space as a condition for optimization of population health quality. He was the author of a big range of scientific methodological works, more than 400 scientific works, 3 of them being monographs. Under the guidance of Gavrikov more than 40 candidate and 8 doctor theses were defended. For more than 20 years Professor Gavrikov was a member of the board of the P. K. Anokhin Scientific Research Institute of Human physiology, a member of the central academic committee on Human physiology at the USSR Ministry of Health, a member of the All-Union task group "Mechanisms of the systematic organization of physiological functions". For more than 10 years he also worked as a free-lancer expert of Higher Attestation Commission. In 1994 he was elected an Academician of the International Academy of Sciences.

**Gazenko Oleg G.** (12.12.1918-17.11.2007; Russia), an Academician of Russian Academy of Sciences, Lieutenant General, one of the founders of space biology and medicine. In 1941 he graduated with distinction from the military faculty of the 2nd Moscow Medical Institute and as an army doctor of the 3d rank (a captain of medical service) was sent to the front-line together with other graduates. He served as a chief of tactical hospital during the whole war. In 1946-1947 he had a special
training in Military Medical Academy (Leningrad), and then he was appointed to the Institute of Aeromedicine, where he started working as a researcher, later as a head of the laboratory and a department supervisor, and finally as a deputy director for science. In 1948-1950 he took part in the high-latitude air expeditions of Air Force "Severnyi Polyus-2, 3, 4", repeatedly worked at the drifting stations, islands and the Arctic Ocean coast, and also in Kara Kum and other places hard for aviator service. In 1951-1952 he was committed in the North Korea. Since 1955 O. G. Gazenko concentrated on the research in the field of space biology and medicine, becoming one of the ideologists, supervisors and active doers of the research programs on artificial biological satellites of the Earth. The results of biological and physiological research on the living organisms under the space flight conditions and earth-based laboratory experiments with imitation of the space flight factors allowed justifying the possibilities of manned space-flights, and when the preparation of Yu. A. Gagarin to the flight started, O. G. Gazenko was directly involved in it. In 1969-1988 he was the director of the Institute of Biomedical Problems. Since 1978 he worked on the substantiation and implementation of the comprehensive physiological, hygienic and psychological measures, which supported long-lasting space flights. Upon the initiative and under the supervision of Gazenko the range of international biological investigations were carried out on the dedicated Kosmos biosatellites. The scientists from Bulgaria, Germany, Czech Republic, Poland, USA, France and other countries participated in these research works. In the 1980s O. G. Gazenko supervised telemedicine project "Space Bridge to Armenia" on behalf of the USSR. In 1988 he retired as Lieutenant General of Medical Service. He was the author of numerous scientific works, books "Animals in the space", "Life and Space", "Space Cardiology", "Humanity and the Space" and others; the organizer and editor in chief of multivolume serial edition "The Problems of Space Biology"; the initiator and coeditor of two revisions of the Russian-American work on space biology and medicine "Foundations of Space Biology and Medicine"; editor of the journal "Success of Physiological Sciences", an editorial board member of a range of journals. In 1987 he was elected the president of All-Union (now Russian) physiological society n.a. I. P. Pavlov. For many years he was also a board member of the International Fund n.a. G. Galileo (USA, since 1982), was one of the supervisors of the committee "Bioastronautics" of the International Astronautical Federation. Gazenko was an awardee of USSR State Prize, awarded decorations and medals for war, labour and scientific achievements.

Gerasimenko Nikolai F. (born in 1950), Doctor of Medical Sciences, Professor, RAMS Academician, Honored Doctor of Russia, received his medical degree in 1973, worked as a surgeon, head of department, chief doctor; in 1980-1985 he headed the medical aviation service department. Gerasimenko was a deputy chief doctor for surgery in Altai Territorial Hospital and took an active part in the development and use of automated telediagnosis systems for surgical pathology. Since 1990 he was employed in administrative and public service; one of the founders of Doctors Improvement Faculty at the Altai State Medical University.
**Gernsback / Gernsbacher Hugo** (16.08.1884-19.08.1967; Luxembourg – USA); an electrical engineer, inventor, businessman, writer, editor and publisher of numerous popular science magazines, the creator of the term "science fiction".

**Gershon-Cohen Jacob** (09.01.1899-06.02.1971; USA), MD. (1936), Professor, one of the teleradiology pioneers. He received his medical degree in 1924, trained in radiology, and opened a private practice in 1929. During the Second World War he served in the Navy. Since 1941 he served as a Professor at several universities in the United States, constantly worked as a consultant in many hospitals and clinics; during 1949-1966 he held a position of the Head of the Department of Radiology at the Albert Einstein Medical Center Philadelphia. Gershon-Cohen was a leading specialist in the field of mammography, one of the pioneers of thermography (1962). He is the author of over 400 publications, including 2 classic textbooks on mammography. He was a director of several professional associations, a public figure, honored with national and international awards.

**Grey Walter William** (19.02.1910-6.05.1977), graduated from college in Cambridge in 1931, worked at the neurophysiological laboratory at hospital in London (1935-1939), then at Barden’s neurological institute in Bristol (1939-1970). Grey participated in many scientific projects, working in the USA, the USSR and European countries; studied the subjects of bio-cybernetics, neurophysiology, brain electrical activity, robotic engineering, made significant contribution into the development of EEG recording.

**Guida Guido** (11.11.1897-19.02.1969; Italy), a physician, organizer and lifetime director of the International Medical Radio Centre (Centro internazionale di radiocomunicazioni mediche - CIRM). In 1922, he received his medical degree and began working at the department of otolaryngology at the University Clinic of Rome, and in the 1930s he was promoted to the position of Associate Professor, and then of Professor. In 1935, Professor Guida opened and funded CIRM. Guido Guida devoted his entire life to the work in the centre.

**Halfen Emmanuil Sh.** (26/06/1923; USSR/Azerbaijan), Candidate (1954) and Doctor (1962) of Medical Sciences, Professor, Honored Scientist of the Russian Soviet Federative Socialist Republic (1980), a pioneer of telecardiology and use of cybernetics in internal medicine. After graduating from the Azerbaijan Medical Institute in 1946 he finished clinical residency, worked as a therapist, senior laboratory assistant, and then - as an assistant at the Azerbaijan Institute of Advanced Medicine. In 1963 he was elected the head of the Department of Hospital Therapy at the Astrakhan Medical Institute. After 4 years Emmanuel Sh. moved to Saratov, where he headed the department of the local medical higher school. In 1980 Prof. Halfen was appointed the director of the Saratov branch of the Leningrad Institute of Cardiology. In 1967 he developed a mathematical model of forecasting of myocardial infarction outcomes and in 1971 - the theory and the basic provisions of the automatic control by computer of the cardiac treatment. Since 1967, Prof. Halfen constantly worked on the concept and implementation of the tele-ECG facilities. He is one of the co-developers of the "Volna", initiated the creation of remote diagnostic centres (1972), and regional hospital telemedicine systems based
on them. Based on the achievements of Halfen, the concept of tele-ECG was extended to the entire health care system of the USSR (1983). He is the author of over 300 scientific papers, including 5 monographs (it should be particularly noted the "Progress of biological and medical cybernetics", 1974, which was marked with a diploma and premium of the USSR Ministry of Health). Under supervision of Prof. Halfen 25 theses were defended. Member of the Scientific Council of the USSR Academy of Medical Sciences of All-Russia Research Centre for Cardiology the Scientific Council of the Ministry of Health of the Russian Soviet Federative Socialist Republic, a board member of the All-Russian Society of Cardiologists, therapists. He was awarded the "Badge of Honor".

