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## MAIN SUBJECT HEADING:

AN	HU	AT	IH	M
ANALYTICS	HUMAN EFFECTS	ANIMAL TOXICITY	WORKPLACE PRACTICES- ENGINEERING CONTROLS	MISCELLANEOUS

SECONDARY SUBJECT HEADINGS: AN HU AT IH M

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NEW MEASUREMENT TECHNIQUES IN STUDYING THE EFFECT OF  
SUPERHIGH FREQUENCY FIELDS ON BIOLOGICAL SUBJECTS

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In connection with the difficulties arising when setting up experiments to study the effect of the millimeter range by means of horn radiators on biosubjects, it is proposed that dielectric waveguides be used. By means of these waveguides the electromagnetic energy is fed to the structures under study both in open form and under the protection of upper layers. The experiments were performed with respect to determining the operating conditions of dielectric waveguides under various loads of a biological nature and when they are surrounded by small layers of biological material.

Investigation of the nonthermal effect of an electromagnetic field in the superhigh frequency range on biological structures is attracting the attention of biologists and physicists as one of the possible paths toward explaining the exchange of energy and information which occurs on the <sup>cell</sup> cellular and molecular levels in biological structures. The theory of chemical interchange existing at the present time is clearly inadequate to explain a number of facts which have been detected in biophysical research. The nonthermal effect of superhigh frequency electromagnetic fields is one of the most effective manifestations of physical processes occurring in molecules and cells under the effect of radio-frequency radiation on them.

The basic investigations of the effect of superhigh frequency fields on biological subjects are being carried out at present in the 3-150 gigahertz range in order to discover the harmful factor of superhigh frequency radiation, and therefore appreciable radiation powers are used

[1, 4]. The basic cause of the occurrence of biological changes is obviously the thermal effect in this case. The subjects are irradiated from the open end of a waveguide or horn, and the entire organism as a whole is subjected to the effect. In determining the electrical parameters of the tissues, samples of tissues are placed directly in the waveguide, and the electric and magnetic permeability are studied.

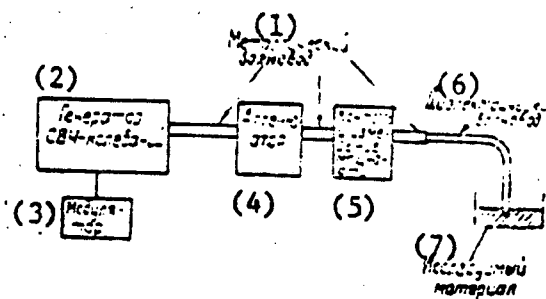
In performing finer studies, for example, of the nonthermal effect, it is necessary to vary the ordinary methods. Above all, the power of the electromagnetic energy should be less than the power at which the thermal effect occurs. According to the data of H. P. Schwan, G. M. Piersol [2] and other authors, the thermal effect is excluded for energy densities less than 7 milliwatts/cm<sup>2</sup>. Therefore, the power of the electromagnetic energy in the experiment should not exceed a given amount. This condition must be satisfied when irradiating any layers of tissue. However, in all cases it is desirable to estimate the absorbed electromagnetic energy. Variation of the frequencies at which the investigations are performed leads to the discovery of the frequency dependence of the effect of the electromagnetic energy on the biological structures.

By using a horn as a radiator, it is possible to theoretically estimate the power absorbed in the various layers and calculate the absorption coefficient by the method proposed in reference [3].

Here, it is necessary to introduce the corresponding corrections connected with the peculiarities of biological layers since the absorbing layer will be not the third layer but the second and, consequently, changes in the values of the transparency, reflection and absorption coefficients will be introduced in the final result.

