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JPRS L/9577

27 February 1981

... FBIS 40TH YEAR 1941-81 ...

USSR Report

LIFE SCIENCES

EFFECTS OF NONIONIZING ELECTROMAGNETIC RADIATION

(FOUO 1/81)

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FOREIGN BROADCAST INFORMATION SERVICE
P. O. Box 2604
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26 February 1981

NOTE FROM THE DIRECTOR, FBIS:

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On behalf of all of us in FBIS I wish to express appreciation to our readers who have guided our efforts throughout the years.

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EFFECTS OF NONIONIZING ELECTROMAGNETIC RADIATION

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CONTENTS

SAFETY STANDARDS AND REGULATIONS FOR PLACEMENT OF RADIO, TELEVISION AND RADAR STATIONS

Moscow SANITARNYYE NORMY I PRAVILA RAZMESHCHENIYA RADIO, TELEVIZIONNYKH I RADIOLOKATSIONNYKH STANTSIY in Russian 1978 pp 1-16

[Approved by the USSR Chief Public Health Physician P.N. Burgasov February 8, 1978, Main Sanitary-Epidemiological Administration, USSR Ministry of Health, No 1823-78]

[Text] 1. General statements

1.1 The main sources of energy emission from electrical magnetic fields of radio waves in populated areas are transmissions from radio-television and radar stations which operate on a wide range of frequencies.

1.2 Current regulations extend to diapason frequencies of 30 kHz-300,000 MHz. These types of radiowaves, which are of concern for public health practices, are classified according to international definitions (see table 1).

1.3 Radiobroadcasting and radio communication stations operate on long (5th band), medium (6th band) and short length (7th band) waves as well as very high frequency wave lengths (8th band). Television stations and television retransmitters operate in the very high frequency band (8th band). Radar stations for radionavigation and radioastronomy operate in the diapason of super high frequency--decimeter (9th band), centimeter (10th band) and millimeter (11th band). Decimeter waves have recently been used for television.

1.4 Transmissions from a radar station are defined by the frequency bands at which they operate, and consist of the following basic elements:

a) radio transmitter
b) feeder lines (a system of cables or wave guides by which the energy is conveyed from the transmitter to the antenna)
c) antenna switches
d) one or several antennae

1.5 Radar stations can be equipped with one or several radiotransmitters. The power of the radiotransmitter is expressed in watts (W) or kilowatts (kW).

1.6 Radio stations broadcast on long, medium and short wave bands, and are equipped with radiotransmitters which are classified according to the power of the transmitters:

a) small power (up to 5 kW)
b) average power (from 5 to 25 kW)
c) powerful (from 25 to 100 kW)
d) high powered (from 100 kW or greater)

1.7 Television stations and television retransmitters are equipped as follows:

a) small power--up to 5/2.5 kW (in the numerator--the power of the transmitter conduit is represented, in the denominator--the power of the transmitter conduit for auditory tracking)
b) average power--up to 25/7.5 kW
c) large power--50/15 kW or greater

1.8 Antenna transmitting equipment and radar stations are the basic emitting elements--that is, the source of energy for the electrical magnetic fields of radiowaves in populated areas.

1.9 Antennae, used for radiobroadcasting and radiocommunication in the medium and short wave bands are characterized by great diversity. According to a beam direction diagram on a horizontal plane, they are subdivided into the following types:

a) non-directional (circular) emission
b) directional emission
c) acute directional emission

1.10 Antennae used in television and for UHF-FM [ultra high-frequency modulation] broadcasting have a circular beam direction diagram on a horizontal plane. They emit electrical magnetic energy evenly in a circle.

1.11 Antennae which are used for radar are characterized by a sharp beam direction diagram on the horizontal plane. They emit electrical magnetic energy in a narrow directional beam. The beam direction diagram can have one or several lobes, in each of which exists a direction of maximum emission.

1.12 Placement of radiotransmitting equipment in populated areas or close to them can cause the population to be exposed to the effects of electromagnetic energy from radiowaves.

1.13 The effect of energy from an electromagnetic field on a population depends on the power of the equipment, the construction features of the emitting system, the location of the population relative to the source of emission and several other factors.

1.14 The systematic effect of magnetic field due to radiowaves with levels exceeding permissible ones can cause changes in the central nervous system, cardiovascular, endocrine and other systems in the human. To prevent the undesirable effects on a population from electrical emissions and magnetic fields from radiowaves, limits defining the permissible level of energy and hygienic regulations for placement of transmitting radio equipment have been established. These basic requirements are outlined in laws currently in effect.

Table 1

International classification			Classification, used in practice of hygienic standardization	
Frequency band				
Basic definition	Parallel definition and threshold of band		Definition and threshold of radiofrequency	Definition and threshold of band wavelength
	Radiofrequency	Radiowave		
5th band	low frequency (lf) 30-300 kHz	kilometer waves 10-1 km		long waves 3-1 km
6th band	medium frequency (mf) 0.3-3 MHz	hectometer waves 1-0.1 km	high frequency (hf) 100 kHz-30 MHz	average waves 1-01 km
7th band	high frequency (hl) 3-30 MHz	decameter waves 100-10 m		short waves 100-10 m
8th band	very high frequency (vhf)	meter waves 10-1 m	ultrahigh frequency (uhf) 30-300 MHz	ultrashort waves 10-1 m
9th band	ultrahigh frequency(uhf) 0.3-3 MHz	decimeter waves		decimeter 10-1 m
10th band	super high frequency(shf) 3-30 MHz	centimeter waves	super high frequency	centimeter 10-1 cm
11th band	extremely high frequency (ehf) 30-300 MHz	millimeter waves 10-1 mm		millimeter waves 10-1 mm

Note: Bands 1-4 are not used for the purposes of broadcasting and, therefore, actual voltage and power are not examined here.

APPROVED FOR RELEASE: 2007/02/08: CIA-RDP82-00850R000300080060-4

2. Units of measurement

2.15 Radiowaves emitted from antennae of transmitting radiostations, travel in space in the form of an electromagnetic field. An electromagnetic field consists of two interconnected components: a magnetic and electrical one.

2.16 The dimensions of electromagnetic energy of long, medium, short and ultrashort waves are defined by the voltage of the field. The voltage units for the electrical component are: volts per meter (V/m) or its derivative (mV/m or μV/m), and for the magnetic component--amperes per meter (A/m) and the corresponding derivative (mA/m or μA/m) (the magnetic component of an electromagnetic field located in a population center has not yet been standardized).

2.17 For the super high frequency (shf) band the electromagnetic field is measured by the density of the energy (flux) (dfe). Watts per square meter (W/m^2) are the units used to describe dfe or its derivative (respectively mW/cm^2, $\mu W/cm^2$).

2.18 The following relationship exists between the levels of the density of energy flux and the voltage of the field:

$$dfe = \frac{E^2}{3.77}$$

where dfe = density of the energy flux in $\mu W/cm^2$
and E = voltage of the field in V/m

3. The maximum permissible dimensions of electromagnetic energy

3.19 The level of electromagnetic energy in populated areas can not exceed the maximum permissible levels as presented in table 2.

4. Requirements for placement of equipment which emits electromagnetic energy from radiowaves in the environment.

4.20 The placement of transmitting long, medium and short wave radio stations, telecenter, television retransmitters, radar stations, radio relay lines of communication must be selected according to the power of the equipment and construction features of the antenna so that the level of electromagnetic energy in the area of residential development does not exceed permissible levels as presented in section 3.

4.21 Transmitting radiocenters, radio stations, telecenters with the power of one transmitter or the combined power of several transmitters of more than 100 kW as well as surveillance radar stations should be placed at the outer limits of populated areas to guarantee adherance to standards for maximum permissible levels of electromagnetic energy.

4.22 In order to decrease the degree of radiation delivered to populated areas antennae of radar stations should be erected on banks (platforms) or natural elevations to maximally limit the effect of the negative angle of incline of the antenna.

4.23 The physical plant of the transmitting radio station, radar equipment, telecenters and television retransmitters must be enclosed in accordance to the requirements of construction regulations and laws for prevention of an accidental fall into the populated areas.

Table 2*

Definition of radio frequency bands	Band thresholds (frequency, length of wave)	Maximum permissible dimensions of electromagnetic energy in an area of residential development
Long waves	30-300 kHz (10-1km)	20 V/m
Average waves	0.3-3 MHz (0-0.1 km)	10 V/m
Short waves	3-30 MHz (100-10 m)	4 V/m
Very high frequency	30-300 MHz (10-1 m)	2 V/m
Ultra high frequency (continuous irradiation)**	300 MHz-300 HHz (1m-1mm)	5 $\mu W/cm^2$

* Radio frequency bands presented in table 2 include the shortest length waves and exclude the longest.

**Only for rotating and scanning antennae with frequencies of not more than 0.5 Hz given the following conditions:
a) time of irradiation with a single sequence intensity not exceeding 1/10 period of rotation or scanning;
b) the ratio of maximum dimension of energy to minimum in equal intervals of time not less than 10.

4.24 Entry of individuals not involved with maintenance into the antenna fields of transmitting radio stations, telecenters, television retransmitters, radio relay line connections is not permitted.

4.25 The placement of residential and public buildings in the physical plant areas which are the source of radiation from electromagnetic energy of radiowaves is not permitted.

4.26 To protect the population from the effects of electromagnetic energy emitted by transmitting radio, television stations and by radar, protective zones between the above-mentioned equipment and residential developments have to be constructed.

4.27 The dimensions of the protective zone must guarantee conformity to the limits established by current standards for the maximum permissible level of electromagnetic energy.

4.28 The dimensions of the protective zone are defined during the design stage by mathematical methods for each piece of equipment in relation to its function, operating frequency, number and power of the transmitters, type and frequency of the antennae and topography of the location. The theoretical computations are verified by actual measurements after the transmitting radio equipment is put into operation.

4.29 The protective zone for transmitting radio stations equipped with antennae of a non-directional effect, for telecenters and television retranslators, as well as for radar stations for scanning is determined according to radius--that is, according to range.

4.30 For transmitting radio stations, equipped with directional antennae as well as for radar stations with antennae which scan a defined sector or which are fixed in one direction, the protective zone is determined by the direction of emitted electomagnetic energy. In this case, it is not necessary to consider the anterior and posterior lobes of the beam direction diagram showing the emissions from the antenna.

4.31 For transmitting radio stations, telecenters, television retransmitters, radar stations with antennae which emit electromagnetic energy at a defined horizontal angle and whose level of emission changes according to the height from ground level, the protective zone is established according to verticles at the following heights (in meters): 3, 6, 9, 12, 15 etc.

4.32 The dimensions of the protective zone of transmitting radio stations, telecenters, television retransmitters and radar stations are presented in tables 3, 4, and 5. They were established for standard radiotransmitting equipment. For non-standard conditions, the definition of measurements for the sanitary-protective zone is produced by computations from actual conditions. The dimensions of these zones depends on the power of the equipment, the type and height of the antenna structure measured from the ground level and diagrams showing electromagnetic energy emissions. Relay placement can be altered to increase or decrease the dimensions of the zone.

Table 3. Dimensions of the Sanitary-Protective Zone for Standard Transmitting Radio Stations

Power of one transmitter	Definition of equipment	Sanitary-protective zone in meters
1. Small power-- up to 5 kW	long wave, medium wave, short wave	10 20 175
2. Medium power-- from 5 to 25 kW	long wave, medium wave, short wave	10-75 20-150 175-400
3. Large power-- from 25 to 100 kW	long wave, medium wave, short wave	75-480 150-960 400-2,500
4. High power-- higher than 100 kW	long wave, medium wave, short wave	more than 480 more than 960 more than 2,500

4.33 Organization of recreational places for the population is not allowed in the territory of the protective zone.

4.34 The level of electromagnetic energy in the building can be lowered by altering certain features of construction. The sanitary-protective zone is subdivided into a zone of "technical function" and one of "restriction."

Table 4. Dimensions of the Protective Zone for Standard Telecenter and Television Transmitters

No.No.PP	Power of one transmitter	Number of programs	Combined power of equipment with calculation for UHF-FM broadcasting	Protective zone in meters
1.	Small power up to 5/2.5 KW	one	up to 10 KW	in limits of physical plant area
2.	Medium power up to 25/7.5 KW	one	up to 75 KW	200-300
3.	Large power up to 50/15 KW	two	up to 160 KW	400-500
4.	High power higher than 50/15 KW	three	on the order of 200 KW	500-1,000

Table 5. Standard Dimensions of the Protective Zone for Standard Radar Stations

No PP	Definition of radar station	Height of antenna installation in M	Protective zone in M	Note
1.	Meteorological radar:			
	"MRL-1;2"	12	3,000	
	"Meteorite-2"	8	3,000	
	"Meteorite-1"	8	250	
	"Meteorite"	4.5	350	
	"MRL-5" II channel	12	2,700	
	I channel	12	5,000	
	"RMP-1"	12	2,800	
	"ARS-3M"	12	4,200	
	"Radiorain" I channel	12	1,600	
	II channel		3,600	
	"SON-4"	12	700	
	"RMP-2"	12	500	
	"ARS-3"	4.5	400	
2.	Surveillance radar, "Saturn" type	8,5	3,000	given a zero angle of antenna inclination

4.35 The "technical function" zone must include the physical plant of the radio-transmitting equipment or the radar station. In some cases, if the "technical function" zone is larger than the physical plant and includes the adjoining territory the borders of which are determined by mathematical calculation on the peripheral border of the "technical function" zone, then the level of electromagnetic energy can not exceed the levels which are permissible for industrial conditions (GOST [state all-union standard]-12. I.006-76)--that is in the radiofrequency bands:

a) long and medium length waves (from 60 kHz to 3 MHz)--50 V/m
b) short waves (from 3MHz to 30 MHz)--20 V/m
c) very high frequency waves (from 30 MHz to 50 MHz)--20 V/m
d) ultra high frequency waves (from 300 MHz to 3,000 HHz)--10 $\mu W/cm^2$.

4.36 The "restricted" zone is the territory which directly adjoins the territory of the "technical function" zone. On the inside border of this territory, the level of electromagnetic energy must not exceed the maximum permissible level for industrial areas and on the outside border--the maximum permissible level for populated areas (point 3.19).