Haukkamaa Maija (born in 1946), got her medical degree in 1975, an obstetrician-gynecologist, in the1980s - an employee of Helsinki University Hospital.

Hess Orvan Walter (18.06.1906-05.09.2002), an obstetrician-gynecologist, the United States presidential advisor; invented radiotelemetry monitor of fetus cardiac function. He was the first in the USA to administer penicillin for the patient with scarlet fever. Got the medical doctor certificate in 1931 in New-York, practiced in trauma orthopedics, surgery, obstetrics and gynaecology; military surgeon and WW II veteran; worked at Yale University until 1975. As a public person, he headed a range of professional public societies, was honored with the national awards.

Hirschman Jim Charles (1.03.1931; USA), after graduating from high school he studied chemistry at Harvard University (until 1952) and then received his doctorate in medicine in 1955 in Indiana. He served in the military medical units of the US Navy for three years, and took residency in cardiology after demobilization. Since college years he dealt with the radio issues (he was a radio amateur, headed thematic public societies), and later developed a method of ECG radio broadcasting and spent the first transatlantic electro-cardiosignal transmission, and also participated in the creation of biotelemetric system for rescue services in Miami (USA). Hirschman was one of the organizers of paramedical system in the United States, the ideologist and organizer of emergency medical care. In 2000 and 2001 he spent many hours of tele-consultations over the radio for the victims from merchant vessels, which had been hijacked by pirates nearby the coast of South America. For this outstanding achievement Dr. J.C. Hirschman was honored with "International Humanitarian Award".

Holter Norman Jefferis (01.02.1914-21.07.1983), Professor, inventor of the continuous outpatient ECG monitoring method. He graduated from University of California in 1937, got postgraduate education in Germany and in a number of other universities of the USA. During the World War II served as a senior physicist in American naval forces. In 1946 headed the governmental research group, which tested a nuclear bomb; then he worked in the United States Atomic Energy Commission; since 1964 - a Professor of University of California in San Diego.

Hon Edward H. (1917, China - 06.11.2006, USA); an obstetrician-gynecologist, an employee of Medical College of Yale University, the inventor of
Doppler fetus monitoring and fetus radiotelemonitoring. Initially lived in Australia, in 1945 immigrated to the USA and entered Loma Linda Medical School. After graduation he practiced in obstetrics and gynecology, worked at Yale University; the author of 150 research works, was honored with awards and medals.

**House Arthur Maxwell** (10.09.1926-17.10.2013; Canada), a physician, Professor, politician, founder of the telemedicine centre at the Memorial University of Newfoundland (Canada). He studied medicine at Dalhousie University in 1947-1952; worked as a general practitioner, specialized in psychiatry and neurology, and worked in St. John General Hospital as a neurologist (1960-1997). Dr. House went his way up from an intern to a manager, the head of electroencephalographic laboratory, a member of the hospital board. Since 1968 he held various positions at the Memorial University of Newfoundland (Director of Continuing Medical Education, Deputy Dean, head of innovation and research programs), and from 1977 to 1996 - Director of the telemedicine centre, which later was transformed into "TETRA" (Telehealth and Educational Technology Resource Agency). In 1997 he was appointed Lieutenant Governor of Newfoundland and Labrador. After retirement in 2002 he held the post of honorary professor and participated in the telemedicine projects of the University. He is the author of numerous scientific papers, a public figure, honored by awards and prizes.

**Hunter Charles Hatch** (18.12.1916-08.04.2008), Bachelor of Biological Science (1937), Master of Physics (1939); after the military service during the Second World War he graduated from the Howard University College of Medicine in 1950, later worked as a radiologist in Washington City. From 1971 till 1977, he headed the radiology department of the Hospital for Veterans in Bedford, where took part in the work and scientific assessment of Massachusetts telemedicine network efficiency; later moved back to Washington City where he worked till his retirement in 1991; author of scientific papers, community leader.

**Jutras Albert** (02.10.1900-16.02.1981; Canada), Professor of Radiology, one of the teleradiology pioneers. In 1930-1934 he studied radiology in France at the Radium institute under the tutorship of Marie Curie. On his return to Canada he worked as a radiotherapist, focused on the beam diagnostics of gastrointestinal tract pathology. In 1938 he began to work in the Hotel Dieu Hospital in Montreal, where he soon became a leading expert and the Radiologist-in-Chief. At the same time he taught at the University of Montreal, where he was a Professor and the head of the Department of Radiology for almost 30 years. Albert Jutras was also Dean of the French-Canadian School of Radiology. In 1949 he was guest lecturer at the Sorbonne in Paris (France). His publications are >200, he was an internationally known expert in the field of diagnostic radiology, President of a number of professional associations, public figure, honored by the national and international awards.

**Kamyshyova Evgeniya P.** (born on 28.12.1925; USSR), Distinguished Professor of Nizhniy Novgorod State Medical Academy (NGMA), Professor, Doctor of Medical Sciences, Honored Scientist of the Russian Federation. In 1948 she graduated from Medical and Preventive Cure Faculty of the Gorky Medical Institute
(GMI), began working as a district physician, and then as a medical intern at the therapeutic department of regional clinical hospital. In 1952 she was enlisted as a teaching assistant of hospital therapy at the GMI on a competitive basis, 1962-1966 she became an Associate Professor, later Professor and then until 2000 - Head of the Department of the Faculty of Postgraduate Medical Therapy of GMI / NGMA. She is an outstanding scientist and public figure. In 1980 under her leadership the standard medical examination model was developed, which included telemetry ECG interpretation and computer-assisted automated analysis. She is the author of over 230 scientific works, including 4 monographs, adapted translation of the "Book about Heart" of the Italian cardiologist F. Burgarello. She was awarded the Order "Badge of Honor", Medal of the Committee of Russian Women, silver medal of Academician I. P. Pavlov, a diploma of the International Biographical Centre of Cambridge.

Kataev Semyon I. (09.02.1904-10.07.1991; Russia), Doctor of Engineering (1951), Professor (1952), Honored Scientist and Engineering (1968), the inventor of modern television, he graduated from the N. E. Bauman Moscow Higher Technical College in 1929, became an electrical engineer, started working at the All-Russian Electronic Technical Institute. In the same year, he filed a patent application for "Device for electric telescopy in natural colours" On September 24, 1931 he filed an application for the invention of television receiving high-vacuum tube, and on April 30, 1933 received a copyright certificate of the USSR No. 29.865. At the same time he held the first image broadcast. In 1932, Kataev worked on a vacuum tube receiver with magnetic focusing of the electron beam, and the next year he improved the receiver box - iconoscope. Later he patented transfer of "electronic image" from conductive photocathode to dielectric material (inventor's certificate dated September 30, 1933, as a priority of February 20, 1932). In 1936, he travelled to the United States for a few months to share experience, where he met V. K. Zvorykin. In the 1950s he worked on satellite communication technologies. Until 1987 he worked at the department of television at the Moscow Electronic Technical Institute of telecommunications, which now bears his name. He is the author of scientific articles and fundamental works "Cathode-ray television tubes" (1936) and "Fundamentals of Television" (1940). In 1944 he, together with a group of professionals, offered the world's first TV broadcasting standard for 625 lines, which is still used nowadays. He trained more than ten Doctors and more than 50 Candidates of Engineering and was awarded the Order of the Red Banner of Labour and medals.

