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## CLINICAL AND HYGIENIC ASPECTS OF EXPOSURE TO ELECTROMAGNETIC FIELDS

(A Review of the Soviet and Eastern European Literature)<sup>1</sup>

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### INTRODUCTION

It has long been apparent that electromagnetic fields impose a health hazard, especially at field intensities greater than approximately 15 mW/cm<sup>2</sup>, which cause thermal (heating) responses in the organism. Only quite recently it is suspected, from the Soviet and East European literature, that these fields might also elicit certain functional or so-called "specific" responses, especially in the nervous system, at field intensities less than 10-15 mW/cm<sup>2</sup>, which do not cause heating.

Prior to 1964, no comprehensive effort had been attempted in this country to review the world (especially the Soviet and East European) literature on the general biological effects of microwaves. Soviet literature was in most cases scattered, quite difficult to locate, and consequently had never come to the attention of the U.S. scientific community. When in 1964, one of the first reviews on this subject was attempted by the writer, then affiliated with the Library of Congress, it was speculated by some authorities on the subject that an extremely low yield of literature would result from the attempt. It was therefore quite surprising that a search of the Soviet and Eastern European literature on the biological effects of microwaves revealed a large and virtually unexploited body of information which had never come to the attention of the U.S. scientific community. The first review (1) contained 132 references to Soviet and East European work on this subject. Subsequent reviews by the author (2-4) and a number of others (5-9) revealed that some of the most active research in the world was being conducted in the Soviet Union and some of the Eastern European countries.

<sup>1</sup> The views expressed by the author do not necessarily represent those of the U.S. Navy.

It is the purpose of this paper to review Soviet and Eastern European studies of the effects of radio-frequency fields on the human organism. An attempt will be made to summarize the more noteworthy findings of some of the literally hundreds of published works devoted to this subject and to underscore the need for a more critical and systematic treatment of this subject. This review will concentrate nearly exclusively on human clinical studies and occupational hygiene surveys and will not consider the more theoretical or experimental aspects of the biological effects of microwaves.

### BACKGROUND

As early as 1933, certain Soviet scientists had already recognized that electromagnetic fields affected the human nervous system. In 1937, Turlygin (10) published one of the first comprehensive Soviet accounts of the effects of centimeter waves on the human central nervous system. He found that CNS excitability was increased by 100% of the control level when a crude spark oscillator in the vicinity of the head of a subject was switched on. In a lengthy review article, Livshits (11) cited no fewer than 28 Soviet publications on the general subject of clinical and biological microwave effects which had been published by the end of the 1930's.

During the 1940's and early 1950's, there was an understandable lull in research on this subject due to World War II. By the middle and late 1950's, there appeared a veritable deluge of Soviet literature dealing, in the main, with the clinical and hygienic aspects of microwave exposure which has continued unabated to this day. By the early 1960's, the Eastern European countries of Czechoslovakia and Poland had also become extremely active in the area of microwave exposure effects. In a cursory

search of the Soviet and Eastern European literature on this subject alone, a total of about 100 publications authored by 75 researchers was found and this figure is probably a conservative reflection of the available works which are estimated to be several hundred.

In an attempt to summarize the prolific Soviet and Eastern European work on clinical and hygienic aspects of exposure to microwaves, it became apparent that a number of human systems and functions had been documented to be affected by this factor (Table 1). By far the most frequently and repeatedly reported human responses to microwaves involve the central nervous system. These responses have been noted for a wide range of frequencies ( $\sim 30$ – $300,000$  MHz) at both thermogenic ( $>10$  mW/cm<sup>2</sup>) and nonthermogenic (microwatts to milliwatts/cm<sup>2</sup>) intensities.

An often disappointing facet of the Soviet and East European literature on the subject of clinical manifestations of microwave exposure is the lack of pertinent data on the circumstances of irradiation; frequency, effective area of irradiation, orientation of the body with respect to the source, waveform (continuous or pulsed, modulation factors) exposure schedule and duration, natural shielding factors, and a whole plethora of important environmental factors (heat, humidity, light, etc.) In addition, the physiological and psychological status of human subjects such as health, previous or concomitant medication, and mental status is also more often than not omitted. These variables, both individually and combined, affect the human response to microwave radiation. Despite these omissions, however, the reviewer cannot help but be impressed both by the consistency of the findings and the large size of Soviet and East European clinical and hygienic surveys which have involved literally thousands of people over the past 20 or more years.