4.37 Structures which are part of radiotransmitting equipment or radar stations can be placed in the area of the "technical functions" zone. This area can also be used for agricultural crops.

4.38 If the "technical function" zone for transmitting equipment exceeds the limits of the physical plant area, warning signs stating "forbidden area" must be erected.

4.39 Administrative-organizational and public buildings can be placed in the "restricted zone" if measures are followed to decrease the level of electromagnetic energy to those which are permissible as specified in point 3.19.

4.40 Design documentation for placement and construction of new and reconstructed transmitting equipment and radar stations must contain data characterizing the distribution of energy of the electromagnetic field of radiowaves in the area adjoining the radio equipment as well as arrangements to protect the population from its effects.

4.41 In residential zones where the level of electromagnetic energy exceeds the maximum permissible dimensions, measures for its decrease must be initiated. Such measures include: limitation of the power of radiotransmitting equipment, changing the direction of the angle of emission and height of the antenna installation, movement of the radiotransmitting equipment from the borders of the residential development or relocation of the population from the zone where the influence of the radiotransmitting equipment is present, etc.

5. Methods to control the voltage and density of the energy flux from the electromagnetic field

5.42 Adherance to levels to maximum permissible ranges of emission from an electromagnetic field must be insured by an organ of the Sanitary-Epidemiological Service which is part of the USSR and Union Republic Ministries of Public Health. These bureaus should oversee construction at the stage of design of the radiotransmitting equipment and monitor its function after installation by means of mathematical determinations as well as by measurement of the voltage and density of the energy flux from the electromagnetic fields in the areas adjoining the transmitting radio stations, telecenters, television retransmitters and radar stations.

5.43 Mathematical determination and measurement of the voltage and density of the electromagnetic field must be conducted according to methods established by the USSR Ministry of Public Health.

5.44 Measurement of the electromagnetic field in terms of the current sanitary inspection rules should be carried out no less than once a year:

--for use of new or reconstructed radiotransmitting equipment
--for use of equipment in new residential tract buildings located near territories adjoining radiotransmitting equipment
--for initiation of changes in the construction of radiotransmitters with antenna systems
--for carrying out changes in the operational pattern of radiotransmitting equipment or parts of its installation which emit electromagnetic energy
--after implementation of repair work on installations which emit electromagnetic energy.

6. Procedures for alteration of regulations

6.46 The present norms and rules are applied at the onset of design and reconstruction of transmitting radio, television and radar stations and other equipment which emit electromagnetic energy in the environmental areas which fall under the jurisdiction of all the ministries and registries of the USSR.

6.47 The responsibility for adherance to the current rules is assigned to the ministries and registries responsible for the equipment which emits electromagnetic energy at radio frequencies.

Note: The publication of the current norms and rules rescinds point 9. "g" section III "The maximum permissible intensity"--"Sanitary norms and rules governing the function of sources of electromagnetic fields of high, ultra high and super high frequencies"--No 848-70.

"Sanitary Norms and Rules for Placement of Radio, Television and Radar Stations" was prepared under the direction and with the participation of Professor M.G. Shandaliy, director of the Kiev Scientific Investigative Institute of General and Communal Hygiene imeni A.N. Marzeyev and Candidate of Medical Science A.I. Zaichenko, assistant chief of the Main Sanitary Epidemiological Maintenance Bureau of the USSR Ministry of Public Health; with the help of colleagues from the Kiev Scientific Investigative Institute of General and Communal Hygiene imeni A.N. Marzeyev: Professor Yu.D. Dumanskim, Candidate of Technical Science and Assistant Professor F.R. Kholyavko, Senior Inspector I.P. Los', Candidate of Medical Science N.G. Nikitina, Candidate of Medical Science A.M. Serdyukov, Candidate of Medical Science M.S. Mukharskov, Candidate of Medical Science G.I. Vinogradov; with the participation of Physician Inspector of the Main Sanitary Epidemiological Maintenance Bureau of the USSR Ministry of Public Health A.S. Perotska; with use of materials from the Kiev Scientific Investigative and Design Institute for Town Building (S.F. Dumanskaya). Institute of Occupational Hygiene and Diseases of the USSR

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Appendix to "Sanitary Norms and Rules for Placement of Radio, Television and Radar Stations" No 1823-78, approved by the USSR Chief Public Health Physician on February 8, 1978

1. Methods for measuring the level of energy from an electromagnetic field.

1.1 In populated centers where radiobroadcasting, television, radio relay and radar stations are placed, controlled measurement of the dimensions of electromagnetic energy should be conducted at least twice a year.

1.2 Measurements of the radiation intensity delivered to population centers must be conducted when the new transmitting systems are installed, when existing transmitters and their antenna-feeder systems are reconstructed and after repair work is performed.

1.3 Measurements should be carried out by radio-specialists who are familiar with similar installations in the presence of a public health physician from the communal division of a sanitary epidemiological station.

1.4 The following equipment can be used for measuring electromagnetic fields:

Equipment type	Frequency band coverage	Thresholds for measurements of an electromagnetic field	Note
PZ-9	0.3-37.5 MHz	0.016 uW/cm^2 -30 mW/cm^2	
PO-1	0.15-16.7 MHz	0.016 uW/cm^2 -30 mW/cm^2	
IEMF-1 [impulse electro-magnetic field]	100 kHz-30MHz	4-1,500 V/m	
PZ-2	200 kHz-30 MHz	0.5-3,000 V/m	
P4-5A	20-MHz-150 MHz	0.001-100V/m	requires additional subgroup
P4-12A	0.15-300 MHz	10^2-10^5 uV/m	"
P4-13A	30-300 MHz	100-10^5 uV/m	"
PZ-13	150 MHz-16.7 MHz	0.5-10,000 uW/cm^2	mean data
M6AZ	200 kHz-300 MHz		manufactured by firm T, German Democratic Republic
M8	"		"

1.5 The location where control measurements of electromagnetic fields are carried out must be selected in accordance with directivity patterns for the antenna on the horizontal plane. Measurements are conducted at various distances from the antenna, both at the point where the beam direction is of maximum emission and in the direction of secondary emission (lateral and posterior lobes of the beam direction diagram).

1.6 Voltage measurement of the field should be conducted at the peripheral border of the antenna field at distances of 50; 100; 300; 500; 1,000; 2,000; 3,000; and 5,000 m from the antenna. Measurements at each point must be carried out no less than 3 times. The results shall represent mean data.

1.7 If an antenna system is positioned close to residential multi-story buildings, controlled measurements should be carried out on each floor.

1.8 For controlled measurements of PPM-SHF energy from rotary and scanning antennae of radar stations, measurements must be carried out for a position of energy emission which is fixed.

The results obtained are applied to the entire sector within the antenna range given its movement in a radius in which the measurements were conducted and these data are not calculated based on the on-off time ratio (the pulse) of the emission.

1.9 The results of the measurements should be submitted to the appropriate specialty journal in the official format for presentation of measurements.
[8144/1227-9139]

9139
CSO: 8144/1227

UDC 615.47:613.647-07

NEW EQUIPMENT AND THE PROBLEMS OF THE UNIFICATION OF METHODS OF HYGIENIC CONTROL OVER SHORTWAVE AND ULTRASHORT-WAVE ELECTROMAGNETIC FIELDS IN THE USSR, GDR, AND CSSR

Moscow GIGIYENA TRUDA I PROFESSIONAL'NYYE ZABOLEVANIYA in Russian No 12, 1979 pp 54-56

[Article by Yu. Kupfer, Z. Gol'tts, S. Eggert (Berlin), B. M. Savin, N. D. Khramova (Moscow), Ya. Musil, and K. Markha (Prague), Central Institute of Labor Medicine of the GDR Ministry of Health, Institute of Labor Hygiene and Occupational Diseases of the USSR Academy of Medical Sciences, and Institute of Hygiene and Epidemiology of the CSSR Ministry of Health, submitted 20 June 1979]

[Text] The problems of hygienic normalization of radio-frequency electromagnetic fields (EMP) as a factor of industrial and living environment are becoming increasingly urgent every year. The development of radio communications, television, as well as the wide introduction of new equipment based on the use of EMP energy in various spheres of the national economy are responsible for a considerable increase in the contingents of people who are regularly subjected to the efforts of hygienically significant levels of electromagnetic radiation.

In order to lower the unfavorable effects of radio-frequency EMP and organize effective protection measures, it is necessary not only to improve further the hygienic norms and sanitary legislation, but also to give more attention to the problems of metrological control over radiation levels. These problems have become particularly important in connection with wide-scale exchange of equipment which includes various types of EMP generators. This determines the urgency of developing uniform hygienic norms and measuring techniques for hygienic evaluation of EMP sources.

Until recently, metrological support has been lagging behind the needs of hygienic practice. This refers particularly to the evaluation of radiation levels in the frequency range of 60 kHz - 300 MHz which cover the range of short and ultrashort waves.

Until 1976, hygienic evaluation of radio-frequency EMP levels of the 60 kHz - 300 MHz range was performed differently in the CEMA-member countries. In the USSR, the field intensity meter IEMP-1 was used for this purpose. The latter was used partially in the GDR and CSSR. However, this instrument has substantial shortcomings in its design: high metering errors (35-40%), great difference in readings between individual instruments, absence of protection against induction, limited interval of operating temperatures (above +10°C), absence of direct reading, heavy weight, etc.

CSSR and GDR did not have specially developed instruments for monitoring EMP levels of shortwave and ultrashort-wave ranges until 1975. In CSSR, modified instruments BM-388 and LB-038 were adapted for this purpose. Both of these instruments also have substantial shortcomings, such as high metering errors, and can be considered, more appropriately, as indicators.

The needs of the sanitation services, as well as the necessity of unifying the methods of hygienic evaluation of EMP within the CEMA countries, put on the agenda the necessity of developing a new and better EMP intensity meter. This problem was solved partially by the development of an electric field intensity meter for the near zone of radiation by the Central Institute of Labor Medicine in the GDR in 1973-1975. The development of the device was a part of the research topic "Unification of Standards for Labor Hygiene. Microwaves and High-Frequency Fields" conducted jointly with the Institute of Labor Hygiene and Occupational Diseases of the USSR Academy of Medical Sciences which, along with the development of the device, included unification of concepts, maximum permissible irradiation levels and methods of measurement. An experimental batch of the instruments with the type designation NFM-1 was produced in the GDR in 1975 and was subjected to industrial and laboratory tests simultaneously in the USSR and CSSR. The purposes, main characteristics, and description of the NFM-1 device are given below. The general view of the device is shown in Figure 1. It is intended for measuring the intensity of the electrical component of EMP in work areas for the purpose of sanitary and hygienic inspection and labor safety. The NFM-1 set includes two measuring antennas and a display unit.

Brief Technical Characteristics

Frequency range 60 kHz - 350 MHz
Measuring range from 1.5 to 2500 B/m
Measurement error ±20%
Transient period of the pointer 1 second
Power supply: working voltage 18 V (2X9 V), current consumption 10 mA
Temperature range from -10° to +40°C
Weight: overall weight 2 kg, weight of the display unit 0.86 kg
Dimensions of the display unit 180X86X100 mm.

The antenna probes are designed on the similarity principle and consist of an antenna head with dipole halves, a carrier tube with a holder, and a connecting cable. The antenna head I is designed in the forms of a double T-shape probe. The overall length of the dipole is 150 mm and the length of

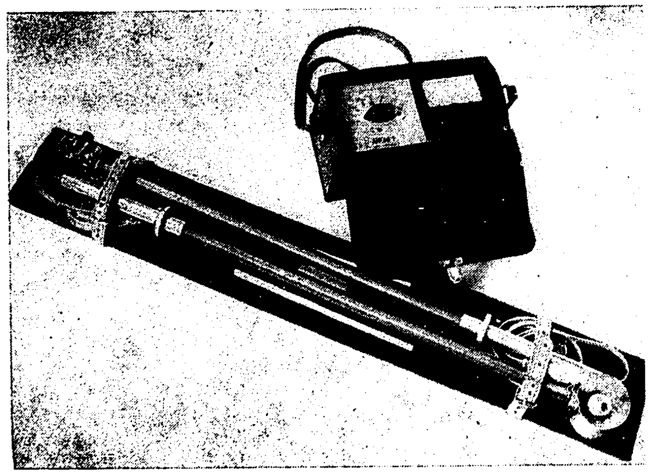

Figure 1. General View of the Device

the cross part is 200 mm. Antenna II has a different design of the antenna head which is a dipole designed in the form of two truncated cones whose total length is 50 mm. The dimensions of the dipole antennas are small in comparison with the wave length of the irradiation being measured, which ensures a nonresonance nature of the interaction of the sensor with the EMP. A high-frequency voltage proportional to the field intensity at the place of measurement is induced in the antenna. This high-frequency voltage is rectified with the aid of a diode situated directly in the head of the antenna (Figure 2).

The rectified voltage goes to the display unit through a high-resistance circuit located in the antenna handle and a connecting cable with a standard five-contact connector. The design of the device and its light weight make it considerably easier to conduct measurements under real conditions (industrial, field, etc).

Industrial and Laboratory Tests of the NFM-1 Device. Industrial tests of the experimental series of the devices manufactured in the GDR were conducted simultaneously in the USSR (Institute of Labor Hygiene and Occupational Diseases of the USSR Academy of Medical Scinces in Moscow and Leningrad Institute of Work Safety) and in the CSSR (Institute of Hygiene and Epidemiology of the CSSR Ministry of Health in Prague) in 1975-1976.

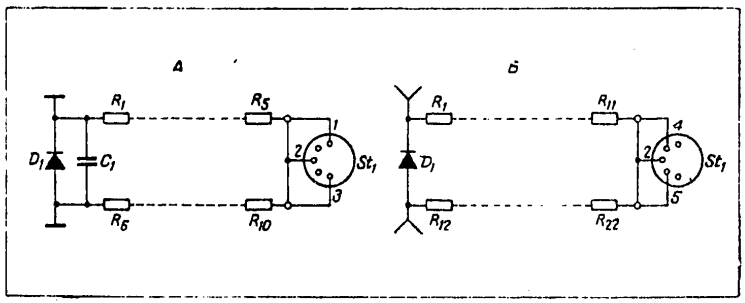

Figure 2. Basic Diagram of the Antenna Probe
A -- Probe I; B -- Probe II

Measurements were done in television and radio broadcasting centers near transmitters, under field conditions in irradiation zones, as well as in shops of enterprises near high-frequency units for induction and dielectric heating of materials.

