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JPRS L/9558

19 February 1981

East Europe Report

SCIENTIFIC AFFAIRS

(FOUO 3/81)

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CZECHOSLOVAKIA

ELECTRONIC INDUSTRY PRODUCTION GOALS, ORGANIZATION IN SEVENTH FIVE-YEAR PLAN

Prague SLABOPROUDY OBZOR in Czech Oct 80 pp 469-471

[Article by Engr Vladimir Hrbek, CSc.]

[Text] There is no need to emphasize the tremendous changes which have been brought about by electronics in recent years in communications, in technological processes, in the automation of human activities, computations and intellectual work in general, in the dissemination of information, culture, and so on. Television, retransmission, and radiocommunication towers add to the present profile of the countryside, households are being filled with electronic equipment, no progressive machinery can be delivered without automation, the equipment used by physicians looks like the equipment of electronic laboratories of research institutes. The market of consumer goods of advanced countries offers a broad assortment of excellent acoustic, broadcasting, and television mechanisms, and equipment to make household chores easier. What is the position of Czechoslovak research and production in the process of "electronization of the national economy"?

The establishment of low-voltage research facilities and of a series of new manufacturing enterprises has been part of the Czechoslovak five-year plans (see for example the book by Frk, Hrbek, et al: "Thirty Years of the Czechoslovak Electrotechnical and Electronic Industry, 1948 to 1978). Czechoslovakia not only supplied products for its own capital market and consumer market, but has also become a significant exporter of this electronic equipment. However, the dynamics and the vitality of electronics and microelectronics on the worldwide scale have surpassed our expectations. What we were used to achieving through innovations within a period of 7 to 10 years was achieved by the most advanced states in 3 to 5 years, and in microelectronics within even shorter periods. These leaps forward in design and especially in the new technologies were the results of scientific research and of the work of the development and applied research apparatus, which required large financial outlays. One new item of technology in microelectronics today costs over 20 million dollars, while the technology of the previous generation cost one-tenth of that amount. In addition, it is necessary to have available not only the scientific-technical base, but also facilities for the manufacture of special materials of a high degree of purity and a number of products delivered under subcontracts.

Under the circumstances which exist in Czechoslovakia, it is necessary to "accelerate the pace." The 15th Congress of the CPCZ, at which the main line of progress was formulated, put emphasis on the need for radical acceleration of the development of Czechoslovak electronics. The CPCZ Central Committee decided at its 14th session in December 1979 to establish an independent branch and a new federal ministry of

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electrotechnical industry. The creation of the new ministry was announced officially by the Presidium of the CSSR Government in its resolutions 306/79 and 55/80. At the beginning of 1980, organizational changes were prepared and a new collective of 222,000 workers of the FMEP [Federal Ministry of the Electrotechnical Industry] was created, and the main tasks were outlined to reach the immediate goals. Conditions are being created gradually at present to bring about an innovation of electronics within the shortest possible time, to create a solid base for microelectronics, and to create conditions in the area of investments, materials, trade and personnel during the Seventh Five-Year Plan for the manufacture and procurement through external economic relations of such an assortment and volume of the products of the electronic industry which are needed by an industrially advanced Czechoslovakia.

1. Electronic Industry Production During the Seventh Five-Year Plan.

Priority will be given to the development of the electronic parts base, which means passive components, semiconductor (discrete) parts, combined microelectronic components or, in other words, integrated circuits, structural elements for radio engineering, products of vacuum electronics, lasers, etc. More parts will be added in the course of time. The production of special machinery and equipment for new and unique technologies, measurements, and testing is related to the manufacture of parts.

The center of gravity of the development of parts is found in combined electronic elements. The density of these elements per chip will be increased several times during the Seventh Five-Year Plan, and the technical parameters will be improved by introducing new technologies, for example the use of electronic lithography, ion implantation, and other methods. Bipolar and unipolar microprocessor systems will be put into production.

With regard to discrete semiconductor components, the assortment of products will be expanded, particularly the assortment of high-output, high-voltage, and microwave parts, elements for opticalelectronics and laser technology, and provisions will be made for the development of hybrid integrated circuits and surface contacts.

The technical parameters for the transmitting electronic tubes and picture tubes will improve. This will include a relative decrease of their input requirements. Their reliability will be increased and the production of a modern color picture tube will be introduced under license.