Keller Vladimir S. (1928-1998; Ukraine & Bulgaria) got his Ph.D. in 1959 and EdD in 1975; Honored coach of the USSR; graduated from Lvov State Institute of Physical Education, rose through the ranks from a teacher to the head of a department at this Institute. From 1962 till 1976 he was a manager of the USSR national fencing team; formed the research area of fencer training; the author of more than 150 scientific publications and three books, the holder of a golden medal "For scientific achievements; in 1989 moved to Bulgaria, where he worked in the Council for Mutual Economic Assistance.
Kharitonov Rem A. - Candidate of Medical Science (1961), got the doctor's degree in 1954, since 1957 has worked at V. M. Bekhterev Scientific Research Institute of Psychoneurology and from 1970 to 2004 headed the pediatric psychoneurological/psychiatry department.

Khorev Aleksandr N. (born on 1948; USSR), Candidate (1980) and Doctor (1992) of Medical Sciences, Professor (1995), graduated from the Yaroslavl State Medical Institute (YASMI) in 1972. In 1977-1980 was a postgraduate student at the Department of General Surgery. Since 1976 he has worked in YASMI, and has worked his way up from senior laboratory assistant to the professor of the Department of surgery (since 1993). In 1970 he participated in the creation and operation of the remote diagnostic centre of acute surgical pathology. Since 2000 he has been working as the chief physician of the medical unit of Novo-Yaroslavl oil refinery. He was the author of about 180 scientific papers.

Knowles John H. (1926-1979), Professor, Director of Massachusetts General Hospital. At the time of his management (1962-1972), a telemedical network was established and a number of significant projects in this field were implemented. He received a Doctor’s Degree in 1951; after the residency and the military service, in 1959, he started working at MGH and got promoted from the Head of Department to the Director; author of 25 articles and 5 books, community leader in medicine.

Kobazev Igor V. (Bryansk, Russia), founder and head of diagnostics automated methods department (with RDC) at the Regional Hospital No.1 in 1983.

Konevskyy Anatoliy G. (born on 30.01.1921; USSR), Doctor of Medical Sciences, Professor, a veteran of the Great Patriotic War. After leaving school he entered the Faculty of Philology of the Leningrad University. In 1941 he was mobilized, went through the war, demobilization he returned to his homeland in the Rostov region, worked in a coal mine as a surveyor. Sometime later he was admitted to the first year of the Stalingrad Medical Institute. After graduation he worked as a doctor in rural hospitals, and 4 years later became an assistant of the department of operative surgery and topographic anatomy of the Volgograd State Medical University. From 1963 to 1988 Konevskyy headed the department. At this time, the department focused on the development of students' practical skills, which was provided greatly with a good experimental base: operating unit for 3 tables, vivarium and autopsy examination. The problem of organ transplantation became the main scientific line of the department. The functional, immunological and morphological aspects of this problem were studied. There is an interesting fact: In 1970 at the All-Union Symposium on organ and tissue transplantation (Volgograd), the members of the department accompanied their performances with demonstration of animals with transplanted hearts, kidneys, second head and replanted limb. Photo of a two-headed dog, operated by Professor Konevskiy, surpassed all known newspapers of the world. In parallel with the experimental studies of organ transplants Professor Konevskyy headed the work on the creation and practical implementation of "Kovyl" health telemetry system, designed to provide remote diagnostic and consultative assistance in cardiovascular diseases to all treatment facilities of Volgograd Region. He is an award-holder: Order of "Patriotic War", "Badge of
Kupriyanov (8.02.1893-13.03.1963), Academician and Vise-President of the Academy of Medical Science of the USSR, honoured man of science, General-Lieutenant; founder of the largest school of surgeons, anesthesiologists and resuscitators.

Labutin Vadim K. (Russia) Doctor of Engineering, an engineer. He is the author of numerous publications and visual aids on radio engineering and bionics. In the 1970s he carried out works on the development and construction of information and diagnostic systems for ECG automated analysis. In the article "40 million books for radio amateurs" (V. A. Burlyand, E. T. Krenkel -http://www.oldradioclub.ru/radio_book/mrb_hystory_02.html) was underlined: We remember how the participant of the VI All-Union Extension Radio exhibition Sergeant re-enlistee Vadim Labutin came to our editorial office. He gave to MRL [mass radio library - author's note] description of visual aids on radio engineering, which he had developed (issue No. 24, 1949). Then Labutin did not have a completed secondary education. A Leningrad school boy, who lost parents and shelter from the Nazi bomb, he joined the army after finishing the 9th grade. Now he is our well-known author. In 1967 he published an interesting work on bionics "Hearing sense and analysis of signals "(issue number 636) which had written together with A. P. Molchanov. This year, Vadim K. Labutin is preparing a doctoral thesis.

Larks Saul D. (1910-24.01.1984), biophysicist, studied electrical engineering at the University of Illinois, worked at Marquette University, then as Professor of physics and physiology at the University of Missouri, invented electrohisterograph in 1959.

Lindberg Donald A. B. (born in1933, USA), MD., Professor, Director of the National Library of Medicine (NLM) USA, one of the pioneers of computer technologies in health care, studied mathematics at Amherst College (until 1954), graduated in 1958 from the Columbia University College of Physicians and Surgeons. After the residency in 1960 he started to work at the University of Missouri, where he was promoted from an assistant to a professor of Computer Science and Pathology, Director of the Informatics group. During this period, together with Dr. P. R. Amlinger he implemented the tele- ECG network, conducted automation of the clinical laboratory of pathology. Since 1984 he headed the U.S. NLM. Lindberg is the first president of American Medical Informatics Association
Lipinski Witold (30.11.1886 - 27.09.1955; Poland), Professor (1940), infectious disease physician, a creator of the first clinical tele-ECG system. In 1909 he received a degree in engineering in Germany, and in 1914 - a doctor's degree in Austria, after which he was called up for military medical service. Until 1921 he served as a military epidemiologist. After the war for 5 years he was a director of the State Institute of Hygiene and, at the same time, a teaching assistant of Experimental Medicine department (Krakow, Poland). In 1925 he moved to Lvov and headed the department of infectious diseases of the State General Hospital. During 1935-1937 he implemented and used the first clinical tele-ECG system (with M. Franke). For a number of years W. Lipinsky worked at the Medical Faculty of the University of Lvov; in 1940 he became Professor, in 1940-1941 and 1944-1946 was in charge of the Department of Infectious Diseases. In 1946, as a result of repatriation he left Ukraine and lived in Lodz (Poland) until the end of his life, where he headed the Department of Infectious Diseases at the Medical Academy. He was the author of about 60 scientific papers.

Manning George William (1911-2.10.1992) received his medical degree in 1940, worked in practical healthcare, after defending his thesis was appointed at the University of Western Ontario. He was actively working in the cardiology department of the University Hospital and became a leading expert in the field of electrocardiography in the region during 1947-1986, author of over 100 articles and 3 books, scholar and public figure.