The results of industrial tests showed that the NFM-1 device has a better design and has a number of advantages in comparison with other measuring devices used for the same purposes (IEMP-1, BM-388, LB-038): direct reading on the scale, higher sensitivity and accuracy of reading in the area of low field intensities (less than 5 V/m), stability of indications, good coincidence of the results obtained by antennas I and II within the covered frequency range (10-30 MHz), small size, and low weight.

The possibilities of the use of the NFM-1 device in sanitation inspection can be expanded by equipping it with antennas for measuring the EMP magnetic component. At the present time, the manufacturing of such antennas has been completed, and it is planned to test them in 1979.

In the CSSR, the NFM-1 device is recommended for the use in sanitation services instead of the IEMP-1, BM-388, LB-038 devices used earlier. A small batch of these devices will be manufactured in the CSSR which will be sufficient for satisfying the needs of the sanitation services of the country.

In the USSR, Gosstandart [State Committee of Standards] conducted state acceptance tests of the NFM-1 device (on the basis of the Belorussias Republican Center of Metrology and Standardization) in September 1976. The program of these tests included the verification and evaluation of technical and operational characteristics provided in GOST 22261-76.

The submitted specimens of the field intensity meters passed the test. The measurement errors do not exceed ±20%, the device is protected sufficiently against external fields, and meets the requirements of group III of GOST 22261-76 with respect to climatic and mechanical factors.

As a result of the tests, the electric field intensity meter NFM-1 was entered in the State Register of Measuring Devices (registration number 6064-77).

At the present time, the NFM-1 devices can be checked in the USSR on the basis of the Belorussian and Ukrainian republican centers of metrology and standardization equipped with reference devices of the types of UPShA-2 and P1-5 with methods given in the technical descriptions of these devices.

The results of studies conducted in the USSR and CSSR showed that further development of measuring techniques for the purposes of sanitation inspection must proceed in the direction of the creation of devices making it possible to measure EMP with various types of modulation, for example, frequency and pulse modulation.

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[216-10,233]

10,233
CSO: 1840

UDC 629.7.05.004(083)

INDIVIDUAL PROTECTION AGAINST MICROWAVE RADIATION AND STATIC ELECTRICITY

Moscow SPRAVOCHNIK INZHENERA PO AVIATSIONNOMY I RADIOELEKTRONNOMU OBORUDOVANIYU SAMOLETOV I VERTOLETOV 1978 pp 390-391, 394-396

[Excerpts from book "Engineer's Guide on Aviation and Radioelectronic Equipment of Aircraft and Helicopters" edited by V.G. Aleksandrov]

[Text] When adjusting antenna-feeder systems, individuals doing this work have to spend a short time (minutes, tens of minutes) in the zone of radiation, where the PPM [stationary paramagnetic fields?] constitute hundreds and even thousands of microwatts per square centimeter. In such cases, if the PPM exceeds 100 μW/cm, one must use personal protection gear. Such gear includes suits, glasses, masks, helmets, etc. (Figures 7.11, 7.12, 7.13). If only the eyes are protected, one uses radioprotective glasses that provide attenuation of over 20 dB. It is hazardous to expose the eyes to SHF energy exceeding 10 μW/cm. The radioprotective suit is made of metal-coated fabric made of cotton with a fine insulated microwire in the threads. Cotton or capron thread wrapped in a spiral with fine metal strips is used. Such a suit permits about 20 dB attenuation. The special suit is laundered and ironed like ordinary clothing made of cotton fabrics.

The clothing materials are divided into three groups according to susceptibility to electric charge. The first (least susceptible) includes linen, cotton, viscose silk (ρ_v* = 10^5-$10^6\Omega\cdot$m); the second (moderately susceptible) refers to real silk and wool (ρ_v = 10^8-$10^{10}\Omega$m); the third (most susceptible) to synthetics (ρ_v= 10^{10} -$10^{13}\Omega\cdot$m).

The volume resistivity of different coating materials on tables is listed in Table 7.6.

The charge drains from the human body concurrently with accumulation thereof. The magnitude of leakage is related to the extent of grounding, i.e., it is determined by the insulating properties of shoes and floor covering.

Shoes have the least resistivity if the soles are made of leather and the most when they are made of microporous rubber.

The floor coverings could have the following values for ρ_v($\Omega\cdot$m): $6.3\cdot10^5$ for concrete and xylolith [wood-stone], 10^6-10^{10} for linoleum, 10^7-10^9 for polyvinylidene tiles and 10^{12}-10^{14} for polyvinyl chloride tiles. The lower the ρ_v the better the conditions for dissipation of charges.

*ρ_v--volume resistivity

Table 7.6. Volume resistivity of surface materials

Material	$\Omega \cdot m$
Textolite [resin-impregnated fabric laminate]	10^7-10^{10}
Getinaks [plastic insulator]	10^8 10^{11}
Rubber	10^{12}-10^{14}
Polystyrene	10^{12}
Butyric-bituminous varnishes	10^{12}
Plexiglas	10^8-10^{11}
Alkaline glass, readily fusible	10^6
Alkaline glass	10^9-10^{10}
Alkali-free glass	10^{12}-10^{14}
Polystyrene varnishes	10^{14}
Ebonite [hard rubber]	10^{13}-10^{15}

Metal chairs with varnished seats and backs are electrostatically charged to a potential of 200 W. If rubber or synthetic tips are installed on [the legs] of such chairs, the potential may reach 1 to 7 kV with friction of clothing.

Electrostatic readings are necessary to study the causes and conditions of electrostatic charging, and to take the necessary protective steps. The potential, voltage of the floor and charge on the object, as well as parameters directly affecting degree of electrostatic charging--resistivity of materials and capacitance--are measured.

One can alter the potential with an electrostatic voltmeter. Since the capacitance of a charge object is known approximately, measurement of the potential will provide only a qualitative estimate of electrostatic charge.

Voltage of the floor and charge density are measured by the noncontact method using electronic electrometers.

The resistivity of floor and table surface materials, resistivity of fabrics and shoes are measured with megaohmmeters (up to $10^8 \Omega$) and teraohmmeters ($> 10^8 \Omega$) in the range of 10^5 to $10^{15} \Omega$.

Electric capacitance of bodies can be measured with any of the commercially produced capacitance gages, for example, type YeG-5A and Ye12-1A.

Figure 7.14 illustrates measurement of resistivity of shoes. A stainless steel plate (external electrode) 3 is placed on base 1 on insulators 2. The shoe 4 is placed on this plate, with the sole pressed down with two rods, an insulating rod 6(d = 17mm) and a metal rod 5 (d = 11 mm) at a pressure of 4 kG/cm^2. Resistivity is measured with measuring device 7. The shoe is considered antistatic if resistivity does not exceed $10^7 \Omega$.

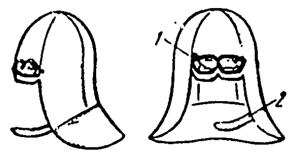

Figure 7.11. Protective helmet with glasses

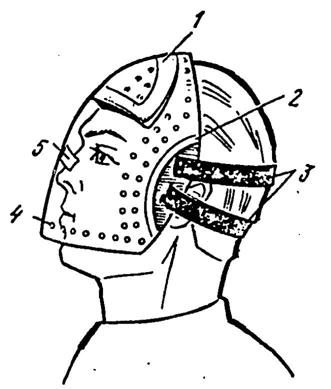

Figure 7.12. Protective mask

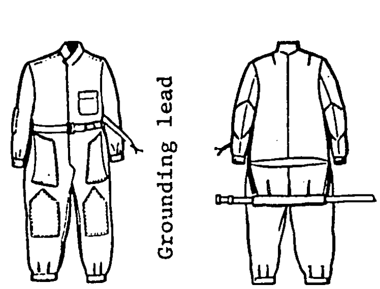

Figure 7.13. Radioprotective suit

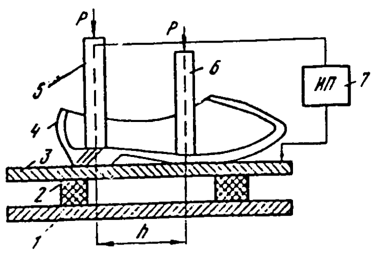

Figure 7.14

Measurement of resistivity of shoes

Elimination of the chief causes of electrostatic charge: For this purpose, one should use surface materials, as well as shoes and clothing, with high conductivity. Materials with volume resistivity below $10^5 \Omega \cdot m$ are virtually not subject to electrostatic charging.

The ρ_v of floor coverings should not exceed $10^6 \Omega \cdot m$. The following materials can be recommended: xylolith, conducting rubber, concrete and antistatic linoleum. The volume resistivity of table surface materials should not exceed $10^6 \Omega \cdot m$.

The soles of shoes should have a ρ_v of less than $10^7 \Omega \cdot m$. The materials to be used include leather and conducting [used for electric wiring] rubber. Conducting rivets, which do not cause a spark upon friction or impact, can be used on the soles that have high resistivity.

Clothing and underwear should be made of cotton.

Containers and various devices should be made of materials that have volume resistivity in the range of 10^5-$10^7 \Omega$.

Chemical treatment of materials, dielectric components of equipment and various devices diminishes their susceptibility to electrostatic charge. The most popular methods involve the use of an antistatic agent to saturate, spray and wipe surfaces. For example, when a thin layer of the antistatic agents, Antistatika and Charodeyka, is applied to the surface, the surface resistivity of textolith decreases by a factor of 10^3, that of linoleum by a factor of 10^5 and polyvinyl chloride by a factor of 10^6. Antistatic treatment of clothing involves ordinary cleaning or rinsing, with addition of a small amount of antistatic agent.

Grounding of objects and bodies is the most effective means of reducing electrostatic charge. In those cases where direct grounding is impossible, electrostatic grounding is used. The object is considered electrostatically grounded when the resistivity of any point of its internal and external surfaces does not exceed $10^7 \Omega$ in relation to the grounding circuit. One should combine the grounding devices for protection against static electricity and electricity. The floor of the work place is covered with electrostatically grounded metal strips on work tables. The housing of equipment, measuring instruments and soldering bit should be reliably grounded.

The seats and backs of work chairs should be covered with cotton fabric. The metal parts of the chairs are grounded through a 1 megaohm resistor. The chair is placed on the grounded sheet at the work place.

Several methods are used to ground people. The charge is removed from the body by grasping a metal object in the hand, touching a grounded busbar, equipment and parts of an aircraft. Electrostatically grounded nippers, bracelets and rings are used. When working with semiconductor products, it is not recommended to wear such items as rings and bracelets since they accumulate electric charges.

It is recommended that an antistatic coat be worn when working in seated position. Coat 1 (Figure 7.15) is connected to pad [pillow] 3 which is grounded. There are current-conducting strips in the fabric of the coat and pad. The charges are removed from the human body via the following chain: hand--coat--pad--ground. Overall resistivity of the discharge chain through measuring instrument 2 should not exceed $0.5 \cdot 10^5 \Omega$.

Individual protective measures for semiconductor products and microcircuitry include devices that provide shielding (for example, lead envelope) or reliable contact [shorting?] of all output leads.

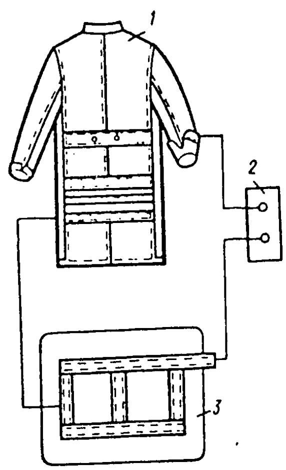

Figure 7.15

Antistatic coat

The steps for protection against static electricity are the most effective when used all together.

[304-10,657]

10,657
CSO: 1840

UDC 577.3:616-006.04

CONSTANT MAGNETIC FIELD: INFLUENCE ON OXYGEN, SUBSTRATE INTERACTION AND THE POSSIBLE MECHANISM OF SOME BIOMAGNETIC EFFECTS

Moscow IZVESTIYA AKADEMII NAUK SSSR in Russian No 3, 1980 pp 415-424

[Article by B.N. Lyu, V.I. Lenin Polytechnical Institute, Alma-Ata, Kazakh SSR]

[Text] The "oxygen" concept of biomagnetic effects is presented, in which the primary element and basic subject to CMF is molecular oxygen. The ability of CMF to forcibly change the movement of paramagnetic O_2 dissolved in liquid and to dissociate it from other participants of oxidizing processes, primarily leads to disturbances in O_2 transport and in bioenergetic cell processes. A series of magnetobiological effects is explained based on the proposed model. Experimental data on the change of pO_2 in tumor tissue under the effect of CMF and the arrested growth of reinoculated tumors (Pliss lymphosarcoma and RS-1) under the combined effect of CMF and hypothermia are cited as indirect support for the oxidizing mechanism of CMF effects and the oxidizing-peroxidizing mechanisms of cancerogenesis.

Various biological effects, elicited by the effect of a constant magnetic field (CMF) are currently generally known (Nakhil'nitskaya, 1974 and others). Facts which represent cellular and subcellular levels of CMF activity are especially important and are indispensible for an understanding of the molecular mechanism of biomagnetic effects. In connection with this, the following known facts can be isolated.

CMF of various strengths decreases cell respiration and brings about a deficiency in ATP, which indicates a decrease in oxidizing processes. This type of reaction, localized in the mitochondria stage of biological oxidation, can lead to a state of hypoxia (Shishlo 1971). Together with the direct effect of CMF on cell respiration, a decrease in the cell (partially embryonic and tumor) oxygen requirement is noted during CMF (Reno, Nutini, 1963; Barnothy 1964). CMF of a strength of 500-3000 e lowers the body temperature in animals (rabbits), which restores itself after 2.0-2.5 hours after the CMF is removed (Inagamov, Chernomorchenko 1974). After sharp hypothermia, CMF inhibits the reestablishment of body temperature in animals, which is related to the decrease in the cell oxidizing processes as well (Shishlo 1967).