With regard to electronic consumer goods, a new color television set will be put on the market. It will involve the use of a new picture tube, integrated circuits, and semiconductor components. The assortment of radio receivers will be enriched by the addition of new portable and non-portable models, in the standard and hi-fi categories, combination record players and casette tape recorders, car radios, both with and without a casette player. Amplifiers of higher quality grades will also be manufactured. However, it is necessary to state that the supply on the world market is so varied in terms of assortment that Czechoslovakia will have to supplement the given assortment by imports.

In investment [capital] electronic production, the largest production volume is represented by communications equipment. Automatic telephone exchanges of the third generation and branch electronic telephone exchanges operating under license will be put in production during the Seventh Five-Year Plan. In broadcast engineering, new equipment will be delivered for radio relay communications and systems with pulse

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code modulation. Radio transmitters with outputs of up to 200 kilowatts will be more efficient, less expensive in terms of investment and maintenance. Television transmitters for channels four and five will be fully automated. Equipment will be delivered for transmission via satellites, also equipment for the public radio-telephone network, and landing radars with a high degree of digital signal processing.

Modern electronic drive systems with digital control electronics for metal working, metal-forming, textile, and other machinery are of key importance to the development of the mechanical engineering fields. The level of NC and CNC systems will be increased substantially through domestic development and purchases of foreign licenses.

In the area of measuring and laboratory technology, automation of the measuring process and rational use of measuring instruments will continue to be followed. The systems to be used are modular automated measuring systems, namely the IMS-2 information system and the CAMAC system for nuclear engineering, which satisfy the IEC and CEMA recommendations. A part of the functional units of these systems will be delivered by other CEMA countries.

In laboratory engineering the systems which have become established in Czechoslovakia are electronic microscopy and spectroscopy, nuclear magnetic resonance, material spectroscopy, chromatography and polarography, and other processes. Other systems which will be added are, for example, installations for electronic lithography and some highly demanding installations for microelectronic technologies.

In computer engineering, we participate in the research, development, and production of computers and peripheral equipment (including for example teletypes manufactured under license) which are included in CEMA programs: JSEP, which means the unified system of electronic computers, and SMEP, which means the system of small electronic computers. One of the representative units of the JSEP system will be, for example, the innovative EC 1026 computer, those of the SMEP will be, for example, the SM3-20, SM4-20 units. Products which will be delivered on the market are minicomputers, control computers, microcomputers and some peripheral equipment, particularly display systems, data transmission and collection equipment, and so on.

In automation engineering, it will be possible to program new higher control systems and their modular parts. Sensors and scanners, regulating equipment, servomotors, and other means of automation will be innovated and new ones introduced in such a way that the complex set of technical means would make it possible to create an automatic control system of technological processes of different functions and scopes.

In health service electronics, X-ray equipment will be improved to achieve greater identification capability, to decrease doses of radiation and to facilitate the introduction of high speed imaging and television technics. The fourth generation of the electrooptical visual presentation system will be designed, skiagraphic and skiascopic sets will be automated and equipped with appropriate programs. Types of equipment which are going to be introduced are electronic diagnostic instruments, instruments for biochemical laboratories and dialysis centers for the treatment of renal insufficiency, apparatus of the Czechoslovak monitoring system for intensive medical care units used for the treatment of 6 to 12 patients, good quality listening instruments [stethoscopes] made of domestic parts, cardiostimulators with a longer service life, new instrumental equipment used to replace body organs. The development can be characterized generally by an advancement of electronics, microelectronics and computer technology in health service engineering.

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In research and development, work continues on a number of additional themes. Additional technical applications of science will be used during the Seventh Five-Year Plan.

The development as outlined will depend on innovations of the technological base, on the production of special materials and components, domestic innovations and great efforts of all the members of the large collectives of this industry, on the cooperation of external suppliers, and on the understanding of other departments. Cooperation with the research and production organizations of CEMA countries and the utilization of licenses purchased from top level firms of worldwide reputation will be an important role.

2. Organization of the Branch of Electrotechnical Industry after 1 April 1980

The industrial branch controlled by the Federal Ministry of Electrotechnical Industry (address: Karlovo namesti 7, 120 07 Prague 2) includes all electronic (low-voltage) industry, instrumental, regulatory, and automation engineering, computer, health service, laboratory, and chronometric engineering, and most of the heavy-current industry of the CSSR. This branch includes seven economic production units, three departmental research institutes, and the commercial enterprise TESLA. The branch is under the administrative control of the Minister of the CSSR Government, Prof Engr Milan Kubat, DrSc.