Matusova Aleksandra P. (17.05.1919-26.03.2010; Russia), one of the clinical pioneers in implementation of cybernetics to cardiology, after the defending the Doctor thesis Matusova worked as a Professor in the department of Intermediate Level Therapy, and from 1962 (according to other sources, from 1967) to 1983 headed the department of internal diseases No.2 of general medicine faculty at the Gorky State Medical Institute (now - Faculty of General Medicine and Nursing of the Nizhny Novgorod State Medical Academy). Under her leadership, the department started applying electronics and computer technologies, automation and mathematical methods - the main lines of medical cybernetics - in scientific and practical purposes. Alexandra Matusova played a major role in the development of the regime and the treatment of acute myocardial infarction, her works were associated with the conduct of patients in the sub-acute stage of myocardial infarction; she also described the course and treatment of Dressler's syndrome. On her initiative the first Cardiac Remote Diagnostic Center was created in Gorky with the reception of information from medical institutions of the city. An automated diagnosis of angina pectoris, pre-infarction syndrome, menopausal myocardial dystrophy and forecasting of the outcome of acute myocardial infarction were developed. Methods of mathematical prediction of fatal complications of myocardial infarction, angina pectoris patients programmed maintenance, diagnostic and
prognostic programs for early forms of coronary heart disease were created too. Using mathematical methods the routes of dispensary management and rehabilitation of patients were defined under her supervision. The Department worked in collaboration with the Scientific - Research Institute of Applied Mathematics and Cybernetics, Radio Physics, Institute of Applied Physics of the Academy of Sciences, Research Institute "Instrument Engineering". The department had a group of mathematicians (M. Haymovich, V. Gladkov, V. Borin et al.) and a group of physiologists. A. P. Matusova is the author of 180 scientific papers, two monographs, five collections of scientific works of the department, 4 handbooks for doctors and medical interns. Under her leadership, 3 doctoral, 20 master's theses were defended.

Mazur Nikolay A. (USSR), Candidate (1966) and Doctor of Medical Sciences (1975), Professor (1982), Head of the Department of Cardiology of the Russian Medical Academy of Postgraduate Education, graduated from Beijing Medical University; 1962-1966 - Clinical residency and postgraduate studies at the Institute of Therapy of the Academy of Medical Sciences of the USSR; 1966-1968 - the Chief Therapist of Ministry of Civil Aviation and the head of the therapy department of the Central Clinical hospital of MCA; 1968-1971 - Senior Researcher of the central research laboratory at the Emergency Treatment Hospital of the 4th Chief Directorate of the USSR Ministry of Health. In 1971-1975 he was a Senior Researcher, and in 1975-1976 became a Deputy Director for Science of A. L. Myasnikov Research Institute of Cardiology. During his work at the institute he organized a remote tele-ECG diagnostic centre. From 1976 to 1979 he worked at the All-Union Cardiology Research Centre. Then Nikolay Mazur organized and headed (until 1987) the Department of Clinical Pharmacology at the A. L. Myasnikov Institute of Cardiology. Since 1987 he has been the Head of the Department of Cardiology of the Central Institute of Medical Doctor Improvement, Russian Medical Academy of Post-Graduate Education of the Health Care Ministry of the Russian Federation. He is the author of over 300 scientific papers, 10 books, co-author of 9 patents. He trained more than 40 candidates and doctors of medical sciences. Mazur was a laureate of the State Prize of the USSR, "Honored Worker of Science", was awarded three medals and was a member of the Russian and European Society of Cardiologists.

Merrell Ronald C. - Professor, received doctor’s degree in 1970, worked as a surgeon, took positions of Professor, dean, clinical director of telemedicine programmes at a number of universities in the USA, for years cooperated with NASA and Ministry of Defense on the problems of space medicine and telemedicine; honoured with awards, a member of Editorial Boards of many scientific journals, a public person, the author of 380 scientific articles.

Murphy Raymond L. H. graduated from New York University; medical practice; Professor of Taft University since 1966; headed the Pulmonology Department of Faulkner and Lemuel Shattuck in the city of Boston, Massachusetts. In 1975 he founded and headed the International Lung Sounds Society. Retired in
1998 and established a company in the sphere of digital auscultation; author of over 50 scientific papers, including those on computer analysis of auscultation.

**Myhre Jon R.** (05.02.1915), got his Medical degree in 1941, headed the laboratory at the University Clinic in Haukeland, was awarded the King of Norway awards for his work in the sphere of telemedicine at sea.

**Nagel Eugene L.** (born on 12.08.1924, USA) is a pioneer of pre-hospital care in San Francisco, Professor. After graduating from high school in 1943 he joined the army; in 1949 received a degree in electrical engineering, and in 1959 became a certified doctor. After residency and specialization he started to work in the anesthesiology department of the School of Medicine at the University of Miami, where he worked until 1974 before receiving a professor's degree and becoming the head of the office at the University clinic of the University of Los Angeles. Nagel worked at a similar post in Baltimore (1977-1980), at the University of Florida and San Francisco (1980-1996). At the end of the 1960s together with James Hirschman he developed and implemented a radio telemetry system for emergency service workers. Nagel is the author of the first paramedic training program. The techniques of cardiovascular resuscitation, chest compression technique, methodology of skill training were special lines in his work. He is the author of numerous publications and textbooks in the field of cardiology, emergency medicine, intensive care, emergency care arrangement. Nagel is a prominent public activist, consultant of the Department of Health Care of the USA. He was honored with numerous national awards and prizes.

**Neyko Eugeniy M.** ((7.10.1932-24.05.2010) Doctor of Medical Sciences, Professor, Academician, Rector of Ivano-Frankovsk National Medical University; in 1986 tele-ECG RDC was opened under his supervision at the Regional Clinical Cardiology Dispensary.

**Neymark Yuriy I.** (24.11.1920-11.09.2011; Russia), Candidate (1947) and Doctor (1958) of Technical Sciences, Professor (1961), Academician of the Russian Academy of Natural Sciences (1991), Honored Scientist of Russia, the founder of the Department of Control Theory and Dynamics of Machines at the Gorky/Nizhny Novgorod State University (GSU). In 1944 he graduated with honors from the Physics and Mathematics Faculty of GSU, finished postgraduate study. In 1958 became the head of department of Computational Mathematics and dynamics of machines, which had been founded by him. In 1963, he participated in the organization of the Faculty of Computational Mathematics and Cybernetics, headed the department of management theory and dynamics of machines on the faculty. Neymark was one of the organizers of the Research and Establishment Institute of Applied Mathematics and Cybernetics. In collaboration with the Gorky State Medical Institute he first outlined a range of issues of using computer technology to diagnose diseases, forecast disease progression and outcome prediction of surgical interventions and to optimize the choice of treatment. Also new efficient coding techniques for large amounts of continuous information data and, in particular, electrocardiograms were offered; decisive rules, specific algorithms for diagnosis, prognosis and to optimize the treatment of cardiovascular, cancer and other diseases.
were developed. He was the author of about 600 scientific papers. Under supervision of Yu. I. Neymark, more than 57 candidate and 17 doctor theses were defended. Neymark was the winner of the International Prize of Norbert Wiener on cybernetics, was awarded the "Badge of Honor" and medals of Tsiolkovsky, Popov, Keldysh; in 2007 he received a golden medal and the title of "The Genius of the 21 century" by the American Bibliographical Society, was included among two thousand outstanding intellectuals of the planet by the International Bibliographic Centre in Cambridge.