The protective action of CMF has been noted in several studies. Thus, under the effect of CMF the resistance of muscles to subsequent gamma radiation has been increased, and the development of radiation syndrome is weakened (Barnothy 1963, 1964; Meyerova 1971). The protective effect of CMF is also established for x-ray radiation of blood leicocites of a healthy person (Sosunov, Vlasov 1976). The authors relate this to possible suppression of free radical processes under CMF. Actually, under magnetic effect on muscle the level of free radical processes, determined by the EPR method, decreases (Piruzyan et al., 1971). On the other hand, the magnetization of normal and tumor tissue increases the SH-group content in them (Kvakina, Mar'yanovskaya 1968).

CMF inhibits cell division in vivo (Galaktionova, Strzhizhevskiy, 1972) as well as in experiments on cell cultures (Kazanin, Trunova, 1970; Sushkov, Neyman, 1972). Especially numerous are the data on growth retardation and tumor regression under CMF (Kholodov, 1970; Ukolova, Kvakina, 1970; Shikhlyarova, 1972 and others); the resorption of some of them is accompanied by a decrease in the concentration of free radicals in the neoplasm (Piruzyan et al, 1969). It has been shown on the cells of ascite tumor [illegible] 134, that magnetic fields suppress DNA and RNA synthesis and the degree of suppression is directly proportional to the strength of the field (Saito, Miyagawa,1976). And only in a few studies is the result somewhat different. Thus magnetic plates 2.4 g in weight and 0.9 mm thick with a field of 350 e implanted under the skin of animals and treated on the surface by hydrocarbons, slowed the appearance of tumors, but the resulting carcomas grew faster than the controls (Kogan, Kulitskaya, 1977).

The given facts can, of course, be interpreted in different ways, given the numerous mechanisms proposed today for the effect of the CMF. However, the facts can be examined from some common points of view, supposing that there is one molecular mechanism but it takes various forms in the various links in the life chain of the animal organism.

The role of oxygen in the biological activity of CMF. In the "oxygen" concept of biomagnetic effects being developed by us, the primary elementary and basic object to receive the effect of CMF is molecular oxygen. The property of paramagnetic O_2 dissolved in liquid, directed to move under the influence of the CMF (Lyu et al., 1978) cannot be ignored in dealing with the results of biological - medical studies with the use of magnets. A result of CMF's ability to alter the movement of molecular O_2 should be the destruction of O_2 transport into cells, and consequently, the destruction of the whole complex of bioenergetic processes related to it. Keeping the O_2 from diffusing into the cells or dissociating it from other participants of intracellular respiratory processes, the CMF thus brings about fictitious hypoxia, when the oxygen present cannot be used in the corresponding metabolic processes and it lowers the intensity of the given processes.

It should be noted that in general the possible mechanism of the dissociating actionof non-uniform CMF (applied to enzyme - substrate interaction) was first studied by Ya. G. Dorfman. It was supposed that for large macromolecules with diamagnetic anisotropy one can find orientation and ordering in uniform magnetic fields and the formation of concentration gradients in non-uniform fields at $10^4 - 10^5$ e (Dorfman 1962). Changes in local concentrations of biologically active macromolecules are reflected in the kinetics of physico-chemical and biochemical processes and are, according to him, the basis of studied biomagnetic effects (Dorfman 1971). However, the tendency of the dissociating action of CMF is represented completely differently in our work; it is limited by the direct influence of CMF of a significantly lower strength on oxygen - substrate interaction.

As is known, normally the respiratory chain of the mitochondria is thebasic channel of O_2 consumption in view of the high affinity of the cytochromoxidase system to it. At a field strength which exceeds a threshold strength, the direct physical effect of CMF on O_2 in the cells will be undoubtedly perceptible: tissue respiration, ATP levels and the O_2 consumption by these cells simultaneously decrease. This is probably the reason that animals (mice) exposed to CMF strengths of 400 and 2000 e for a given length of time have a decreased resistance to a lack of O_2 (Kholodov 1970).

The dependence of the inhibition of O_2 consumption by magnetic fields in a suspension of tumor cells on temperature is interesting (Reno, Nutini 1963). It turned out that this inhibition decreases at increased temperatures and, in particular, at 37°C it is 3.5% less than it is at 32°C. This type of dependency can be understood if the known property of O_2 of significantly lowering its magnetic susceptibility at increased temperature (this property is the basis of the principle behind all magnetic O_2 gas - analyzers) is taken into account. Increasing the temperature of the medium in the given experiments apparently led to a decrease in the CMF effect on paramagnetic O_2, and consequently, a smaller inhibition of its consumption by the cells.

Other well-known users of O_2 in the cell are the oxidizing processes in the endoplasmic reticulum membranes. According to our view, thermal homeostase of warm-blooded organisms is normally supported by microsomal oxidation reactions, which are not linked to the transformation and accumulation of energy, and partially, by processes of peroxide oxidation of membrane lipids: enzymatic NADP · N - dependent and non-enzymatic ascorbate - dependent. The nature of the CMF effect on these processes obviously is analogous to that found in mitochondria: a lowering of the oxidation reaction level and of the O_2 requirement. This "antioxidant" action of CMF explains the effect of decreased thermal output of cells and body temperature on the whole in animals which have been subject to magnetic fields: this is why CMF inhibits the re-establishment of temperature after sharp hypothermia. The given changes are identical to those found during hypoxia, when heat production and temperature also lower (Horstman, Banderet 1977).

The stated ideas correlate well with the radioprotective action of CMF. The existence of this defense is applied in the formation of false hypoxia in cells and in the limitation of radiation possibilities in the formation of free (and among these, peroxidal) radicals and toxic products of free radical oxidation. Corresponding to the known oxygen effect in radiobiology this type of antioxidizing and antioxidant action of CMF should also be radioprotective, In addition, the ability of thiolic compounds to bind free radicals and to deactivate peroxide (Vladimirov et al. 1975) is weakly realized under these conditions, which, apparently, leads to a reduction in the consumption and an increased level of SH - groups in tissues which had been exposed to magnetic fields. Here we find a reflection of our opinion that the current concentration of thiols in the cell probably indirectly reflects the current levels of pO_2, free radicals and peroxides.

The mechanism of antimitotitic activity of the CMF can be studied from the point of view of the recently proposed model of the cell cycle (Lyu, Efimov 1978). In proliferating cells towards the end of period G_2 and during mitosis a state of hyperoxia is postulated, which results from the suppression of respiration. The lipid peroxides which are formed and which inactivate some respiratory enzymes, can complete the cycle with a positive feedback and thus support the hyperoxide state. It is possible that this also explains the increased radiosensitivity of dividing cells as described in the literature. The given characteristic in the energetics of these cells determines the sequence of events: lowering of ATP and cAMP synthesis, increase of the cGMP content (in relation to the trigger character of changes in the cAMP and cGMP in the cell), activation of the phosphorizing of H1 histone (the supposed repressor of DNA replication and mitosis) with the help of cGMP - dependent histonkinase, and an increase in mitotic activity. However, the antioxidation action of CMF in all probability disturbs the function of the "energy" channel control in the cell cycle, resulting in the inhibition of cell reproduction.

The antimitotic effect can be obtained only at a strength of CMF and a duration of its effect which separate our only the action of "excess" oxygen. At high strengths of the CMF the opposite result is possible: in addition to excess O_2 which is basically used in peroxide reactions, the requirement of O_2 in the respiratory chain of the mirochondria is more actively suppressed which leads to false hypoxia, a decrease in tissue respiration and in ATP and cAMP content. But these conditions, as has been noted above, exactly facilitate the stimulation of mitosis, but now under the effect of CMF. This probably explains the fact that eight 24 - hour exposures to CMF of 39.4 ke stimulated mitotic activity of corneal epithelium in mice (Strzhizhevskiy, Galaktionova 1976).

Free radicals, formed in cells and tissues are also strong paramagnetics. This is the basis for the opinion often expressed in the literature about the possibility that the activity of the CMF is through the free radicals; about the participation of the latter in the primary mechanisms of the biological activity of the CMF (Kvakina et al. 1972). As was already mentioned, during the application of CMF on mice, a decrease in the level of free radicals was found, as determined by the EPR technique (Piruzyan et al., 1971). It is not impossible, however, that in these experiments the change in free radical states takes place through a mediator, through the effect of CMF directly on O_2.

In order to determine even approximate limiting conditions under which biomagnetic effects, according to out proposed mechanism, take place, special studies are, of course, necessary. It is already clear that the major factor, in our understanding, is a sufficiently wide range of CMF strength: it apparently most often includes the interval from 100 to 5000 e and gives results as in the experiments of the authors cited above. This allows a direct dependence of the degree of expressed biomagnetic effects (at least some of them) an the CMF strength. Cellular and subcellular changes under the influence of non-uniform CMF actually also depend on the duration of the exposure and the field gradient (Sushkov 1974), whose limits for cells of various organs and tissues are yet to be determined.

On the cancerogenesis mechanism and the antitumor action of the CMF. Data on growth inhibition and tumor regression under CMF are very convincing, although the mechanics of this problem are questionable. In light of our oxidizing peroxide model of cancerogenesis (Lyu, Efimov 1976) this mechanism can turn out to be very simple.

Let us note that the model postulates a hyperoxidal state only for cells of actively growing parts of tumors, peripheral ones and those growing near normally functioning circulatory vessels. In the description below we will be talking precisely about these kinds of actively reproducing tumor cells. The lipid peroxides formed in them are seen as endogenous cancerogenes which continue the function of the primary exogenous cancerogenes or their metabolites after the inactivation of a given spectrum of regulatory proteins and respiratory enzymes. Apparently, in addition to peroxides, protein inhibitors of mitochondrial respiration also take part in the formation of the closed cycle with positive feedback after the creation of a pathological peroxidal condition (Rapoport, Schewe 1977), and their synthesis can be related to the function of the cell cycle (Lyu, Efimov 1978), and has a systematic character in cancerogenesis. The events and processes described also take place in normal dividing cells. The difference, however, lies in the fact that in neoplasm cells they are not transient as they are in normal cells, but take on a stable, established character, determining the usual function of the membrane and the usual energy channels in the regulation of the cell cycle. According to the model, any factor which disturbs respiration in tumor cells is antimitotic and antitumor. Of the many latest facts on the given aspect of the problem one can point, for example, to the following: anthozym (a complex of substances found in red beets), which increases respiration in tumor cells by 500 times, inhibits tumor growth in experiments and in many human tumors (Seeger 1978).

A series of facts bear witness in favor of the oxidizing - peroxidizing model of cancerogenesis. Thus, an increased level of free radicals in the stages of diffuse - focussed hyperplasia and in small primary tumors, induced by various types of cancerogenic factors, indicates a state of hyperoxia and excessive peroxidation in tumor cells (Saprin 1974). EPR signals of free redicals of the peroxidal type were recently registered in samples of reinoculated hepatoma (but not liver), which were exposed to radiation at liquid nitrogen temperatures and gradually warmed (Pulatova et al. 1978).

Hyperthermia of the neoplasm is an important signal indicating a persistent destruction of the bioenergetics of tumor cells. According to some data (Fourre 1975) more than 90% of malignant tumors are already accompanied by hyperthermia at an early stage. Apparently, the destruction of mitochondrial respiration, hyperoxia and the forced O_2 requirement in peroxidation reactions of lipids in tumor cells increase heat production, which now becomes the constant characteristic of the actively growing peripheral zone of the neoplasm.

One of the major results of "energetic" pathology of tumor cells is the systematic harmful effect of endegenic lipid peroxides on membranes and membrane related enzymes. Destructive changes in mitochondria and microsome membranes, in the nuclear and plasma membrane, determine certain energetic, synthetic, biocybernetic and other characteristics of tumor cells. From this point of view the antitumor activity of various antioxidants, in antioxidation, antiradical and antiperoxidation levels is completely natural (Lyu, Efimov 1976).

Spontaneous magnetization regularly found in cell and tissue cultures, especially in unilayered ones, is caused, apparently by the conditions of cultivation: it, as is known, takes place in the presence of pO_2 at a level which is significantly higher than is normally established in the organism. The hyperoxidizing condition itself prepares the culture cells for tumor mutations and brings them closer to the actual moment (Lyu, Efimov 1976). On the other hand, under hypoxia conditions the appearance and growth of experimental tumors are slowed (Blatteis et al. 1974). The vascular contracting effect of the known radioprotector mexamine leads to the situation where together with the artificial decrease in dO_2 the growth of the tumor is also inhibited (Rampan, Berezhnova 1970).

Taking into account the discussion above, the antitumor effect of CMF is seen as a result of its dissociating action in tumor cells on O_2 and other participants of direct and non-enzymatic peroxidal oxidation, the rupture or weakening of the closed cycle of the formation of peroxidal products. The similar action of the CMF directly or indirectly normalizes cell respiration, increases the levels of ATP and cAMP, which, according to our model of the cell cycle, should result in the inhibition of DNA synthesis and mitosis. If this state is maintained for a sufficient length of time with the help of CMF a complete attenuation of the tumor process can be achieved.

From the given points of view it is somewhat more difficult to explain the interesting results obtained in the already mentioned work of A. Kh. Kogan and V. I. Kulitskaya (1977). It may be possible that the delayed onset of tumor growth (which is understood by us) on the one hand, and the more rapid growth of already present sarcomas (which is not yet clear) on the other hand, exhibit the CMF effect obtained by the unusual method of implanting metal plates and some additional factors related to it (direct contact of the magnet with tissue cells, constant exposure, etc.).

In order to examine individual positions on the "oxidizing" mechanism of magnetobiological effects we conducted several series of experiments, the results of which are briefly given below.[1] [[1] The experiments were conducted by members of the Kazakh NII of oncology and radiology, R. M. Yakupova and S. K. Kauashev.] The selection of material for study, various types of inoculated tumors, was dictated by our professional interest in oncology.