In addition to the simple integration of the VHJ TESLA, ZSE, ZAVT and Chirana enterprises, the enterprises which have been integrated in the branch are the chronometric engineering enterprises Chronotechna in Sternberk and Elton in Nove Mesto nad Metuji, the DIAS enterprise in Turnov, and the VUMA [Research Inst.tute for Mechanization and Automation] research institute in Nove Mesto nad Vahom.

The economic production units are as follows:

TESLA--Electronic Components, concern in Roznov (almost 30,000 workers; Jaroslav Hora, general director) with the following enterprises: TESLA Roznov, TESLA Piestany, TESLA Lanskroun, TESLA Hradec Kralove, TESLA Elstroj, Chronotechna Sternberk, Elton in Nove Mesto nad Metuji, DIAS Turnov. The VHJ includes the Research Institute of Electrontechnical Ceramics in Hradec Kralove. The VHJ produces the following: active and passive components for electronics, ceramic materials and other components, chronometric engineering and technological equipment for electronics and microelectronics.

TESLA--Investment Electronics, concern in Prague (over 30,000 workers; Eng. Zdenek Konsel, general director) with the following enterprises: TESLA Karlin, TESLA Pardubice, TESLA Elektroakustika (in Bratislava), TESLA Strasnice, TESLA, National Enterprise (Prague 9), TESLA Liptovsky Hradok, TESLA Stropkov, TESLA Kolin, TESLA Vrsovice. The VHJ includes TESLA--Telecommunications Research Institute (Prague 10), TESLA--Vacuum Electronics Research Institute (Prague 9). The VHJ manufactures telecommunication, radiocommunication, and special electronic equipment.

TESLA--Measuring and Laboratory Instruments, concern in Brno (almost 15,000 workers; Jiri Stetina, general director) with the following enterprises: TESLA Brno, TESLA Liberec, TESLA Valasske Mezirici, TESLA Vrable, Metra in Blansko (not including manufacturing establishments in Brno and Sumperk), Laboratory Instruments (Prague 6) together with ZPA in Vinohrady. The VHJ includes TESLA--Research Institute for Nuclear Engineering Instruments (in Premysleni). The VHJ manufactures the following: measuring, scientific, and laboratory instruments.

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TESLA--Consumer Electronics, concern in Bratislava (over 19,000 workers: Engr Jozef Stank general director) with the following enterprises: TESLA Bratislava, TESLA Orava, TESLA Litovel, TESLA Prelouc, TESLA Holesovice, and Bateria in Slany. The VHJ manufactures the following: television sets, radio receivers, tape recorders, phonograph sets, lighting sources, batteries and cells, instruments and equipment mostly in the nature of consumer goods.

ZAVT Manufacturing Enterprise for Automation and Computer Equipment (Prague 5 Smichov; over 47,000 workers; general director: Eng. Vladimir Hojka) with the following enterprises: ZPA Kosire, ZPA Jinonice, ZPA Cakovice, ZPA Novy Bor, ZPA Trutnov, ZPA Dukla in Presov, Aritma (Prague 6), Computer Engineering Works (Banska Bystrica), Zbrojovka Brno, ZPA Supplying Enterprise (Prague 4), Office Machines (Prague 1), Datasystem (Bratislava), ZPA Pragotron (Prague 9). The VHJ includes the following institutes: Computer Research Institute (Prague 1), Research Institute for Automation Devices (Prague 4), Computer Engineering Research Institute (Zilina), and Institute for Application of Computer Engineering (Prague 5). The VHJ manufactures the following: computer and automation equipment.

Heavy Current Electrotechnical Engineering Works (Prague 2, Vinohrady, almost 62,000 workers, general director: Engr. Miroslav Matousek) with the following enterprises: Bratislava Electrotechnical Works, MEZ (Moravian-Silesian Electrotechnical Works) Vsetin, MEZ Frenstat, MEZ Mohelnice, MEZ Brno, MEZ Nachod, MEZ Brumov, Electrothermal Equipment Works (Prague 9, Julius Fucik Electrotechnical Works (Brno), MEZ Postrelmov, Elektropristroj (Electric Instrument) in Praha-Modrany, Slovak Electrotechnical Works (Krompachy), Elektro-Praga (Jablonec nad Misou), OEZ (Letohrad), Electrotechnical Works in Teplice, Kablo in Kladno, Kablo in Bratislava, Elektrokarbon in Topolcany, Elektroprocelan (Electroporcelain) in Louny, Electroinstallation Works in Prague, Electroinstallation Works in Bratislava, Electroinstallation Works in Brno, Elektroodbyt (Marketing of Electric Equipment) in Prague. The VHJ includes the following institutes: Research and Development Institute for Electric Rotating Machine (Brno), Research Institute for Cables and Insulating Material (Bratislava), Research and Development Institute for Electrical Instruments and Distributors (Brno). The VHJ manufactures the following: electricmotors, transformers, low voltage and high voltage instruments, condensers, distributors, electrothermal equipment, cables and conductors, electroporcelian, insulators, electrographite, and performs electrical installations.