**Nicogossian Arnauld** (born in 1936 in Dnepropetrovsk, USSR/Ukraine), in 1945 his parents immigrated to Iran, then to the USA. Received doctor’s degree in 1964, Master of Aerospace Medicine, Professor. From 1971 to 2003 took different positions at NASA, related to space medicine and biotelemetry, simultaneously taught at a number of universities in the USA and Russia; honored with dozens of awards, a member of Editorial Boards of many scientific journals, a public person.

**Nose Yoshiaki** ((born in 1944) received his medical degree in 1969, PhD in 1973, went from the resident to the head of the Department of Medical Informatics at the Kuyshu University (1987), editor in chief of «Japan Journal of Medical Informatics».

**Papakonstantinou George K.** (born in 1942), Professor at the National Technical University of Athens, PhD (1971), a specialist of the international level in the field of electrical and computer engineering, author of over 100 scientific articles and 9 manuals.

**Parin Vasilii V.** (5(18).03.1903-15.06.1971; Russia / USSR), Candidate and Doctor (1941) of Medical Sciences, Professor, a member of the Academy of Sciences and the Academy of Medical Sciences, Academician-Secretary, a member of the Presidency and the Vice-President of the USSR Academy of Medical Sciences; an outstanding scientist, one of the pioneers of medical electronics and cybernetics, creator of many methods of biotelemetry and mathematical analysis of functional parameters using computer technology, the founder of space cardiology. Parin graduated from the Medical Faculty of the Perm State University in 1925, in 1927-1933 he worked in the alma mater, having risen from lecturer to professor, department chairman of physiology and dean. In 1933, Parin was enlisted to work with the Sverdlovsk Medical Institute as the head of the department Human physiology, which had been organized by him. At the same time he performed a great administrative work (1933 - Dean, 1934 - Deputy Director for Research and Academic Affairs, and from 1940 - Director of the Institute). In 1941 he was promoted to Professor, the department chairman and the director of the I. M. Sechenov 1st Moscow Medical Institute. In 1942 Parin was appointed Deputy People's Commissioner on Science of Health Care Service of the USSR. During the Great Patriotic War, he organized the epidemiological service in the republics of Central Asia, the evacuation of medical institutions of the North Caucasus, the restructuring of the system of higher medical education in line with the objectives of war. In 1943-1944, Parin with N. N. Burdenko spent most of the work on the establishment and organization of the Academy of Medical Sciences of the USSR.
On February 18, 1947 after returning from a four-month trip to the United States he was arrested on charges of spying for the United States; spending more than 6 years in prison, released on October 29, 1953 and fully rehabilitated on 13 April 1955. Main positions: 1954-1956 - Head of the Laboratory of Pathophysiology of the Institute of Therapy of the Academy of Medical Sciences of the USSR; in the 1956-1960 - Head of the Department of Clinical and Experimental Physiology of the Central Postgraduate Medical Institute; In 1960-1965 - Director of the Institute of Human and Pathological Physiology; 1965-1968 - Director of the Institute of Biomedical Problems; 1969-1971 - Head of the Laboratory of Management functions of the human body and animals of the Academy of Sciences of the USSR. In 1957, Parin was elected an academician-secretary of the USSR Academy of Medical Sciences; in 1960-1962 - Member of the Presidium of the USSR Academy of Medical Sciences; 1963-1966 - Vice-President of the Academy of Medical Sciences of the USSR; In 1966 he was elected a full member of the Academy of Sciences of the USSR and Deputy Academician-Secretary of the Department of Physiology, of the Academy of Sciences of the USSR. Parin is a founder of space bioradiotelemetry, he personally escorted Yuri Gagarin to the pad of space port and was directly involved in the medical examination of the first cosmonaut. He was the author of numerous scientific publications, a member of the editorial boards of scientific journals, including the founder and first editor in chief of the journal "Space Biology and Medicine", under his editorship in 1971 the book "Biological telemetry" was published.

**Patrushev Vasiliy I.** (25.12.1910-22.04.1962), Doctor of Biological Sciences, Professor, Director of the Ural branch of Academy of Sciences; in 1947 he organized first experiments on ECG radiotelemetry in Sverdlovsk.

**Pruett Carl Eugene** (17.06.1920-22.01.1991; USA), Captain of the U.S. Navy. As senior medical officer, he served in a number of US Navy ships in the 1954-1957. In the late 1950s - early 1960s he worked in NASA projects related to aerospace medicine (including "Mercury"); headed a group of medical support, which worked with the biotelemetry systems in the program of stratospheric flight (later, these systems were used during manned missions into space). In 1969-1970 he was President of the Society of Illinois.

**Radyuck Oleg M.** (1931-9.10.2013; USSR-Russia), Candidate of technical sciences, an outstanding leader, who made a great contribution to the development of Research and Production Enterprise (RPE) "Almaz" Saratov, a developer of tele-ECG system "Volna", on October 29, 1965, at the age of 34 years Oleg Radyuk was appointed director of the Federal State Unitary Enterprise "RPE "Almaz". In this position, he worked for 30 years - until November 14, 1995. More than forty years of his life Radyuk devoted to electronics industry, having risen from an ordinary engineer to the Director-General. In 1987 he was appointed the chief designer of one of the scientific and technical areas of the industry. The special merit of Oleg Radyuk included the development and implementation at the company quality assurance system of the implementation of scientific research and production. Oleg M. Radyuk was Commander of the Order of Lenin, the Order of the October
Revolution, the Order of the Red Banner, the Order "Badge of Honour", laureate of the State Prize (1980), "Honorary Radio Operator of the USSR" (1991), author of over 40 scientific publications and inventions.

Ray Charles Dean (01.08.1927-21.08.2011), gained higher technical education in 1952, and higher medical education in 1956, underwent a training course at the Mayo clinic, worked as Assistant Professor at the John Hopkins University, then ran medical engineering departments at Hoffman-LaRoche and Medtronic companies, headed hospitals in Virginia and Minneapolis. He was an inventor. One of his achievements was the artificial invertebral disc. He was a co-founder of numerous medical professional associations, author of 340 articles, 53 patents in the USA and more than 100 international patents.

Remond Antoine (15.01.1917-05.07.1998), doctor, scientist, neurologist and electrophysiologist, from 1939 he worked on topics related to electroencephalography. In 1947 he organized and headed EEG and neurophysiology laboratory at the Paris Hospital de la Salpetriere; took part in medical experiments of the Apollo space programme (USA), studied problems of biofeedback and was the author of more than 500 scientific articles.

Rosewell C. Williams (died in 1976), pastor, professor, worked at Creighton University since 1945, Head of Department of Journalism in 1948-1956, later worked as Communications Director till his retirement in 1973. Understanding the importance of television technologies, he introduced them in the educational process, trained the employees of radio and TV broadcasting companies, equipped training classes with cable telecommunication, initiated the use of teleconferences in teaching medicine and organized the first telesurgical conferences.

Rowen Burt (30.03.1921-01.10.2012; USA), US Air Force Colonel. In 1942 he graduated from Lafayette College, served in the infantry, then entered and successfully completed the accelerated course of New York University College of Medicine. Since 1945, he served as a military doctor. Later he studied at the School of Aviation medicine. He did military service in various military units, including in Western Europe. In 1955 he attended special course at National Naval Medical Center, and then assigned to Flight Test Center, Edwards, California (1956-1962). He was responsible for evaluating life support systems in numerous projects. At the same time, he was medical director of the X-15 program, under his supervision biotelemetry systems were developed and used to control a pilot state in suborbital flights. He was deputy commander of Aerospace Research Laboratory. Also, he participated in the Vietnam War. In 1972-1974 he commanded the School of Health Care Sciences at Sheppard, and then served as Chief at the Medical Standards Division. He retired in 1986.