Purpose and methods of study. In the first series of experiments we studied the combined effect of CMF and hypothermia on the growth of Pliss lymphocarcoma in white sterile rats in the right side region. Seventy-two hours after the inoculated of the tumor and daily thereafter a permanent magnet was attached by a rubber band to the appropriate area in the rats of the first group. Circular magnets were used in the experiments: the field strength in the center of the magnet was on the average 770 e, the external and internal diameter equal to 38 mm and 18 mm, thickness of 6 mm. The exposure was for 4 hours every 24 hours. Every 3 - 4 days the rats of this group were simultaneously with CMF subject to the effect of hypothermia. The latter was obtained by submerging the rats with the magnets attached in an ice bath for 1.0 - 2.0 hours, during which time their body temperature decreased by 16 °C. At the same time the rats of the second group experienced only daily doses of CMF, the third, only hypothermia and the fourth served as the control group.

In the second series of experiments, which in method were analogous to the first, we studied the combined effect of CMF and hypothermia on the growth of inoculated tumor RS-1. The differences here consisted of the following. All groups of rats were subject to the given effect 10 days after the inoculation of the tumor. The circular magnets were of 600 e strength in the center, external and internal diameters were 21 mm and 9 mm, thickness 7 mm. Hypothermia was affected every 4 - 5 days. The separate effect of hypothermia alone on the growth of the RS-1 tumor was not determined, since it was already known (according to the data of the Kazakh NII of Oncology and Radiology) that it is practically non-existent.

The optimal daily exposure to CMF equal to 4 hours in both series was established by data from previous experiments. From this it was concluded that effective inhibition of tumor growth was not that much different for the 4-hour exposure than it was for 6, 8, and 24-hour exposures, but the 4-hour exposures were significantly better than the 2-hour ones.

The experiments of the third series consisted of determining the changes in the strength of oxygen (pO_2) in the Pliss lymphocarcoma and in RS-1 tumors during uninterrupted exposure to CMF (the magnets were the same used in the experiments of the first series). For this purpose we took rats with tumors 1.5 - 2.5 cm in diameter. The oxygen strength was determined by the polarographic method at various points in the tumor at a depth of 5 mm and more from the surface. The dynamics of change in pO_2 in the neoplasm were fixed for 3 hours, of which the first 2 hours were exposure to CMF and one hour was without the magnet. Platinum electrodes were calibrated the usual way (Kovalenko et al, 1975).

Results and discussion. The interest in doing experiments to determine the combined effect of CMF and hypothermia on the growth of inoculated tumors is aroused by the fact that the magnetic receptivity of oxygen significantly increases at lower temperatures and consequently one could expect an increase in the effectiveness of magnetotherapy under hypothermal conditions up to the prevention of neoplasm formation or the complete inhibition of its growth somewhere in the early stages. This prognosis was completely fulfilled.

Fig. 1

(1) tumor size

(2) 24-hour periods

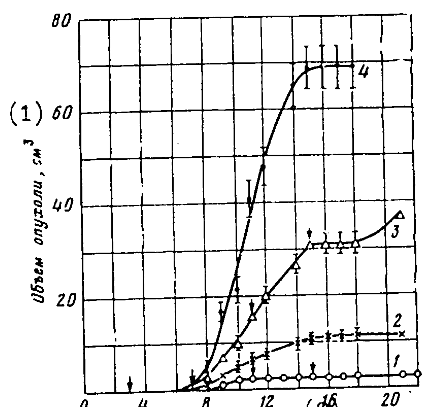

Fig. 1

Fig. 1. The influence of a constant magnetic field and hypothermia on the growth of the Pliss lymphocarcoma: the dynamics of tumor growth under the combined effect of CMF and hypothermia (1), under the effect of CMF (2), hypothermia (3), and the controls (4); arrows indicate days of hypothermia.

As can be seen from Fig. 1, CMF together with hypothermia completely blocks the growth of the Pliss lymphocarcoma already one week after the moment of its first exposure and the size of these tumors at the end of the experiment (the 18-21 st day) is on the average only 3% that of the control group tumors, i.e., their growth is inhibited by 97%. This difference is statistically valid (t=3.9 at $P < 0.01$). Magnetotherapy is significantly more effective than hypothermia : at the given frequencies and durations of CMF exposures and hypothermia they separately inhibit tumor growth by 84% (the difference from the control group on the 18th day is statistically valid: t=3.4 at R 0.01) and 46% (not much different from the control group), respectively.

Analogous results are obtained for the combined effect of CMF and hypothermia on RS-1 tumors (Fig. 2). Their growth is practically completely inhibited already in the early stages of their development. Toward the end of the experiment (on the 40th day) the size of these tumors is on the average 1.46% that of the control group tumors, i.e., growth is inhibited by 98.5%. And in two rats out of 10 no tumors were found. These were the results of the experiment in spite of the fact that after the 32nd day of the experiment all influence on the tumors was stopped.

Fig. 2

(1) tumor size

(2) 24-hour period

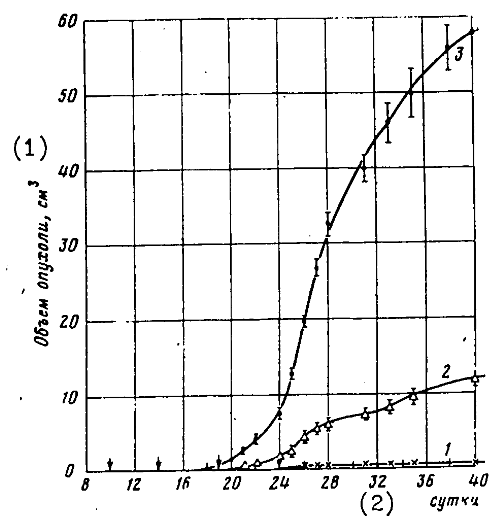

Fig. 2. The effect of a constant magnetic field and hypothermia on the growth of inoculated RS-1 tumor: growth dynamics of the tumor under the combined effect of CMF and hypothermia (1), under CMF alone (2) and the controls (3); arrows indicate days of hypothermia.

The magnetic field alone inhibits tumor growth only by 79.3% when compared to the control group, and this difference on the death of the latter on the 40 - 42nd day of the experiment is statistically valid (t=13 at R< 0.01). From the 32nd day of the experiment on, when the daily exposure to CMF is stopped, the tumor growth began to increase (Fig. 2, 2).

It should be emphasized that the effect of tumor growth inhibition is found in 100% of the cases exposed to CMF in combination with hypothermia, gives good experimental results and can therefore be considered a regular development.

Data on the change of pO_2 in tumor tissue under the influence of CMF are fundamental and have great theoretical and practical significance. After the application of the magnet, pO_2, as is expected, increases in the tumor and when the magnet is removed, it decreases and gradually approaches its original value. The rate of pO_2 increase in the initial period of magnetic activity is actually greater than the rate of pO_2 decrease after uneven removal of the CMF. These features of the dynamic characterization are completely understandable since in one case we have an acceleration in the forced movementof dissolved oxygen in tumor tissue, and in the other, its free diffusion in the tissue toward equilibrium. The nature of the changes described in pO_2 is studied in the whole tumor, but the deeper one goes into the tumor, the less noticeable they become. The "magnetic" principle studied, which governs the strength of oxygen, is apparently valid for any normal or tumor tissue.

The sum of obtained results indirectly supports the proposal that at the base of the biological, and partially antitumor, activity of the CMF, lies a physical mechanism, related to the transport and accumulation of paramagnetic oxygen in areas of greatest CMF strength and to the prevention of its participation in various respiratory processes. The phenomenon of increased pO_2 in "magnetized" tissue exactly demonstrates this point of view. The CMF here creates a false hyperoxia, but at the same time limits its consequences, "forbidding" the consumption of free oxygen (false hypoxia). The acceptance of this proposal helps us to understand the apparent contradiction between out proposed "oxidizing" mechanism of the CMF effect and some of the resulting effects.

The ambiguity of individual results of CMF's biological effects and in part, those of unusually strong fields, is apparently a consequence of the dose-effect dependency, and in this regard the model studied in the given work needs modification and correction.

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APPROVED FOR RELEASE: 2007/02/08: CIA-RDP82-00850R000300080060-4

ELECTROMAGNETIC FIELDS IN ACTIVITY OF NERVOUS SYSTEM DISCUSSED

Moscow ELEKTROMAGNITNYYE POLYA V NEYROFIZIOLOGII in Russian 1979 signed to press 24 Mar 79 pp 2-6, 167-168

[Annotation, introduction and table of contents from book "Electromagnetic Fields in Neurophysiology", by Yu.A. Kholodov and M.A. Shishlo, Izdatel'stvo "Nauka", 1,650 copies, 168 pages]

/Text/ The book analyzes the role of external and internal electromagnetic fields in the activity of the nervous system. It describes reactions to nonionizing radiation realized at organism, system, cellular, subcellular and molecular levels. When the biological effect of electromagnetic fields is discussed, the nonstability of nuclear configuration of multiatom systems, the cooperative Jahn-Teller effect and the vibronic mechanism of amplification of weak low-symmetry perturbations are examined. The great importance of the processes occurring in biological membranes with the participation of calcium ions in the perception of external electromagnetic fields by biological systems is stressed. Among the practical applications of electromagnetic biology ecological, hygienic, therapeutic and diagnostic research trends are noted. The book is intended for neurophysiologists, biophysicists, biochemists, biologists of broad specialization and physicians.

Introduction

The number of publications on the biological effect of electromagnetic fields is increasing intensively and approximately one-half consists of references on the reactions of the nervous system to electromagnetic fields. At the same time, professional neurophysiologists are not often interested in the role of external and endogenic electromagnetic fields in the activity of the nervous system. Here it is appropriate to note the Soviet researchers M. N. Livanov /96 and 97/, P. K. Anokhin /5/, P. G. Bogach /20 and 21/, K. V. Sudakov /158/ and others. Among foreign neurophysiologists W. Adey /204, 209 and 210), N. Chalazonitis /239 and 240/ and others should be singled out.

Usually, the role of electromagnetic fields in the activity of the nervous system is not discussed in handbooks of neurophysiology and of general biology. At the same time, taking into consideration the fundamentality of such a physical phenomenon as electromagnetic fields, it can be assumed that in the process of evolution the biosystem and, in particular, the central nervous system should have not only adapted itself to this omnipresent environmental factor, but also utilized it in its activity.

The scientific and technical revolution sharply changes the environment and greatly increases the electromagnetic background in industry and in everyday life. There is a danger of an "electromagnetic pollution" of the environment. Therefore, a hygienic evaluation of electromagnetic fields has become the dominating problem in electromagnetic biology and many symposiums have been devoted to it /104, 117, 161, 197, 207-209 and 223-228/.

However, the therapeutic trend in electromagnetic biology can be considered the oldest. This trend has now again begun to develop intensively, drawing new ranges of electromagnetic fields into its orbit /35, 102, 207, 208, 316 and so forth/.

Electromagnetic fields have begun to be considered an ecological factor comparatively recently. However, generalizing publications also analyzing this important role of the given physical factor have already appeared /130, 131, 148, 216, 227 and so forth/.

The trend in which the functional importance of electromagnetic fields of biological origin is recorded and clarified is the youngest /47, 48, 97, 130 and so forth/. In our opinion, however, the trend in electromagnetic biology, which for theoretical purposes utilizes electromagnetic fields as a distinctive research tool capable of clarifying the fundamental principles of biological organization should be considered the most promising /130, 180, 227 and so forth/.

Along the path of the wide utilization of various electromagnetic fields in biological research it is necessary to remember that this physical factor is a complex phenomenon of nature and in connection with this possesses several biotrophic parameters. The (electric or magnetic) component of electromagnetic fields, intensity, gradient, vector, frequency, pulse shape, exposition and localization can be included here.

The entire spectrum of electromagnetic fields can be conventionally divided into two large ranges--ionizing and nonionizing radiation. When quantum energy is sufficient for the ionization of a substance, biological effects are initially determined by this phenomenon--the ionizing and penetrating power of electromagnetic fields. However, if the quantum energy of electromagnetic fields is lower than the energy necessary for the ionization of a substance, the field effects are determined by other mechanisms based on the redistribution of the energy of the target system over its degrees of freedom. An analysis and disclosure of the mechanisms of action of nonionizing electromagnetic fields acquires a special meaning in modern biology. As the quantum energy of electromagnetic fields decreases, the role of the properties of the target in the final result of its interaction with the field increases considerably. This opens up wide prospects for the utilization of electromagnetic fields for a study of the properties and mechanisms of functioning of the living tissue.

We would like to note that theoretical biophysicists are only beginning to get interested in this problem. Numerous attempts to interpret the biological effects of nonionizing electromagnetic fields from the standpoint of thermodynamics lead to ideas of their fluctuation probability effect realized through trigger amplifying mechanisms of the living system, which determine the final effects of interaction of the field and biological system [9, 36 and 114].

Along with this in the last few years an idea has been formed on the informational resonance mechanism of biological effect of nonionizing electromagnetic fields based on the assumption that there is a certain relationship between the properties of the target and space and time characteristics of the field ensuring a multiple amplification of the final result of interaction of electromagnetic fields with the biological system [36, 130 and 176].

The formation and development of biology and medicine are inseparably connected with the study of the constancy of the internal environment of the biological system--the study of homeostasis. However, the constancy and pattern of occurrence of numerous internal processes determine only one aspect of biological systems, because along with this they are highly sensitive to a number of external effects, including electromagnetic fields, which characterizes them as unstable systems.

The thesis that the living system in a stationary state is characterized by a stable nonequilibrium and the very constancy of the internal environment is the result of this stable nonequilibrium was formulated in E. S. Bauer's original works [15]. This thesis is profoundly substantiated in the works on the mathematical modeling of processes occurring in the cell [38 and 136]. At present it becomes obvious that the biological system represents a distinctive interweaving of both unstable (probability and random) and stable (regular and necessary) processes, which is clearly manifested in the existence of biological rhythms [31, 86, 125 and 143]. As yet we know very little about the role and physical principles of unstable probability processes in biological phenomena. In connection with this one can hope that the study of the biological effect of electromagnetic fields and their mechanisms will open new pages in this problem of modern biological science.

The evolution of biological systems occurred through unicellular to multicellular organisms with a specialization of individual cells and tissues and the formation of a nervous system performing the function of perception of external signals and regulation of the internal environment of the organism. Highly developed biological systems are characterized by the presence of powerful mechanisms of regulation and maintenance of energy, adaptive and reproductive homeostasis, which protect the system from unfavorable environmental factors.