Chirana, concern (Strara Tura, over 11,000 workers, general director: Pavel Zeman) with the following enterprises: Chirana Stara Tura, Chirana Piestany, Chirana Prague 4-Modrany, Chirana Brno, Chirana Nove Mesto na Morave, Chirana Commerical Technical Services (Prague 7 Holesovice), Foreign Trade Sector (Piestany). The VHJ includes Chirana, Research Institute for Health Service Engineering (Brno). It manufactures health service equipment.

The departmental enterprise is TESLA, Commercial Enterprise (Prague 1, enterprise director: Miloslav Sevcik).

The following are departmental research institutes: Mechanization and Automation Research Institute (Nove Mesto nad Vahom, director: Engr. Frantisek Slanina, CSc.), TESLA--A. S. Popov Research Institute for Communications Engineering (Prague 4, director: Engr. Zdenek Kanka), and Research Institute for Heavy Current Electrotechnical Engineering (Prague 9 Bechovice, director: Oldrich Hora, CSc).

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Let us close the brief information report by expressing our wishes that this industrial branch, starting with electronic components, would soon again find itself among the main group of manufacturers in the world, so that the "electronization of the CSSR national economy" could be carried out as fast as possible and that the new ministry could overcome the obstacles on the road forwardwith optimism and tenacity.

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CZECHOSLOVAKIA

SELF-CONTAINED LIQUID NITROGEN CRYOSURGICAL UNIT PRODUCED, TESTED

Prague CESKOSLOVENSKY CASOPIC PRO FIZIKU in Czech No 5, Oct 80 pp 485-491
received 23 Apr 80

[Article by Zdenek Malek, Ladislav Zobac, Frantisek Soukup, Ivan Krysl, Oldrich Hora, Jan Jelinek, Antonin Ryska and Stanislav Safrata [Malek, Hora, Jelinek and Ryska of Research Institute of High Voltage Electrical Engineering, Prague; Zobac of Institute of Instrumental Engineering, CSAV [Czechoslovak Academy of Sciences] Brno; Soukup and Safrata of Institute of Physics, CSAV, Prague; Krysl of Surgical Research Base, IKEM [Institute of Clinical and Experimental Medicine] Prague-Krc: "A Self-Contained Cryosurgical System With a Cooling Power of 60 Watts at -195°C"]

[Text] A cryosurgical instrument cooled with liquid nitrogen which uses a porous heat exchanger in its freezing tip is described. Because of its high efficiency, a volume of about 400 cm^3 of liquid nitrogen located in a vacuum-insulated container in the handle is sufficient for more than 30 minutes net operating time at the lowest temperature In practice the full cooling power is used only during cooling down of the instrument; cooling to -195°C takes less than 20 seconds at full thermal load with a tissue contact area of 10 cm^2. After the preselected temperature value is reached (-195°C or some other value), the cooling rate is maintained electrically at a value equal to the heat input power from the tissue below the tip. The system is provided with two needle-type thermocouples which make it possible to measure the local temperature of the tissue during cryolysis to within 1°C; this is shown by a digital readout. The complete system has been tested successfully in more than 200 operations, primarily involving cryolysis of benign and malignant tumors.

1. Introduction

The experimental study of the therapeutic effects of local cooling of tissue was begun 129 years ago by the work of Arnott,[1] who tried to treat malignant tumors by applying a vessel containing a cooling mixture at -24°C. The results were not convincing, and accordingly the method did not win acceptance.

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It was only the results of more recent cryobiological research, summarized for example in references 2 and 3, which provided a solid basis for the application of low temperatures in the destruction of pathological tissue. In view of the results of other work (references 4, 5, 6) it can be stated in summary that cryolysis is sufficiently effective given extremely rapid cooling of the tissue to a temperature of -20° to -40°C (according to reference 4, the speed must be greater than -200°C per minute), and relatively slow warming back to body temperature (according to reference 7, slower than +10°C per minute). With rapid freezing, the water outside and within the cells freezes almost instantly, ice crystals are produced in the cells and the concentration of dissolved materials rises to toxic levels; at the same time changes occur in the pH, denaturation of phospholipids in the cell membrane, cessation of protoplasmic movement and other processes which degrade cell viability. During slow warming the larger crystals within the cells recrystallize at the expense of the smaller ones, reaching a size at which the cell membranes are mechanically ruptured. At the same time, the duration of the destructive effects of concentrated solutions is extended. Because even under these conditions between 10^{-5} and 10^{-4} percent of the malignant cells may survive,[4] recently a number of authors have agreed in recommending that the freezing cycle be repeated several times during the operation, producing an exponential decrease in the probability of survival of the frozen cells.