Rozenblat Vladimir V. (09.12.1927-30.04.2000; Russia), Candidate (1953) and Doctor (1964) of Medical Sciences, Professor (1966), Academician of the Russian Academy of Medical and Technical Sciences (1996), the founder of the sports radio telemetry, he studied at the Sverdlovsk Medical Institute, and in the years 1950-1953 finished clinical residency at the Sverdlovsk Institute of Physiotherapy and Health
Resort. From 1953 to 1960 he was an employee of Sverdlovsk Municipal Medical and Sports Clinic. Here he held the positions of: the doctor of medical control of the clinic, the head of the laboratory of medical radio-electronics. In September 1960, Rozenblat was elected the head of the laboratory of functional diagnostics of the Sverdlovsk Research Institute of Hygiene and Occupational Diseases on a competitive basis. Since 1966, concurrently he served as Professor of Physiology of Labor at the Economics Faculty of the Ural State University. V. V. Rozenblat was one of the greatest scientists - physiologists of labor, widely known for his work on fatigue and physiological norms. A special place in the scientific work of Vladimir Rozenblat was occupied by biotelemetry (radiopulsophone, telemetry of heart rate, respiration, brain bio currents). He was an activist of the arrangements of medical-sports service in the Urals. Rozenblat was a founder of "Sverdlovsk bioradiotelemetry group." Rozenblat worked in various institutions (the Research Institute of Occupational Health, Institute of National Economy, the Forestry Institute, etc.). On his initiative, all divisions and groups involved in the further development of the equipment for dynamic bioradiotelemetry, were created. Suffering from innate process of atrophy of the optic nerves of both eyes from childhood, Rosenblat got completely blind in the early 60s, but that did not stop him from continuing his active scientific and social activities. Since 1961, when regional scientific medical society for physical therapy and sports medicine was formed, he became his permanent chairman. Being already blind, Vladimir V. Rozenblat defended his doctoral thesis. The main scientific activities of Rozenblat were: developments in applied physiology (physiology of muscular activity, labor and sports), the problem of creating biotelemetric equipment and its use in human physiology and clinical findings. He was awarded the Diploma of Honor and two silver medals of All-Union Exhibition of Achievements of National Economy, was the author of over 400 scientific papers (including 4 textbooks, 4 inventions and 3 monographs, one of them was a conceptual work on sports radio telemetry); prepared 5 doctors and 32 candidates of sciences. The movie "Waltz-Boston" about prof. V. V. Rozenblat was filmed by Rotenberg.

**Russell Earl Stuart** (1920-12.10.2008; Canada); Professor of Anesthesiology; served in the army during the WW II and the Korean War; received his M.D. degree in 1950, majoring in Anesthesiology (1955). In the period 1962-1964 he took part in the creation and the work of Medical Faculty at the University of Lagos (Nigeria); later worked at the Queen's University in Kingston, and from 1968 – at the University of Western Ontario (Canada). He also headed anesthesiology department at Victoria Hospital. His scientific and practical activity was devoted to the problems of pain and pain relief, an award-holder, an author of numerous publications.

**Saltseva Maria T.** (25.12.1924-22.10.2009) Doctor of Medical Sciences, Professor, Honored Doctor of the Russian Federation, Chair of Hospital Therapy of Gorky Medical Institute; from 1962 to 2000 was chief cardiologist of Gorky/Nizhny Novgorod Region; at the beginning of the 1980s took an active part in the development of the regional tele-ECG network.
Sausmarez Carey Lewis Stafford de (09.08.1925-10.11.2009) Professor, received his medical degree at the Queen's University, he worked as a radiologist in the USA. For about 20 years he headed the chair of diagnostic radiology and nuclear medicine at the University of Western Ontario and is one of the telemedicine pioneers in Canada.

Shklyarenko Mikhail P. (13.06.1936–06.2010; USSR-Ukraine), Head of the Poltava Regional Cardiological Dispensary, Honored Doctor of Ukraine, Emeritus Professor of the Ukrainian Medical Dental Academy. After the graduation from the Dnepropetrovsk Medical Institute in 1959, Mikhail Shklyarenko began working as a head of the local hospital. Subsequently, he was transferred to the post of the chief physician of a health resort; since 1960 he returned to the position of the head of the hospital, being at the same time the chairman of the expert examination of labor capacity at collective farmers, and was in charge of Continuing Education Courses for the district paramedics until 1970. In the period of 1970-1984 he headed the department of cardio-rheumatological specialization. From 1984 to 2009, Shklyarenko headed the Poltava Regional Clinical Cardiology Hospital and at the same time worked as a regional cardiologist. Under his leadership, in the mid-1980s an extensive tele-ECG network was arranged in the Poltava Region. M. P. Shklyarenko was awarded "For Excellence in Health Protection" badge, numerous diplomas of General Directorate of Health State Administration, the Distinction Badge of the President of Ukraine, the medal named after Academician M. D. Strazhesko, he was also a laureate of "Golden Fortune" rating, the award-winner of the All-Ukrainian project "Events and personalities of the twenty-first century."

Shurigin Dorofei Y. (18.06.1923-20.07.1982) Doctor of Medical Sciences, Professor, Major-General, a veteran of World War II, since 1947 worked at the Military Medical Academy, in the 1970s he carried out works in the field of design and construction of information and diagnostic systems for ECG automated analysis; author of 70 scientific papers and four manuals, was awarded 3 military orders and 12 medals.

Soule A. Bradley (1903-1983), Radiologist, received Doctor’s Degree in 1928; worked at the Medical Faculty of Vermont University for 54 years; founder of residency school, author of multiple scientific papers, awarded with medals and diplomas of many professional associations.

Stark Lawrence W. (21.02.1926-22.10.2004) Professor, a neurologist and engineer, he is famous for his works in the field of physiology of vision organ and physiological optics.

Sureau Claude (27.09.1927), Professor (1961), academician, obstetrician-gynecologist and physiologist, Doctor of Medicine since 1955, ran a number of departments and laboratories at several universities and hospitals in France, studied perinatal physiology, electrical activity of gravid uterus, developed recording technique of fetal EC and monitoring. He actively worked on problems related to biotics and was the author of numerous scientific works, public person, Chevalier of the Legion of Honor.
Tampas John P. - Professor of Radiology, received Doctor’s Degree in 1954; joined the University of Vermont in 1962 as an Assistant Professor where he got promoted to the Clinical Director; community leader, awarded with medals and diplomas of various professional associations.

Traeger Alfred Hermann (02.08.1895-31.08.1980; Australia), engineer, inventor "of the pedal radio". Since childhood, he was fond of radio, and made a home phone at the age of 12. He studied mechanical and electrical engineering at the South Australian School of Mines and Industries (associate diploma, 1915), worked for the Metropolitan Tramways Trust and the Postmaster-General's Department. During the First World War, he applied for admission into the army, but his application to join the Australian Flying Corps was refused because of his ethnic origin (his grandfather immigrated to Australia from Germany). About 1923 Traeger joined a private company in Adelaide, handling their car generator and electrical repairs; at the same time, apparently, he built his first pedal transmitter-receiver." Shortly thereafter, Traeger established a company producing radios of his own design, which were successfully sold not only in Australia but also abroad (Nigeria, Canada). From 1928, together with John Flynn, he began work in Adelaide on a transceiver for the flying doctor network, constantly upgrading and improving the design of "pedal radio", which became a technical basis of the national telemedicine network. He was a member of the Institution of Radio Engineers, Australia.