The application of dielectric waveguides as irradiating systems when studying the nonthermal effect has a number of indisputable advantages. As is known, investigation of the nonthermal effect requires local irradiation of the tissue cultures considering that the surrounding tissue or nutrient were subjected to minimal irradiation. The best conditions are created in this case with the contact method; however, utilization of metal waveguides is sharply limited here with respect to the conditions of performing the biological experiment: metal is poorly suited to biological processing, it has greater thermal conductivity, it is inflexible, and so on. Dielectric waveguides do not have these disadvantages; therefore, it is possible not only to perform contact irradiation with them but also to insert them into live tissue to improve the conditions of transmission of the electromagnetic energy to certain formations [5].


However, when using dielectric waveguides as contact-type radiators it becomes necessary to study the conditions of reflection from the end of the dielectric waveguide under its load on the tissue medium. The shape of the cut at the end of the dielectric waveguide has no little significance in this case. Some results of our investigations of the



- Key:
1. metal waveguide
  2. superhigh frequency generator
  3. modulator
  4. attenuator
  5. power control and measuring device
  6. dielectric waveguide
  7. investigated material

the standing-wave coefficient performed according to the schematic in the figure are presented in Table 1. As follows from the experimental data, the best results are obtained when working with a round-ended waveguide (both under load and without it).

Table 1  
Values of the standing wave coefficient for various sections of the dielectric waveguides when operating on water and on the fatty layer (the data in parentheses)

$\lambda$ , cm	Shape of section 			
	$\theta = 45^\circ$	$2\theta = 90^\circ$	$R = d/2$	$2\theta = 180^\circ$
0,42	1,45 (1,30)	1,35 (1,31)	1,30 (1,20)	1,90 (1,40)
0,49	1,51 (1,21)	1,85 (1,37)	1,15 (1,12)	1,18 (1,12)
0,54	1,35 (1,23)	1,41 (1,20)	1,52 (1,23)	1,17 (1,14)
0,65	1,38 (1,22)	1,49 (1,23)	1,37 (1,21)	1,45 (1,25)
0,74	1,30 (1,11)	1,25 (1,17)	1,16 (1,15)	1,52 (1,40)
0,83	1,70 (1,41)	1,90 (1,33)	1,17 (1,14)	1,35 (1,14)

During further investigation of the effect of low power on biological structures it became necessary to irradiate the cells of the animal tissue. In these cases the cell structures were beyond the skin and fat layer. Therefore, under ordinary external irradiation the amount of electromagnetic energy passing through these layers with great absorption was very low and did not suit the people conducting the experiments.

Increasing the primary power was impossible since this led to violation of the conditions of absence of thermal heating of the upper tissue. Therefore, implanted dielectric waveguides were used by means of which the electromagnetic energy was transported to the investigated structures. In defining the conditions of transmission of energy in various frequency ranges along the dielectric waveguide when violating its homogeneity by tissue cultures absorption loss coefficients were investigated as functions of the length of contact of the tissues with the waveguide surface.

Table 2  
 $m = P_{out}/P_{inp}$  as a function of frequency for fat and tissue (data in parentheses)

$\lambda$ , cm	Length of contact surface, mm			
	1	2	3	4
0,80	0,77 (0,59)	0,63 (0,48)	0,48 (0,36)	0,28 (0,23)
0,70	0,69 (0,57)	0,55 (0,44)	0,38 (0,32)	0,20 (0,20)
0,62	0,66 (0,53)	0,43 (0,41)	0,30 (0,29)	0,14 (0,18)
0,56	0,45 (0,48)	0,31 (0,33)	0,13 (0,24)	0,06 (0,14)
0,44	0,33 (0,39)	0,22 (0,26)	0,09 (0,16)	—

For this purpose the results of the loss coefficient ratio  $m = P_{out}/P_{inp}$  as a function of frequency and length of the contact surface (Table 2) were investigated. This permitted determination of the energy supplied to the investigated subject to a sufficient degree.

Thus, the methods we used in investigating the effect of superhigh frequency radiation on biological subjects permit more exact setting-up of experimental projects in the area of the irradiation process, and they also permit us to obtain information about the electromagnetic effect on biological structures. In addition, the methods indicated in the article solve the problem of direct transmission of electromagnetic energy to a biological subject independently of its form and composition to a sufficient degree.

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