Probably the first cryosurgical system theoretically capable of approaching the above requirements was developed in 1961 by Cooper[8] in cooperation with the Linde Division of Union Carbide. The operating tip was designed for neurosurgery; cooling was effected with liquid nitrogen forced out under pressure from a separate tank through a vacuum-insulated tube into the hand-held operating tool. Subsequently various modifications of this initial version with separate tank were developed which are still commercially available; they are reviewed in reference 9. Advantages of this system are the low weight of the operating tool and the large supply of liquid nitrogen from the external tank, generally sufficient for an entire day's operating work. The mobility of the tool is, however, limited by the system of connecting tubing, whose length delays cooling of the tool at the beginning of the operation and requires a relatively large operating pressure (currently up to 0.8 megapascals [MPa]), which if the thin-walled tool system or the flexible tubing breaks may result in danger to the patient and the surgeon from the violent spray of liquid nitrogen.

Another concept for cryosurgical instruments is the self-contained system, in which the tank is part of the instrument. The short path for the liquid nitrogen between the container and the applicator makes it possible to assure its movement by gravity alone provided that the container is located above the tip, or with an overpressure on the order of 0.01 MPa if the container is located below the tip. This system is practically pressureless and accordingly is entirely safe, while the mobility of the tool is limited only by the thin flexible wires connecting the instrument with the control and indicator electronics. A disadvantage is the greater weight of the instrument and the smaller supply of liquid nitrogen, which generally is sufficient only for a single operation. Probably the first device of this type was built by A. I. Shalnikov at the Institute of Physical Problems, USSR Academy of Sciences in 1962; since that time he has

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developed a number of modifications of this basic conception.[10,11] These devices have, however, relatively small cooling power, and accordingly are suitable for smaller incisions.

Another type of automatic cryosurgical instrument with liquid nitrogen cooling was put on the market a few years ago by Spembly in England, but they no longer offer the self-contained version.

In view of the results in reference 12, which are further analyzed in reference 13, it is clear that sufficiently rapid cooling of the pathological parts of the tissue--at least in the case of rather large incisions with a volume of several tens of cubic centimeters--can be achieved only when the operating tool in thermal contact with the live tissue in question reaches the operating temperature of -195°C in about 20 seconds and remains at this temperature for the entire period of the operation. From this follows the requirement that the cooling power of the tool be at least 50 watts throughout the temperature range down to -195°C. Under these conditions a tissue cooling rate of about -200°C per minute can be achieved at a distance of 10 mm from the operating tool, and at the same time the tissue damage can be sharply circumscribed, i.e. the condition that the distance between the 0° and -20° isotherms (boundaries of tissue necrotization) should be less than 1 mm apart at the edge of the damaged area can be met.

The purpose of this article is to describe the physical conception of a device which meets the above conditions.

2. The Cryogenic Operating Instrument

Joint work by the Research Institute of High-Voltage Electrical Engineering in Prague-Bechovice, the Institute of Instrumental Engineering, CSAV, in Brno, the Institute of Physics, CSAV, in Prague, and the Institute of Clinical and Experimental Medicine in Prague produced in 1977 a self-contained cryosurgical system cooled with liquid nitrogen; the first report of it was published in reference 14. The idea of designing a self-contained system which would allow a wider range of operations arose on the basis of results published in reference 15. The greater than 90 percent efficiency of cooling of the surface of an anisotropic porous exchanger (described in reference 15) offered the hope that because of the small coolant path a self-contained model might make it possible to achieve an extremely rapid drop in the applicator temperature and produce a cooling effect on the order of tens of watts throughout the operation with only a few hundred cubic centimeters of liquid nitrogen.