Tsybulina Ekaterina V. (USSR), Candidate (1961) and Doctor (1970) of Medical Sciences, Professor, graduated from the Volgograd State Medical Institute (VSMI) in 1953. In 1972-1997 she headed the Department of Intermediate Level Therapy VSMI. She was the author of about 120 scientific papers. Medical and scientific and pedagogical experience of Tsybulina is more than 50 years. She made an invaluable contribution to the training of highly qualified scientific and pedagogical staff in the department and expanded the clinical base of the department. In the mid to late 1970s she took an active part in the development of telemetry system "Kovyl" and in the formulation of the indications for tele-ECG consultations.

Uhley Herman Noah (17.10.1926-01.02.2012; USA), MD., Scholar, teacher, innovative researcher, Professor Emeritus. At the age of 17, he enlisted the U.S. Navy, acquiring a special interest in research involving the development of radar. After demobilization he went to medical school at the University of Wisconsin in Madison, which he successfully finished in 1951 and began his doctor training at Michael Reese Hospital in Chicago. In 1956, he moved to San Francisco, where Dr. Uhley began a 50 year career as an internist specializing in cardiology at Mt. Zion Hospital. He was promoted from an internist to the chief physician. Throughout his medical career Uhley created many life-changing devices, including the development of a pacemaker in 1958, and in the 1970s ambulance-to-hospital EKG telemetry system. He was one of the founders of the system for providing urgent pre-hospital care, the inventor of numerous devices and intensive care methods for ambulances. He was the author of over 300 research-based publications in peer-reviewed medical journals.
Usichenko Ivan I. (born on 08.19.1938; USSR) was born in the Kyiv Region in the family of farmers, graduated with honors from the Cherkasy midwifery school and the Dnepropetrovsk Medical Institute. In 1963-1975 he headed the Krivoy Rog ambulance station. During the work the station became a school of excellence in Ukraine. Since 1975 he was the chief doctor of the Kiev ambulance station. He organized the implementation of tele-ECG at the Ambulance Service of Kiev. He was the Honored Doctor of Ukraine (1997), and was awarded the Order "For Merit" III Art. (1998). In addition, he was a Chairman of the National Committee of the Red Cross Society of Ukraine and President of the Ukrainian Red Cross Society (since 1986).

Utyamyshev Rustam I. (1926-1999) – Doctor of Engineering, Professor, and Academician of Russian Academy of Natural Sciences, for 17 years was a director of All-Union Scientific Research and Testing Institute of Medical technique of MH of the USSR. He was a foremost authority in the field of aviation, space and medical technology. Author of over 300 scientific works, 120 inventions created more than seventy items of cosmic medical equipment.

Velikovskaya Lyubov M. (USSR), Candidate of Medical Sciences (1974), Physician of Superior Merit. In 1951 she graduated from Gorky State Medical Institute, then during 59 years worked in the Municipal Hospital No.38, and headed the remote diagnostics centre. For more than 20 years she was a teaching assistant of Intermediate Level Therapy Department of Gorky State Medical Institute.

Vilyanskyy Mark P. (07.12.1924 -03.24. 1991; USSR), Candidate and Doctor of Medical Sciences, Professor, Honored Science Worker of the Russian Soviet Federative Socialist Republic, graduated from Moscow Medical Institute and was enrolled to postgraduate training program to the department of operative surgery and topographic anatomy. From 1949 to 1953 was an assistant Professor of the same department, combining the main job with clinical work in the hospitals of Chelyabinsk. Since 1953 he supervised the surgical department of the Municipal Hospital in Zhukovka, Moscow Region. In 1960-1965 Vilyanskyy headed the Chair of departmental surgery of Omsk Medical Institute, and was also a surgeon-in-chief of Omsk Public Health Administration. Between 1965 and 1968 he headed the department of surgery combining the post of Pro-rector for Research at the Tyumen Medical Institute. Starting from 1968 the life and work of Mark P. Vilyanskyy were connected with Yaroslav Medical Institute, where he headed the departments of general surgery, surgery of Doctors Improvement Faculty and departmental surgery. For many years he was the manager of group "Medical cybernetics" of the RF Ministry of Health. He was the author of 200 scientific works, including 12 monographs; was honored with Award for excellence in health protection and medals.

Vinogradova Tamara S. (USSR), Doctor of Medical Sciences, Professor, an employee of Moscow Regional Research Clinical Institute n.a. M. F. Vladimirskyy, an organizer and a chief of the department of functional Diagnostics (1963), where in 1974 a remote diagnostic centre was established. The latter became the basement of tele-ECG network in the localities near Moscow. Her scientific work is connected
with the development of objective assessment criteria for functioning of the blood
circulatory system as well as for treatment control and disease state forecasting.

**Vishnevsky Aleksandr A.** (11(24).05.1906-19.11.1975; Russia), Doctor of
Medical Sciences, Professor, Academician of Academy of Medical Sciences of the
USSR, Colonel General; received his M.D. degree in 1929, gave lectures at the
Kazan University and at the RKKA Military Medical Academy (1931-1933). Since
1939 he was a head of surgical department of All-Union Institute of Experimental
Medicine; took part in military campaigns of 1939-1940 as an army surgeon and a
surgeon-in-chief of Volkhovskiy, Karelian front line. Since 1948 worked as the
Director of the Institute of Surgery n.a. A. V. Vishnevskyy, since 1956 as surgeon-
in-chief of Soviet Army, too. He performed important research on anesthesiology,
lungs, heart and vessels surgery, solved the problems concerning cybernetics,
electronics application and the use of lasers and polymer substances in surgery. In
1953 he was the first in the world to conduct cardiac surgery with local anesthetic
and in 1957 he performed first in the USSR open-heart operation with the
application of domestic artificial blood-circulation apparatus.

**Voynov Vasily I.** (born on 3.11.1929) - Honored Doctor of the RSFSR and
Russia, Chief Doctor of Orenburg Regional Clinical Hospital No.1. In 1979
Regional tele-ECG RDC was opened under his supervision.

**Weinstein Ronald S.** (born in 1939, USA); Professor of Pathology; received his
M.D. degree in 1965, completed his internship and residency at Massachusetts
General Hospital and Harvard Medical School. He was the youngest M.D.- NIH
funded researcher. Since 1975 he held the position of Professor of Pathology in a
number of Medical Colleges. From 1990 to 2012 Weinstein was the Head of
Pathology at the University of Arizona; an outstanding scientist and a public person.

**Williams Horatio Burt** (17.09.1877-01.11.1955, USA) was the first clinical
electrophysiologist in America and perhaps its first biomedical engineer. He
practiced medicine at Cornell University Medical School (until 1911), became an
associate professor of physiology (1916-1922), professor and chairman of the
Department of Physiology (1922-1942) at Columbia University; created ECG
machine at Columbia University in 1912 after meeting with W. Einthoven. Williams
improved on the string galvanometer to make it accessible to patients confined to a
bed and performed innovative researches in physiology.