At the same time, however, the entire system becomes highly sensitive to the characteristics of regulatory mechanisms maintaining homeostasis.

In connection with this the study of the effect of electromagnetic fields on the nervous system of multicellular animals acquires special importance, because it opens up new ways to the control of system reactions of the whole organism and disclosure of the patterns in their formation.

An attempt at an analysis of the role of external and endogenic electromagnetic fields in the activity of the nervous system is presented in this work. The analysis is based on a system approach with due regard for the hierarchical principle of functional organization of the nervous system. In addition to the authors' own conclusions and experimental data, this work utilizes the literary sources from recent years, mainly the 1970's. The explosive nature of publications on electromagnetic biology /234, 237, 250 and 259/ makes an exhaustive description of the literature on the selected subject too difficult. In connection with this references to generalizing publications, that is, collections, monographs, dissertations and so forth, are mostly made.

A physical description of oscillatory and wave electromagnetic processes is absent in the account of the primary mechanisms of action of electromagnetic fields, because the general ideas of them are known, available to a wide audience and quite sufficient for reading this work. In connection with this it can only be noted that in the last few years the generalization and interpretation of a number of laws of electromagnetic induction have been made on the basis of the theory of relativity, according to which all physical processes depend on the relative speeds of systems with respect to each other /55/. It is precisely this principle that forms the basis for the emergence of Lorentz force on the charge moving in a constant magnetic field and in the phenomenon of emergence of a magnetic field in the movement of charges.

The phenomenon of emergence of an electric field of a "charge equivalent," which occurs in physical objects when the mean squares of speeds of positively and negatively charged particles change, that is, when the energy of particles carrying unlike charges changes, attracts special attention in this series of electromagnetic effects (V. I. Dokuchayev, [176]). The field of the "charge equivalent" is characterized by the property of a monopole component and by the penetrating capacity through solid electric conducting screens. The assumption that fields of a monopole nature emerge in biological systems makes it possible to understand the exchange of information between living organisms in liquid media with a good electric conductivity. At the same time, there is every reason to expect the effect of emergence of the charge equivalent and the generation of fields of a monopole nature in electrochemical processes occurring in the nerve and muscle tissues of biological objects.

The authors made an attempt to unify the uncoordinated experimental data on electromagnetic physiology, gradually changing over from the lower levels of organization of the nervous system, which are characteristic of any biological system, to higher levels, including sensory processes. It is up to the readers to judge how successful this attempt is.

We consider it our pleasant duty to express our thanks to M. N. Livanov, academician of the USSR Academy of Sciences, in whose laboratory a significant number of experimental investigations were performed, for his constant attention to our work, and profound gratitude to Prof O. A. Krylov for the useful discussions of the mechanisms of biological effect of electromagnetic fields. We thank Prof N. I. Losev, Doctor of Medical Sciences M. G. Ayrapetyanets and Doctor of Medical Sciences R. I. Kruglikov for their valuable critical remarks in the course of preparation of the manuscript for publication.

Contents

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UDC 577.391

MICROWAVE-INDUCED THERMAL STRESS

Moscow IZVESTIYA AKADEMII NAUK SSSR: SERIYA BIOLOGIYA in Russian No 5, 1979 pp 724-731

[Article by V. S. Tikhonchuk, V. V. Antipov and B. I. Davydov, submitted 30 Jun 78]

[Text] Summary

In experiments on 159 fully matured dogs with an average weight of 6.5+71 kg [sic], the dynamics of physiological indicators (rectal temperature, respiratory and cardiac activity) were studied in reaction to thermal stress and various (percentage) effects of death according to power density (500,300, 100 mW/cm^2) and time of microwave (2,400 MHz) irradiation.

On the basis of the data, it was found that the relationship between power density (PM) and time of microwave irradiation, with an equal probability (0.1 percent) of death, can be interpolated ($100 < PM < 500$) by an indicative function equation of the type $y = 1416\ x^{-0.8156}$, where y = PM, mW/cm^2, x is irradiation time in minutes.

The probability characteristics of adaptative resources of functionally responsible systems of the test population were derived for threshold values of death not exceeding undetermined values.

Specific physiological characteristics of thermal stress in dogs have been studied by Howland, Thomson, Michaelson (Howland, Michaelson, 1959; Howland et al., 1961). They established a directly proportional relationship between the magnitude of rise in rectal temperature, time and density of power (PM) of microwave irradiation, its exponential decrease after cessation of irradiation, and the presence of adaptation to exposure; several systemic (blood) shifts have been described. From our point of view, this research indicated the advisability of studying physiological characteristics of thermal stress to correlate them with well known functional relationships of the irradiation time-versus-effect (death) type.

The goal of the research was to obtain information on the quantitative relationship between the magnitude of a lesion reaction and functional shifts undergone by the respiratory, cardiovascular systems, dynamics of rectal temperature and time of microwave irradiation with PM = constant; on the basis of these data, we wanted to derive a probability characterization of adaptative resources of functional systems of the test population of animals with threshold values of death not exceeding 0.1 percent.

Methods

The experiments included 159 fully mature dogs with an average weight of 6.5 ± 0.71 kg. The animals were irradiated with microwaves (2,400 MHz) in an echo-free chamber with PM = 100, 300, 500 mW/cm^2 at ambient temperature of $21.0 \pm 0.92^{o}C$. Unevenness of the experimental power field of microwaves did not exceed 3 dB. The system of securing the animals was borrowed from the work of Ely and Goldman (1956). The first three groups of animals from subgroups of 8,8,8,9,8 (PM = 100 mW/cm^2), 11,10,10,10,10 (PM = 300 mW/cm^2), 8,8,8,8,8 (PM = 500 mW/cm^2) of animals were irradiated for 34.0; 36.5; 39.0; 41.0, 45.5 minutes (PM = 100 mW/cm^2), 5.0; 7.0; 8.0; 9.0; 12.0 minutes (PM = 300 mW/cm^2), 4.0; 5.0; 6.0; 7.0; 8.3 minutes (PM = 500 mW/cm^2), respectively. The 4,5,6th groups of animals in subgroups of 4,4,3 (PM = 300 mW/cm^2), 4,4 (PM = 500 mW/cm^2), 4,4 (PM = 100 mW/cm^2) animals were irradiated for 3.0; 6.3; 8.3 minutes (PM = 300 mW/cm^2), 3.85; 5.8 minutes (PM = 500 mW/cm^2), 26.4; 39.0 minutes (PM = 100 mW/cm^2), respectively. The dynamics of rectal temperature (thermistor method), number of respiratory movements and rate of cardiac contractions in 10 seconds (average value of six 10-second intervals each minute) during and after microwave irradiation and dynamics of animal death were studied. When necessary, empirical distributions expressed an algebraically adopted level of reliability of $P < 0.05$.

Results and Discussion

Figure 1 shows the empirical and corresponding theoretical distributions of elevated rectal temperature (curves 1, 3, 5) and effect of death (curves 2, 4, 6) as a function of time of microwave irradiation at PM = 500, 300, 100 mW/cm^2, respectively.

The relationship between magnitude of elevated rectal temperature and the time of irradiation in a wide range of injurious effects is described quite well by a linear functional equation which becomes asymptotic at extreme values (Figure 1, curves 1, 3, 5). The theoretical relationship between death and time of microwave irradiation (Figure 1, curves 2, 4, 6) can be interpolated by a linear function (probit-analysis) of the kind: $y = 17.2605x - 8.1959$; $y = 12.2733x - 6.0840$; $y = 18.1780x - 23.9172$, respectively, where y is the value of death in probits, x is the log of time of irradiation in minutes. For equally assigned effects of death, for example 0.1, 50.0 and 99.9 percents, the relationship between PM and time of microwave irradiation is interpolated within the test PM values by indicative type functions : $y = 1416x^{-0.8156}$, $y = 2291x^{-0.8529}$, $y = 3540x^{-0.8608}$, where y is PM in mW/cm^2, x is time of irradiation in minutes.

The experiment data (Figure 1) provide an idea of the interrelationship of the process of elevated rectal temperature and the dynamics of injury in microwave irradiation. In comparable time segments

$$V_{\Delta T_1} > V_{\Delta T_3} > V_{\Delta T_5},\ V_{\text{пор}_2} > V_{\text{пор}_4} > V_{\text{пор}_6},$$
$$(V_{\text{пор}_2} > V_{\Delta T_1}) > (V_{\text{пор}_4} > V_{\Delta T_3}) > (V_{\text{пор}_6} > V_{\Delta T_5}),$$

where $V_{\Delta T1,3,5}$, $V_{por2,4,6}$ are the rate of increase of temperature and effect of damage at 500,300, 100 mW/cm^2, respectively.

In the first approximation, the relationship between the temperature gradient ΔT and PM for equally probably (Figure 1, z-axis) levels of death can be interpolated by a direct kind of equation y = Ax + B, where A = 0. For our case, y_{1-3} equal 2.16°; 3.52°; 4.78° or, taking ΔT_{max} = 4.78° as 100 percent, 44.5, 73.3 and 100 percent, respectively.

In Figure 2 is shown the dynamics of the number of cardiac contractions and respiration during microwave irradiation in percentages of the maximum increase in pulse rate at PM = 500 mW/cm^2, which is taken as 100 percent. If the relationship between the test indicator and irradiation time is a function approaching the parabolic, assuming the maximum expression of adaptation resources of the dog organism to be at the apex of the parabola, the figure makes it clear that the time of acquisition of the parabolic apex is inversely proportional to PM; its relative and absolute magnitude are inversely proportional to PM; as PM diminishes the range of injury from 0.1 to 99.9 percent (Figure 2, hatched region) is displaced from the parabolic peak to the left, in inverse proportion to PM (exception: frequency of respiration at PM = 100 mW/cm^2). When comparing the dynamics of indicators (Figure 2), we may assume greater injury to the respiratory center than to the vasomotor. In fact, at high PM (500 mW/cm^2), the respiration rate drops below its initial level almost immediately after the onset of irradiation and continues its intensive drop, whereas the pulse rate shows a reliable increase. At PM equal to 100 mW/cm^2, when the rate of temperature rise triggers the entire complex of adaptation reactions, the range of injury effects from 0.1 to 99.9 percent is related to a drop in respiratory activity, while cardiac activity rises during comparable times of irradiation.

The logical premise from analysis of test data represented in Figures 1 and 2 (system of inequalities due to correlation of rate of increase in rectal temperature gradient and injury effect; relationship with later functional shifts in respiratory and vasomotor centers) is the presumptive existence of an inverse functional relationship between the absolute value of the rectal temperature gradient and PM under equally probably conditions of injury effect. An increase in absolute value of the gradient could be anticipated with a decrease in the PM of microwave irradiation. Indeed, we have a unique effect of "programming" by the organism of animals of an equally probably death at the same value of T, regardless of the power density of microwave irradiation and its biological analog--the rate of rectal temperature increase (Figure 1, z-axis). This phenomenon, in principle (according to the value of absolute death) agrees quite well with the theoretical calculations of Hoeft, 1965) and at first glance, contradicts the well known pattern between dose (product of absorbed PM

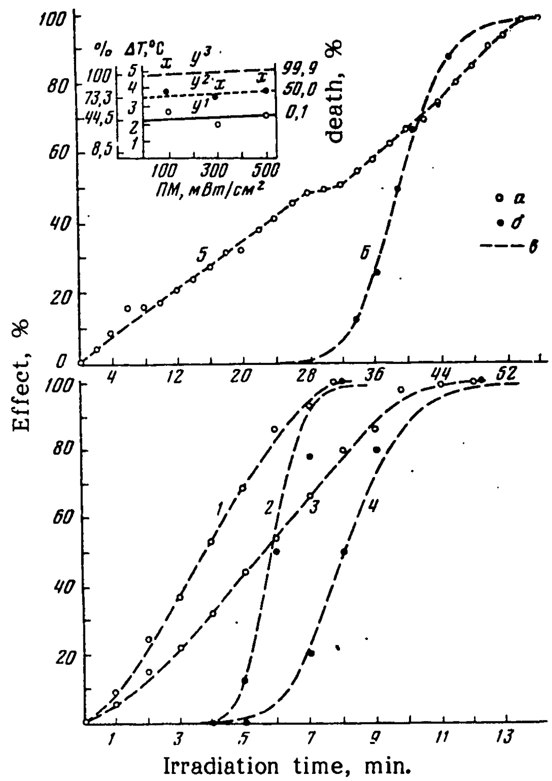


Figure 1. Magnitude of rectal temperature gradient (1,3,5 in percents of ΔT_{max} = 4.26; 4.27; 5.8°C, resp.) and injury effect (2,4,6) as a function of time of microwave irradiation with PM = 500 (1,2), 300 (3,4), 100 (5,6) mW/cm^2. Z-axis: gradient of rectal temperature (°C, percentage of ΔT = 4.26°) versus PM with equally probable: 0.1, 50.0, 99.9 percent (y_{1-3}, respectively) injury effects. Dots show empirical distribution, dashes show theoretical ones.

times irradiation time) and effect (for the given case, the quantity Δ T). However, if the death curve is viewed as an integral reaction due to functional activity of systems vital to thermal regulation, then the functional relationship (Figure 1, z-axis) can be evaluated as a "programmed" multisystemic adaptative reaction of animals developed in the evolutionary process in support of thermochemical constancy and retention of optimum homeostasis.

Experimental data on the correspondence of time parameters of equally probably effects (Figure 1) and the dynamics of respiration and pulse rates during the irradiation period (Figure 2) indirectly suggest that the animal organism should compensate for and simulate such "programmed" reaction because of the different type of function of systems guaranteeing this kind of balanced state. If this tendency (system of inequalities) is considered during microwave irradiation, this difference should become more obvious after cessation of irradiation . Analysis of test data of 4-6 groups (Figs. 3,4) confirm this assumption.