The main component of the system is the heat exchanger, of which one variant is shown in Figure 1. Liquid nitrogen passes through tube 1 into a porous medium 2 consisting of round, flat copper screens oriented at right angles to the coolant flow which are in thermal contact with inner housing 3 around their circumference. This fulfills the condition of anisotropic thermal conductivity of the exchanger which was examined in detail in reference 15. Nitrogen gas passes out through passage 4 to coaxial passage 5, where it cools the outer walls 6 of the applicator, and passes through channel 7 to tube 8 located in vacuum cavity 9, which is separated from the applicator system by partition 15. The temperature of the

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exchanger is measured by thermoresistor 10. Heating coil 11 is used for warming. The heat taken up from the tissue by interchangeable operating tip 13 is led off by thermally contacting plane 12 and screw 14 to housing 3 and then mostly to porous exchanger 2. The two highly heat-conductive components 3 and 6 are soldered together so that the heat taken up by the surface of cylinder 6 is mostly conducted to exchanger 2, with a small proportion being given up to the nitrogen gas in 5 and 7.

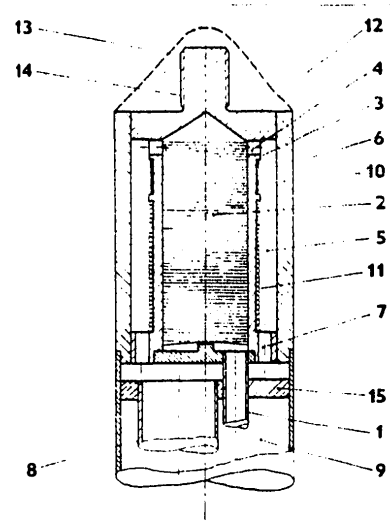

Figure 1. Layout of Applicator with Screen-Type Exchanger

This type of applicator is highly effective for the types of incisions in which the applicator is in thermal contact with the tissue not only at tip 13 but also over cylindrical surface 6. For operations in which the tissue is to be cooled only with top 13 and cooling by surface 6 is not desirable, a similar exchanger with a smaller diameter was developed which is enclosed in an insulating vacuum cavity 9. In this case, only the round front surface 12 of the applicator and connection screw 14 are cooled.

The arrangement of the entire cryogenic instrument is shown schematically in Figure 2. Operating instrument A (numbers 1-15) is interchangeable, is inserted into handle and container B (Nos 16-27) and is connected by a cable to the display and control unit C. Only the porous exchanger 2, the heating element 3 and the electrical temperature sensor 4 are shown in applicator 1 of the operating instrument. The instrument consists in addition of the horizontal 7 and vertical 8 parts of the vacuum container, evacuated by sorbent 9. To it are attached the liquid nitrogen feed 5 and the nitrogen gas outlet 6. The exiting nitrogen is heated in cavity 12 by heater 13 to room temperature and drawn off via nozzle 15 to regulating valve 25. The pressure above the surface of the liquid nitrogen 10 in tank 17 is regulated by bellows 19, which controls switch 20 of the

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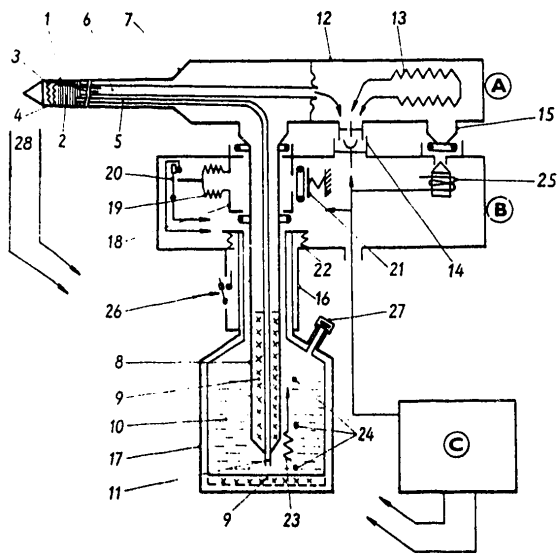

Figure 2. Cryogenic Part (Operating Tool) of Cryosurgical System

circuit for heater 23 in tank 17. The level of the liquid nitrogen is indicated by level sensors 24. The tank can be filled without disassembling the device through filling neck 27. The handle 16 contains function switch 26 and 2 pressure release valves 21 and 22. The electrical installation passes from the operating part of the instrument 1 through tube 6 to connector 14. The electrical readout and control unit C, which will be described in section 3, carries out digital measurement of the temperature of the operating unit and the 2 needle-type thermosensors 28 to within 1°C, as well as automatic control of all functions and monitoring of selected operating parameters. The operating instrument A + B is connected with part C only by a multistrand electric cable, which does not limit the surgeon's freedom of movement. The device can be inclined to ±60° and its function changed whenever desired (switch 26 on front part of handle in Figure 2) between 2 preselected temperature regulation regimes of applicator 1, either at +37°C (preoperation and warming conditions), or at the selected low temperature (generally close to -196°C). The low temperature is regulated by limiting the cooling power with valve 25 in such a way that at any variable thermal load that can realistically come into consideration the preselected temperature can be maintained in section 1. The fine structure of the heat exchanger tube necessitates reliable filtration of any solid impurities in the liquid nitrogen, which is performed by filter 11 at the entrance to tube 5.