**Wittson Cecil L.** (14.01.1907-10.10.1989), Professor, founder and first Director
of the Nebraska Psychiatric University (1950); in 1964-1968 was the Head of
Medical College, in 1968-1972 – Chancellor of the University Medical College
(Omaha, Nebraska). After retirement in 1972 obtained the title of the Honourable
Chancellor and after that worked in the National Healthcare Institute for 3 more
years.

**Woolsey Frank M.** (born in 1911; USA), Professor, one of the founders of the
use of telecommunications in medical education, co-founder and the head (1959-
1961) of Non-governmental organization "Council On Medical Television". He
received his medical degree in 1938 from Duke University; after an internship and
residency he served in the army (1943-1946). In 1950 was appointed the head of the medical unit at the Veterans Affairs Hospital in Albany. Since 1951 he has been a member of the University of Albany Medical College and was promoted from an assistant professor to the Director of the Department of Postgraduate Education and the Chairman of the Committee on continuing education of physicians.

**Yanushkevichyus Zigmas I.** (3 (16).10.1911-26.05.1984; Georgia-Lithuania/USSR), therapist, Doctor of Medical Sciences (1954), Academician of the Academy of Medical Sciences of the USSR (1967) and the Academy of Sciences of the Lithuanian SSR (1968). In 1927 he finished gymnasium, and in 1935 graduated from the Medical Faculty of the Vytautas Magnus University, worked as a doctor, a resident physician. In 1942-1944 was in military service. Then he worked as a teacher at the Kaunas Medical Institute and in 1953 became its rector and the head of the Hospital Therapy Department. His major works dealt with the diagnosis and treatment of cardiovascular diseases, medical cybernetics and organization of research work. He was awarded the USSR State Prize (1969) for the development of new methods of diagnosis and treatment of patients with myocardial infarction. Yanushkevichyus was a deputy of the Supreme Soviet of the Lithuanian SSR of the 4-9 convocations, was awarded the Order of Lenin and four other orders. The Kaunas Research Institute of Physiology and Pathology of the cardiovascular system has been named after him. He was the author of over 450 scientific articles, the creator of his own cardiac school.

**Yazdovskyy Vladimir I.** (24.061913 - 17.12.1999; Russia), Candidate and Doctor of Medical Sciences, Professor, laureate of the State Prize of the USSR (1952), a member of the International Academy of Astronautics, an honorary member of the Academy of Cosmonautics n.a. K. E. Tsiolkovsky, medical colonel, founder and the first director of the research program on space biology and medicine. In the 1920s he received higher technical education in the city of Samarkand, worked in the system of water management, and later moved to Tashkent; in 1941 he graduated from the medical institute and prepared his thesis on neurosurgery. In November of the same year he was drafted into the army, served in the army during the Great Patriotic War as a chief medical officer of the 289th Assault Aviation Division. After the war, he was transferred to the Moscow Institute of Aviation Medicine of the USSR Ministry of Defense (1947-1964). At the Institute Yazdovskyy worked his way up from a researcher, head of laboratory, department and administration to the deputy chief of the Institute for Science (space biology and medicine). From 1964 to 1967 Vladimir I. Yazdovskyy worked at the Institute of Biomedical Problems as a head of a sector and deputy director for science; studied the problem of human life support in space flight (substantiation, design and use of medical monitoring systems for space flights). Later he worked at the All-Union Research Institute "Biotechnika" as a chief of the laboratory and as a chief research worker. He is the author of over 270 scientific papers, was awarded 6 orders and more than 30 medals for labour, military and scientific achievements; winner of the International Aeromedical Academy (Belgium) award. Under his supervision candidate and doctoral theses were defended. Yazdovskyy is the author of the famous monograph "On the trail of the Universe" on the contribution of space
biology and medicine to space exploration. Under the leadership of Yazdovskiy in the late 1940s and in the 1950s medical problems, developments of spacesuits and hermetic enclosures were studied, biological research of the upper atmosphere and outer space was carried out. The team, led by V. I. Yazdovskyy, was engaged in medical training of Yuri Gagarin and other cosmonauts of the First Squad.

**Yeager Charles Levant** (1907-1996); in 1935 started using EEG in Mayo Clinic. From 1947 till 1974 he was an employee and chief of EEG laboratory of The Langley Porter Psychiatric Institute, California, USA.

**Yemeshin Konstantin N.** (born on 19.06.1945; USSR), Candidate of Medical Sciences, an Assistant Professor, an Academician of International Informatics Academy. In 1962 he entered the Altai Medical Institute, after graduation performed postgraduate studies, then became a teaching assistant and finally vice-rector for education. In 1971-1978 Yemeshin arranged the courses on "Medical Cybernetics" and "Medical Biophysics" at a higher medical establishment; implemented the project on computerization of the Medical Institute. In 1980-1982 he was a co-developer of the All-Union and republic-wide conception of informational support. He implemented the quality management system of the regional medical aid. From 1984 till 2000 he was the Director of Altai Regional Medical Computer Information Centre and at the same time an assistant manager of regional health service department. Later on he headed a range of information analysis groups. Since 2006 he has been the chief of the Office for Patient Rights Protections of Autonomous Nonprofit Organization "Medicine and Law". Konstantin N. Yemeshin was a presidium member of a task group of the USSR Academy of Medical Sciences (the Russian Federation) "Medical Cybernetics", a chairman of the Academy of Medical Sciences of the Russian Federation for "Fundamental groundings of individual and public health", a public person and a political leader. He is the author of more than 130 scientific works, a member of more than 80 international conferences.

**Zvorykin Vladimir K.** (17(29).07.1889-29.07.1992; Russia) - an engineer, inventor of modern television, graduated with distinction from St. Petersburg Technical Institute, got the degree of engineering technologist. Zvorykin was a student of B. L. Rozing. For a year he studied at le Collège de France looking into X-ray diffraction, then moved to Germany to complete a course on Theoretical Physics at Charlottenburg Institute of Technology. During the World War I he was “under colour”, i.e. officers' radioschool; in 1917 he managed to establish the radio communication between the Taurida Palace and Kronshtadt by the order of Interjacent Government. During the Civil War he moved to Siberia, where he joined the government of A. V. Kolchak. In 1919 he went on a business trip to New York. In the USA he was an employee of a range of the commercial companies, dealt with developments in the field of visual communication. By 1929 he had designed a high-vacuum receiving tube - a kinescope, developed numerous elements for electronic television facilities. The ground-breaking invention was the creation of transmitting electron-beam tube with charge accumulation and high photo-response, which was patented in 1931. In 1933 the television system with expanding up to 240 lines was made, in 1934 – the expansion reached 343 lines with video interlace. In 1936 in the
USA television shows using this system were appeared, and since 1938 the production of cable boxes on the basis of Zvorykin's system started in the USSR. In the second half of the 1930s Zvorykin studied the problems of electronic optics, developed electron microscope together with James Hillier. During the World War II night-vision devices designed by Zvorykin were used in the US army to equip tanks and motor vehicles, and also as a scope. In 1954 he resigned the headship of the electronic laboratory of RCA Company, started to carry on active managerial and scientific work, founded a range of societies in the field of television and radio electronics, including in the spheres of medicine and biology. He is the author of more than 80 scientific works and 120 invention patents. He was awarded 30 different grades, including the U.S. National Science medal and French Order of the Legion of Honour.

* USSR (Union of Soviet Socialist Republics) and Russia are used as synonyms in the text.