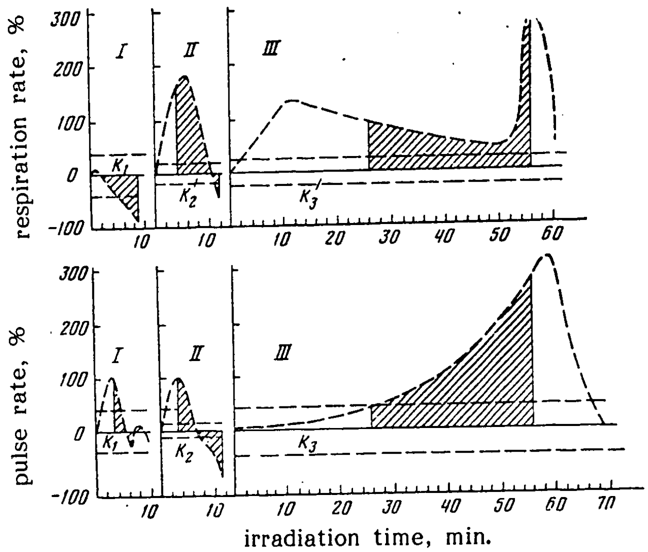
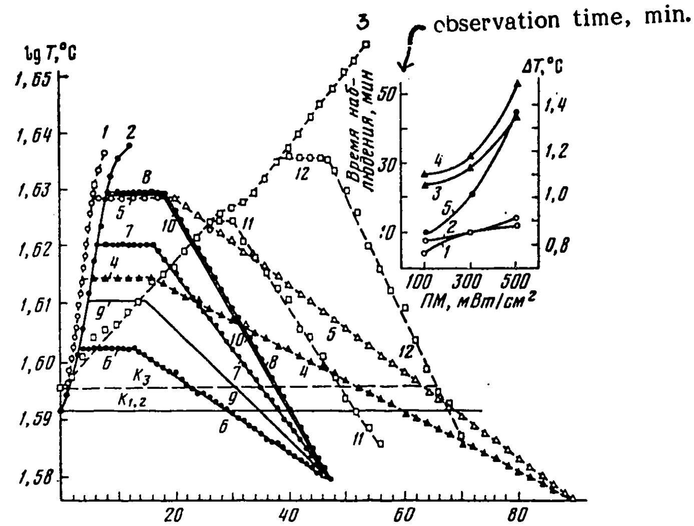


Figure 2. Dynamics of pulse and respiration rates in microwave irradiation with PM = 500 (1), 300 (II), 100 (III) mW/cm^2. Data are represented in percents of maximum rise (15 in 10 sec.) of pulse rate at PM = 500 mW/cm^2, taken as 100 percent, with initial value for cardiac (20,17,19 in 10 sec.) and respiratory activity (16,10,19 in 10 sec.), resp. Shaded areas of figure (from left to right) are the range of injury effects from 0.1 to 99.9 percent.

The dynamics of average magnitudes (according to subgroups of 4,4,3 dogs of the 4th group) of the rise (curve 2) and drop (curves 6-8) of rectal temperature after 3; 6.3; 8.3 minute irradiation with PM = 300 mW/cm^2. It is characterized by a linear rise during irradiation (curve 2), by a plateau for 10 minutes and exponential section interopolated for curves 6-8 by this kind of equations:

$$C_6 = 39{,}95e^{-15{,}5\cdot 10^{-4}t},$$
$$C_7 = 41{,}7e^{-29{,}61\cdot 10^{-4}t},$$
$$C_8 = 42{,}5e^{-38{,}3\cdot 10^{-4}t}.$$



time, min.

Figure 3. Magnitude of rise (1-3) and decrease (4-12) of rectal temperature versus time of microwave irradiation with PM = 500 (1,4-5), 300 (2,6-10), 100 (3, 11-12) mW/cm^2. Z-axis: duration of linear plateau (1-2), time of attainment of initial level (3,4) and magnitude of negative gradient ($-\Delta T$, °C) of rectal temperature (5) with respect to initial background with equally probable 0.1 percent (1,3,5) and 50.0 percent (2,4,5) effects of injury versus PM of microwave irradiation.

where C_{6-8} is rectal temperature, °C; t is observation time in minutes. All three exponents have a common asymptotic convergence at t = 47 min (along the x axis, 38.02°). Assuming unidirectionality of the noted tendency within time limits of microwave irradiation ($2 < t < 12$), we can theoretically calculate the exponential relationship of the drop in rectal temperature during microwave irradiation equal to 4.48 and 8.0 minutes (assuring an injury effect of 0.1 and 50.0 percent according to data shown in Fig. 1, curve 4), assuming a duration of plateau after cessation of irradiation for 10 minutes

$$C_9 = 40{,}81e^{-21{,}92\cdot 10^{-4}t},$$
$$C_{10} = 42{,}5e^{-38{,}33\cdot 10^{-4}t}$$

(Figure 3, curves 9, 10). Irradiation time for the 5th (100 mW/cm^2) and 6th group (500 mW/cm^2) was selected to induce 0.1 and 50.0 percent death (according to data shown in Figure 1, curve 6, 2), after which were studied the dynamics of rectal temperature. With irradiation times of 26.4; 39.0 minutes (100 mW/cm^2) and 3.85; 5.8 minutes (500 mW/cm^2), there was an almost linear relationship of rise in rectal temperature (Fig. 3, curves 3, 1) and after cessation of microwave exposure—a linear plateau and exponential segment interpolated by the equations

$$C_{11} = 42,1e^{-34,5\cdot 10^{-4}t},$$
$$C_{12} = 43,17e^{-48,12\cdot 10^{-4}t},$$
$$C_{4} = 41,17e^{-12,1\cdot 10^{-4}t},$$
$$C_{5} = 42,49e^{-17,4\cdot 10^{-4}t}$$

(fig. 3, curves 11, 12, 4, 5, respectively).

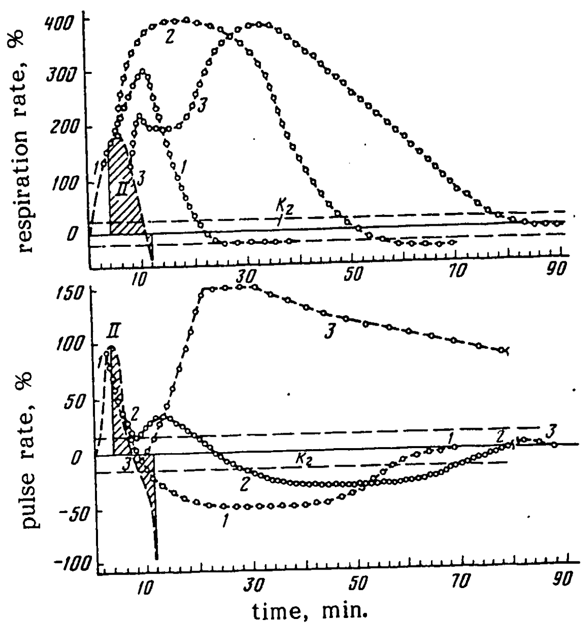


Figure 4. Dynamics of cardiac contractions and respiratory movements at: 3; 6.3; 8.3 minutes (II) microwave (PM = 300 mW/cm^2) irradiation and after its cessation (1-3). Data are presented in percents, as in Fig. 2.

Analysis of data presented in Figure 3 shows the specific relationship of the parameters studied versus PM of microwave irradiation. With equally probably effects of injury, e.g., 0.1 nd 50.0 percent, the duration of the plateau, time of attainment of initial elevel and magnitude of maximum decrease in rectal temperature are directly proportional to the PM of microwave irradiation and magnitude of injury effect (Fig. 3, z-axis, curves 1-5, resp.).

The data in Figure 4 serve to illustrate the qualitative difference in reactions of the CV and respiratory systems. It presents the dynamics of pulse and respiration rates (Fig. 4, II) in microwave irradiation with PM = 300 mW/cm^2 (they are similar to those shown in Fig. 2, II) and after cessation of 3; 6.3; and 8.3 minute exposures (Fig. 4, curves 1-3, resp.). In more detail, they come down to the following: with comparable effects of injury (PM = const), the reaction (maximum of absolute changes and time of their appearance, attainment of initial parameters and anlayzed indicators) increases in direct proportion to the probability of injury, while in terms of absolute values of the analyzed indicators, this tendency is more pronounced on the part of the respiratory system than the CV; comparison of dynamics of respiratory and CV activity during microwave irradiation and afterwards (Figs. 2, 4) suggests the greater pathogenetic responsibility of the respiratory center for the final lethal outcome, and its greater susceptibility and injurability in microwave exposure.

These are the general tendencies of evolution of thermal stress in dogs in microwave exposure.

Test data, in our opinion, provide and opportunity to quantitatively determine the adaptative resources of the functionally responsible systems of the canine organism for threshold values of death not to exceed natural (0.1 percent) attirbution for the test population. This approach in principle is based on the "concept of intolerability of the technological risk of irradiation" (Knizhnikov, 1975; Saurov, Knizhnikov, 1975) and widely known theoretical studies (Khug, Kellerer, 1969; Bond et al., 1971; Akoyev et al., 1972) on the stochastic nature of formation of the death effect of mammals which permits quantitative and functional assessment of the observable developmental trends.

Research has shown that the relationship bertween power density and microwave irradiation time with equally probable (0.1 percent) effect of death can be interpolated within 100 $mW/cm^2 \leq PM < 500$ mW/cm^2 by an equation of the exponential function of the kind $y = 1416x^{-0.8156}$, where y is PM in mW/cm^2, x is irradiation time in minutes. With threshold time of irradiation (effect of injury equals 0.1 percent), the absolute values and direction of shifts during irradiation on the part of CV and respiratory systems imprecisely differ from variation of the initial background. The relationship between the gradient of rectal temperature and PM of microwave irradiation is interpolated by an equation of the kind $y = Ax + 2.16$, where y is ΔT, ^oC; x is PM in mW/cm^2, A = 0. Experimental value of ΔT equal to 2.16^o reliably differs from variation of the initial background. The period of total recovery, evaluated by the time of attainment of initial level of rectal temperature, depends on the power density of microwave irradiation, and its magnitude may be defined by the following equation of the exponential function: $y = 251.2x^{0.3762}$, where y is the time of attainment of initial level of rectal temperature in minutes, x is power density of microwave irradiation in mW/cm^2.

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EFFECT OF NONTHERMAL RADIO WAVES ON SOMATOTROPIC HORMONE CONTENT OF THE RAT ADENOHYPOPHYSIS

Leningrad FIZIOLOGICHESKIY ZHURNAL SSSR in Russian No 2, 1980 pp 263-267

[Article by N. K. Demokidova, Scientific Research Institute of Industrial Hygiene and Occupational Diseases, USSR Academy of Medical Sciences, Moscow, submitted 22 Mar 79]

[Text] Electrophoresis on poly-crylamide gel was used to show that radio waves of nonthermal intensity indice changes in STH content of the adenohypophysis of male Wistar rats (and mongrel rats), an inverse correlation being demonstrated between sodium excretion (chlorides) and STH content of the adenohypophysis. The changes found in STH content are unrelated to stimulation of growth processes, and they are associated with changes in adrenocortical and thyroid activity, i.e., they are referable to stress.

Key words: radio waves, adenohypophysis, STH, gel electrophoresis.

According to data in the literature of recent years, there is a change in somatotropic hormone (STH) content in the blood of man and animals under the influence of stress factors [11, 18].

Studies of biological effects of microwaves in acute experiments, which were reported in the literature, revealed a decline in STH of rat blood plasma with the use of thermal intensity, in addition to other hormonal changes [17]. It is known that radio waves of nonthermal intensity can also affect the neuroendocrine system [4, 10].

In this work, we studied the effects of an electromagnetic field of nonthermogenic intensity on STH content of the rat adenohypophysis and some indices of functional state of other endocrine glands.

Methods

We used 80 young mongrel rats and 90 adult male Wistar rats in the experiments. Each experimental and control group consisted of 10 animals. The rats were exposed to electromagnetic fields of superhigh (SHF or MKV [microwave--?] and ultrahigh (UHF) frequencies. We tested the following intensities of UHF fields:* 1) 150 $\mu W/cm^2$ (1 h daily for 3 weeks); 2) 1 mW/cm^2 (1 h daily for 2 days); 3) 4 mW/cm^2 (1 h daily for 2 days); 4) 10 mW/cm^2 (25, 50 and 100 min daily for 2 months).

The tested intensity of electromagnetic fields in the UHF range (frequency 69.7 MHz) constituted 150 V/m (1 h exposure daily for 3 months).

The intensity of radio waves was measured using PO-1 and IEMP-1 instruments. The animals were exposed in plexiglas cages; the control group was put in similar cages and kept outside the generator room (pseudo-exposure).

Electrophoresis on polyacrylamide gel, as modified by the Institute of Experimental Endocrinology and Hormone Chemistry (Z. F. Yevtikhina) and, in part, the method of Kurts et al. [6] were used to assay STH in the rat adenohypophysis.

Electrophoresis was performed on columns of 7.5% polyacrylamide gel. The adenohypophyses were combined in pairs, electrode buffer was added (at the rate of 1 mℓ/30 mg tissue), the specimen was ground in a glass homogenizer and centrifuged. Supernatant was applied on a previously prepared column of gel at the rate of 0.1 mℓ. The initial power of electrophoresis was 2 mA on the tube, then 5 mA. Electrophoresis lasted about 1.5 h. The layer corresponding to STH was cut out of electrophoregrams stained and washed in 7% acetic acid soltuion, it was washed in water and ground in a glass homogenizer with 0.6 mℓ mixture of acetone and 1 N NaOH (1:1). After centrifugation, the eluate was submitted to colorimetry in microcuvettes from the apparatus of A. A. Pokrovskiy for demonstration of enzymes on an FEK-56 M [photoelectric colorimeter] using a red light filter.

On the day before the animals were sacrificed, we also assayed sodium (or chlorides, which are an indirect indication of its level) in urine by the method of flame photometry and some parameters of adrenocortical function (weight of organs in mg% and area of zones [5]) and thyroid (weight in mg%, number of follicles per section and height of thyroid epithelium).** The adrenals were fixed according to Romeys and the thyroid in 4% formalin. They were stained with hematoxylin-eosin.

*This study is part of a series of experiments conducted for the purpose of defining standards.