The entire operating instrument (cryocauter), together with the electronic display and control units is shown in Figure 3.

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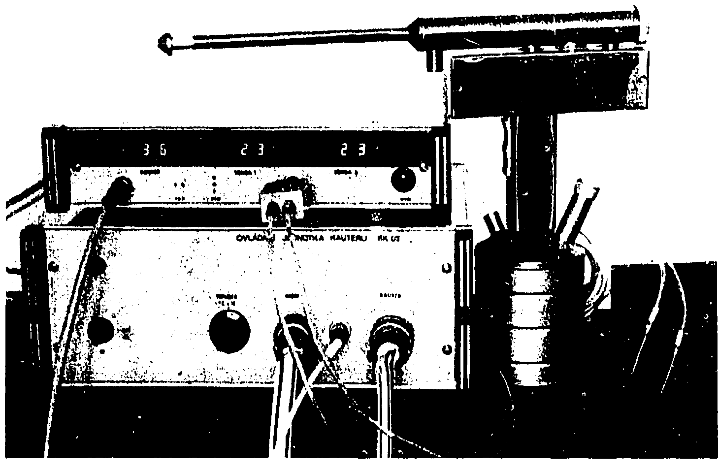

Figure 3. The Complete Self-Contained Cryosurgical System With Inserted Temperature Sensor (Lower Right) and Electrical Display and Control Unit.

3. Electrical Display and Control Unit

A simple diagram of the main functional blocks is given in Figure 4.

The temperature T_A of the applicator is measured by a temperature-variable resistance 4 (the numbers of the individual parts in Figure 4 correspond to the numbers in Figure 2), whose output is converted to the corresponding celsius temperature and shown on the proper display (at left of upper panel in Figure 3), and also fed to the control unit, in which T_A is compared with the present value and depending on the sign of the difference either coolant circulation is started by means of valve 25 or the valve is closed and proportionately controlled heating of the applicator in winding 3 is begun (in this case the heating function is indicated on the display panel at the right under the T_A display by an LED). The control unit always maintains in the applicator the reference temperature which the surgeon selects by pressing or releasing function switch 26 on the handle. The upper temperature is fixed at +37°C, while the lower temperature can be selected by means of a potentiometer in the middle of the lower panel (Figure 3) in a range between 0° and -195°C. The control unit may switch the function from cooling to the low temperature to heating to +37°C if the selected thermocouple 28 located in the monitoring location in the healthy tissue, which must not be threatened with lowering of the temperature below a set level, reaches the set temperature level. Finally, the control unit switches the reference temperature value at which the exit gas heater 13 stabilizes; this temperature is measured by a thermoresistor, which is connected to the heater body; in the rest condition the heater is preheated to +50°C, while it is heated to +80°C during open circulation of the nitrogen.

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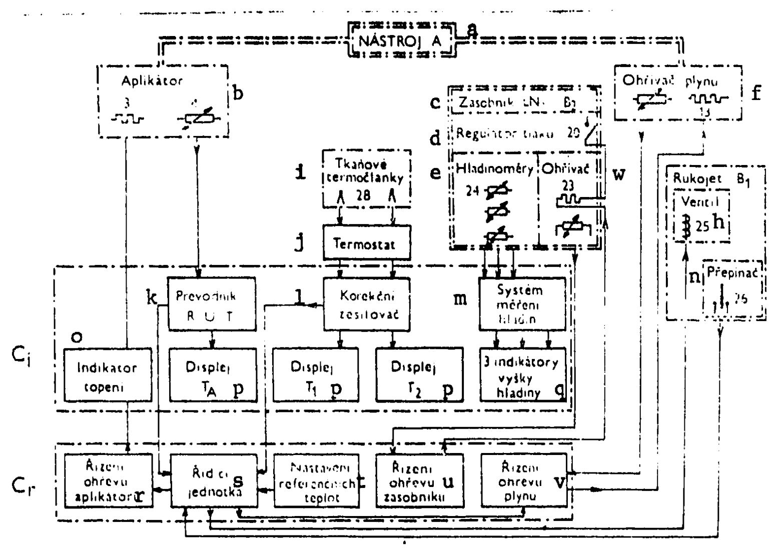