**Morphometric indices of activity of the gland were checked by determination of changes in metabolism.

Results and Discussion

According to the data submitted below, electromagnetic fields of nonthermal intensity are capable of inducing significant changes in STH content of the adenohypophysis of mongrel rats and Wistar rats, and this can be observed in both acute and chronic experiments. As can be seen in Table 1, in the case of exposing Wistar rats to microwaves, intensities of 1 and 4 mW/cm^2 have opposite effects: in the former case there is a drop in STH content and in the latter, a rise. The changes are reliable ($p<0.02$ and $p<0.05$, respectively). The opposite directions of effects are apparently attributable to phasic nature of reactions. As we know, the presence of phases is inherent in many of the effects of radio waves [3, 7].

Table 1. Effects of radio waves on STH content in the rat adenohypophysis and on excretion of sodium in urine

Animal group	Irradiation: range	Irradiation: intensity	Irradiation: duration of session	Irradiation: total exposure time	STH content (extinction)	Sodium content (chlorides) (mg/day)
Control	-	-	-	-	0.193 ± 0.008 (10)	—
Experiment	SHF	1 mW/cm^2	1 h	2 days	0.104 ± 0.026 (10) $p < 0.02$	—
"	"	4 "	"	"	0.268 ± 0.033 (8) $p < 0.05$	—
Control	-	-	-	-	0.295 ± 0.017 (10)	4.7 ± 0.57 (10)
Exper.	SHF	10 mW/cm^2	25 min	2 months	0.143 ± 0.014 (10) $p < 0.001$	10.3 ± 1.23 (10) $p < 0.001$
"	"	"	50 min	"	0.235 ± 0.014 (10) $p < 0.05$	8.7 ± 1.30 (10) $p < 0.01$
"	"	"	100 min	"	0.144 ± 0.024 (10) $p < 0.001$	14.6 ± 1.87 (12) $p < 0.001$
					$r = -0.67$	
Control	-	-	-	-	0.257 ± 0.025 (10)	9.6 ± 1.75 (12)
Exper.	SHF	153 $\mu W/cm^2$	1 h	3 weeks	0.178 ± 0.040 (12) $p < 0.05$	18.8 ± 3.37 (12) $p < 0.05$
Control	-	-	-	-	0.189 ± 0.025 (10)	12.3 ± 1.7 (12)
Exper.	UHF	150 V/m	1 h	2 weeks	0.224 ± 0.025 (10) $p > 0.25$	12.7 ± 1.9 (13) $p > 0.5$
Control	-	-	-	-	0.332 ± 0.024 (10)	13.4 ± 2.6 (12)
Exper.	UHF	150 V/m	1 h	3 months	0.272 ± 0.011 (12) $p < 0.05$	24.4 ± 4.6 (11) $p < 0.05$

It is known that among other metabolic effects STH has the property of causing sodium retention, which is manifested by decreased excretion of this electrolyte (and chlorides) in urine, although there is no agreement as to whether STH has a direct effect on the renal tubules, or whether its action is mediated through the glomerular zone of the adrenal cortex [8, 19, 20]. With this in mind, it is interesting to compare the changes in STH content of the adenohypophysis to level of sodium (chloride) excretion, which we assayed concurrently. According to Table 1, there was reliable decline of STH level in the rat adenohypophysis in the case of prolonged exposure (3 weeks to 2 months) to both the lowest (150 $\mu W/cm^2$) and highest (10 mW/cm^2) of the tested MKV intensities. In all of the cited cases, this decline was associated with increased excretion of sodium (chlorides) in urine, there being an inverse correlation between STH level in the adenohypophysis and amount of sodium excreted ($r = -0.67$ with 10 mW/cm^2). It is logical to conclude, on the basis of the antinatriuretic effect of STH, that the decline in hormone level with prolonged irradiation reflects a decrease in production and release thereof into blood; an elevation would indicate the opposite.

We failed to demonstrate a clearcut relationship between STH content (and, in part, chloride excretion) and duration of irradiation sessions: the lowest reaction was induced by a session of medium duration (50 min).

Unlike this, the weight of the endocrine glands was related to duration of sessions in our experiments, as indicated in Figure 1. Thus, 25-min exposure failed to induce visible changes; 50 min led to a reliable increase in weight of the hypophysis and adrenals; 100 min led to a reliable increase in weight of the pituitary, adrenals and thyroid, the increase in adrenal weight being more significant than under the influence of 50-min exposure.

As we examined the changes in STH content of the adenohypophysis, of course the question occurred to us as to whether these changes would result in impairment of dynamics of growth processes, which different authors reported were affected by electromagnetic fields [2, 9].

In the experiments on young rats exposed to UHF electromagnetic fields for 3 months, we observed the same changes as under the influence of the SHF range: phasic changes in STH content (tendency toward increase after 2 weeks and reliable decrease by the end of the experiment) and an inverse relationship between level thereof and sodium excretion (Table 1).

In spite of the reliable weight gain observed in these animals by the 3d month of exposure (as compared to the control level), such specific growth parameters as body length and width of the tibial cartilage remained virtually unchanged (Table 2), although transient narrowing of the cartilage was observed after exposure for 2 weeks, which could have been the consequence of predominant release into blood of ACTH and glucocorticoids which, as we know, are inhibitors of chondrogenesis [12, 13]. The fact that narrowing of the cartilage preceded a period of increased adrenocorticotorpic function of the hypophysis in this experiment is confirmed by our demonstration of a decrease in weight of the thymus 1 day after the first session of irradiation; the thymus, as we know, undergoes involution under the influence of both exogenous and endogenous ACTH and glucocorticoids. Thus, the mass of the thymus at this time constituted 192.6±22.3 mg%, versus 252.2±18.8 mg% in the control ($p<0.05$). After exposure for 1 month, this parameter reverted to normal, constituting 167.3±8.8 mg% in the control and 191.7±12.7 mg% in the experiment ($p<0.1$), as did the width of the tibial cartilage at this time.

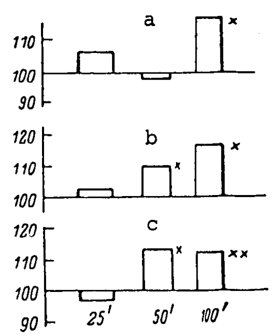

Figure 1.
Weight of endocrine glands of adult rats after 2-month exposure to MKV (10 mW/cm^2), as percentage of control level. The numbers at the bottom refer to duration of exposure session, min
a) thyroid
b) adrenals
c) pituitary
x) $p<0.05$ xx) $p<0.02$

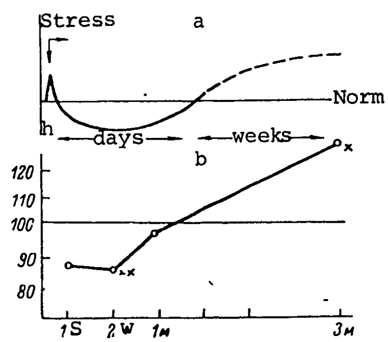

Figure 2.
Dynamics of functional activity of thyroid. X-axis, duration of exposure (S--session, w--weeks, m--months); y-axis, height of follicular epithelium, as percentage of control level.
a) with stress according to Dewhurst et al.
b) under the influence of UHF-range electromagnetic field
x) $p<0.05$
xx) $p<0.02$

The reliable increase in area of the reticular zone of the adrenal cortex (1.83±0.15 mm^2 in the control and 2.68±0.30 mm^2 in the experiment; $p<0.02$), which we discovered after sacrificing young rats exposed to electromagnetic fields in the UHF range, was also indicative of the increased production of ACTH under the influence of irradiation.

Table 2. Some parameters of growth of young rats exposed to UHF-range electromagnetic field (1 h daily for 3 months)

Animal group	Exposure time	Weight gain (g)	Body length (cm)	Cartilage thickness (microns)
Control	-	202.4±5.1	19.0±0.3	292.5±7.7
Experiment	2 weeks	204.0±5.3	19.4±0.3	265.0±7.5
		$p > 0.5$	$p > 0.25$	$p < 0.02$
Control	-	218.5±6.1	—	254.0±5.4
Experiment	1 month	231.6±7.6	—	264.0±8.7
		$p > 0.1$		$p > 0.25$
Control	-	321.7±10.2	24.6±0.3	109.4±2.1
Experiment	3 months	354.0±11.5	25.3±0.3	107.5±3.5
		$p < 0.05$	$p > 0.1$	$p > 0.5$

The dynamics of changes in thyroid activity of young rats in the same series of experiments are illustrated in Figure 2. For the sake of comparison, schematic depiction of the functional state of this organ in the presence of stress according to Dewhurst et al. [14] is also illustrated. The similarity of the curves is obvious: in both cases, there is a decline of thyroid activity at the start of exposure, with elevation thereafter. The difference in time could be attributable to the differences in force and nature of stimuli.

Thus, evidently there is first an increase in discharge into blood of STH and ACTH (with dominant influence of the latter) and decreased release of thyrotropic hormone (TTH) under the influence of electromagnetic fields of nonthermal intensity. Thereafter, excretion of STH (ACTH?) diminishes whereas that of TTH increases. It is known that such dynamics of release of these hormones into blood are inherent in stress states [1, 14-16].

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EFFECT OF PULSED MAGNETIC FIELD ON WORKERS' HEALTH

Kiev VLIYANIYE IMPUL'SNOGO ELEKTROMAGNITNOGO POLYA NIZKOY CHASTOTY NA ORGANISM in Russian 1978 pp 2-4

[Annotation, foreword and table of contents from book "Effect of a Pulsed, Low-Frequency Electromagnetic Field on the Organism", by G.I. Yevtushenko, F.A. Kolodub, I.S. Ostrovskaya and N.V. Maksimenko, Izdatel'stvo "Zdorov'ya", 132 pages]

/Text/ The book presents the physical characteristics and methods of measuring electromagnetic fields and information on some technological units using the energy of a pulsed electromagnetic field and on the hygienic working conditions and state of health of workers.

It generalizes the results of experimental investigations characterizing the reactions of organs and systems to the effect of a pulsed electromagnetic field and presents the authors' views and data in the literature on the possible mechanisms of effect of this environmental factor on the organism.

A separate section is devoted to measures of protection against the unfavorable effect of a pulsed electromagnetic field.

The book is intended for scientific workers engaged in this problem, physicians at medical and sanitary units and plant polyclinics, health officers engaged in preventive sanitary supervision and specialists in safety techniques.

39 illustrations; 7 tables; bibliography: 126-130

Foreword

In a socialist society the development of new technology and the introduction of more advanced techniques proceed not only along the path of increase in labor productivity, but also facilitation and improvement of working conditions up to a complete elimination of occupational diseases. The decree of the CPSU Central Committee and the USSR Council of Ministers "On

Measures To Further Improve People's Health" pointed out the need "... to ensure the fulfillment of measures envisaged by the overall plans for 1978-1980 for improving the working conditions and labor protection of workers, paying special attention to a further decrease in industrial injuries and occupational diseases..." All-around investigations are conducted in the USSR for the purpose of studying the effect of factors in the industrial environment on the human organism. The development of sanitary and technical measures and establishment of hygienic standards contributing to an improvement in working conditions and to a reduction in the frequency of occupational diseases are the results of these investigations.

The second half of the 20th century can be characterized as a period of extensive use of electromagnetic energy in industrial processes.

Such properties of electromagnetic waves as the ability to propagate at the speed of light, to transmit energy over a distance, to create pressure on a surface, to be reflected from the surface of objects to the path of wave propagation and so forth are now used.

Electromagnetic units for changing the configuration of metal objects, for joining heterogenous materials and for changing the structure of metal articles have already been developed and operate. Electromagnetic energy is used in metal remelting, timber hardening and drying, metal and plastic welding and many other industrial processes. The use of electromagnetic energy in the range of low (1 to 30 kHz) frequencies is characteristic of most of these processes.

The biological effect of radio waves of a high and superhigh frequency range, especially in cases when the thermogenic effect is pronounced, has been studied most completely.

There is less information in the literature on the effect of low-frequency electromagnetic fields and the biological effect of pulsed, low-frequency electromagnetic fields has hardly been studied at all. Meanwhile, individuals working at these units have to be in the sphere of dissemination of an environmental factor insufficiently studied with respect to biological activity.

Assuming that true prevention boils down to the avoidance of the development of possible pathology, not to the ascertainment of pathology and then to a search for means of treating and preventing its development, we conducted an all-around investigation of the biological effect of a pulsed, low-frequency electromagnetic field on the organism.

The effect of a pulsed electromagnetic field depending on the field intensity and the time of its effect on the organism was studied in an experiment on animals. To detect the responses of the organism as a whole and its systems and organs, a comprehensive study with the use of hygienic, physiological, pathomorphological, hematological, immunological, biochemical and biophysical methods of investigation was conducted.

It seemed important to us to disclose the patterns in the responses of the organism to the effect of a pulsed, low-frequency electromagnetic field and to express opinions of the possible mechanism of effect of this fact of the industrial environment. Knowledge of the mechanism of effect of a pulsed, low-frequency electromagnetic field can serve as the basis for both the development of criteria of an early diagnosis of the unfavorable effect of a pulsed, low-frequency electromagnetic field on the organism and for a directed search for pathogenetic methods of preventing possible pathology.

In this work an attempt was made to generalize the scanty data in the literature and, mainly, the results of our own long-term investigations of the nature and mechanisms of effect of a pulsed, low-frequency electromagnetic field on the organism.

If to some extent we have succeeded in expanding and deepening the modern ideas of the nature and characteristics of interaction between a pulsed, low-frequency electromagnetic field and the organism and to make, as far as possible, our contribution to improving the methods of measuring electromagnetic fields and of protecting the human organism from their unfavorable effect, we will consider our object attained.

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LOW FREQUENCY ELECTROMAGNETIC FIELD'S MECHANISM OF ACTION TOWARDS LIVING ORGANISMS

Moscow BIOFIZIKA in Russian Vol 25, No 1, Jan-Feb 80 p 189 manuscript received 11 Jul 78

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[Article deposited in VINITI under #3680-79, 25 Oct 79]

[Text] It has been confirmed that the low frequency spectrum of the natural electromagnetic field (sunlight, atmospherics, etc) is one of the suppliers of the mechanical form of energy to living organisms. This confirmation is based on the rule of the partial transformation of the energy of low frequency electromagnetic fields into the energy of resilient (mechanical) vibrations during their passage through a substance.
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