Figure 4. Block Diagram of Display, Regulation and Control Part of Cryosurgical System

Key:

a. Tool a
b. Applicator
c. Liquid nitrogen tank
d. Pressure regulator
e. Level sensors
f. Gas heater
g. Handle
h. Valve
i. Tissue thermocouple
j. Thermostat
k. Converter
l. Correction amplifier
m. Level measuring system
n. Switch
o. Heating indicator
p. Display
q. Three level indicators
r. Applicator heating control
s. Control unit
t. Reference temperature setting
u. Tank heating control
v. Gas heating control
w. Heater

Thermocouples 28, intended for insertion into the tissue being operated on (lower right in Figure 3) are firmly attached to their reference connectors located in a thermostat stabilized to +52°C (plug on the upper panel in the center of Figure 3). This unit is replaceable and the shapes and dimensions of the thermal probes are selected as needed for the type of operation planned. Correction amplifiers with linearizing circuits and devices for converting to Celsius temperature are permanently located, along with the relevant displays, on the indicator panel (center and right of the display in Figure 3).

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To assure transport of liquid nitrogen to the applicator, heater 23 is located in the tank; its power supply is disconnected if the thermoresistor which is in contact with the heater is not immersed in the liquid nitrogen; in addition, the circuit also is controlled by switch 20 of the pressure regulator in the tank.

The liquid nitrogen tank has 3 level sensors 24, whose positions correspond to the locations of the LED's on the indicator panel at left under the central display (Figure 3).

The indicator and control systems are separated into two units designated C_i and C_r in Figure 4, and are shown in actual form in Figure 3. Unit C_r also contains the necessary power supplies for all subsystems. This part of the system need not be close to the operating table, because operations are almost always conducted with the lowest selectable lower temperature value. During the operation, the surgeon may place the light panel C_i within his field of vision.

4. Capabilities of the Equipment and Its Evaluation

This system, designated model 1, was supplied in two complete exemplars, each of which has one tool with an exchanger as shown in Figure 1 and one tool whose cylindrical applicator surface is vacuum-insulated. The first type is used for more extensive incisions in deep tissue structures, for example in the proctological field or in operating on large tumors. The second type is suitable for gynecological, dermatological and stomatosurgical operations, where the cooling effect is useful only in the front surface of the applicator. Other sets of screw-on tips are available for both instruments, making it possible to change the shape of the applicator and thus to assure optimal heat transfer between the tissue and the instrument.

An instrument with a diameter of 12 mm with an applicator as in Figure 1 gives a maximum cooling power of 60 watts at any temperature down to -195°C. In thermal contact with blood-containing tissue, it cools from 37°C to -195°C in an area of 8 cm^2 in less than 20 seconds, which makes it possible to fulfill the conditions for effective cryolysis described in section 1 to a depth of 10 mm from the tip.

The effectiveness of the exchanger and the automatic regulation of the cooling power make operation so economical that a filling of 400 cm^3 of liquid nitrogen is sufficient for more than 30 minutes of operating time, equivalent to powers from 3-5 times to 1/10-1/15 as great. The short travel distance from the tank to the exchanger makes it possible to work with a tank overpressure of only 0.02 MPa, which is very important in terms of the patient's and surgeon's safety. A disadvantage is the greater weight of the instrument, approximately 2.1 kg when full of liquid nitrogen, than that of the system with tubing, and the necessity of occasional refilling of the liquid nitrogen tank in the handle of the device. In contrast to foreign systems with a separate tank, however, there is no need for any external connecting tubing which would limit the freedom of movement of the operating instrument. There remain only the flexible cables connecting the device with the electrical indicator and control unit.

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After laboratory measurements in simulated blood-containing tissue, IKEM Prague tested the device on live rabbits, verifying its functional capabilities and operating reliability. Then followed palliative operations on inoperable malignant tumors, and after positive results were obtained, further neurosurgical, proctological, gynecological, stomatosurgical and dermatological operations conducted by experienced surgeons in more than 10 medical institutes in the Czech Republic. As of 30 November 1979, this system has been used, with the technical assistance of staff members from VUSE [Research Institute of High Voltage Engineering] Prague-Dechovice or FZU CSAV Prague to perform a total of 206 operations, in all of which cases the equipment fulfilled the operating requirements and made possible the intended cryolytic effects including approximately 60 incisions with volumes of about 10 cm^3, and approximately 10 with volumes of more than 50 cm^3, of pathological tissue.

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