## CLINICAL MANIFESTATIONS OF EXPOSURE TO RADIOFREQUENCY FIELDS

### *General Clinical Syndromes*

Many Soviet clinical workers have attempted to categorize the chronological stages of human responses to microwaves. Panov et al. (12) proposed three categories or stages of responses to microwaves (Table 2). These were listed as the asthenic syndrome, characterized by fatigue, depression, and a number of other changes. This first stage is not

TABLE 1

*Effects of electromagnetic radiation on the human organism*

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|                                     |
|-------------------------------------|
| I. Central Nervous System           |
| II. Autonomic Nervous System        |
| III. Neurohumoral Systems           |
| IV. Endocrine Glands and Functions  |
| V. Eye and Ocular Functions         |
| VI. Blood and Hematopoietic Systems |
| VII. Miscellaneous Organs           |

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marked by severe episodes such as fainting or dramatic changes in pulse or blood pressure and the subject responds to outpatient treatment. The second category is called the "syndrome of autonomic and vascular dystonia". The essential feature of this stage is pulse lability (brady- and tachycardia), blood pressure lability (hypo- or hypertension), EKG changes, and general neurocirculatory asthenia. Severe episodes such as fainting spells may occur and the subject requires hospitalization of unspecified nature or duration. The third stage is referred to as the diencephalic syndrome in which visceral dysfunctions and crises are observed. Typical episodes during this stage are listed as "apathic amblic" disorders, hypersomnia, hypokinesia, hypothalamo-pituitary-suprarenal weakness, and inhibition of sexual and digestive reflexes. Panov claims that these changes are not always reversible and that subjects require hospitalization. It should be noted that Panov did not specify the nature or duration of outpatient or hospital treatment, nor did he relate these symptoms to specific irradiation parameters.

### *General Subjective Complaints (Indirect Effects on the CNS)*

A large number of East European and especially Soviet clinical and hygienic workers (13–22) have consistently and repeatedly documented an astonishing number of subjective complaints which are usually referred to as evidence of the direct or indirect effect of microwaves on the central nervous system (Table 3). These responses have been reported for a wide range of wavelengths (30– $300,000$  MHz) and field intensities (microwatts to several milliwatts/cm<sup>2</sup>). Unfortunately, it is often difficult to attach any significance to Soviet clinical findings in the absence of pertinent data on exposures and on patient backgrounds. Typical, for instance, was a survey conducted by Sadehikova (21) in which three groups of occupational personnel (technicians, assemblers, and maintenance workers around centi-

TABLE 2

*Soviet classification of general clinical syndromes of exposure to electromagnetic radiation EMF's*

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- A. The Asthenic Syndrome (reversible; outpatient treatment)
1. fatigability and emotional changes
  2. acrocyanosis
  3. increased perspiration of extremities
  4. increased pilomotor reflex
  5. dermatographism
  6. pulse lability
  7. blood pressure lability
- B. Autonomic Cystonia (reversible; hospitalization)
1. hyper- or hypotension
  2. bradycardia and tachycardia
  3. changes in EKG signs
  4. fainting spells
- C. Diencephalic Syndrome (usually reversible; hospitalization)
1. insomnia
  2. adynamia
  3. hypothalamo-pituitary-suprarenal inhibition
  4. inhibition of sexual function and digestive reflexes
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meter wave generators) were exposed to: (1) periodic intense radiation (3-4 mW/cm<sup>2</sup>); (2) moderate radiation (tenths of mW/cm<sup>2</sup>); and (3) weak radiation (hundredths-tenths of mW/cm<sup>2</sup>). As can be seen in Table 4, the group exposed to the weakest radiation was shown to display the highest incidence of complaints. This finding and lack of pertinent exposure data such as duration and affected body area make these data difficult to accept on face value. On the other hand, Edelwejn (14) has conducted interesting and comprehensive neurological examinations and interviews of Polish personnel exposed for up to six hours/day to microwave field intensities of 10 microwatts to several milliwatts/cm<sup>2</sup>. He found that many of the subjective complaints listed in Table 3 (headaches, dizzy spells, fatigue, perspiration, etc.) depended upon the length of employment and degree of exposure. Only subjects exposed to high (mW/cm<sup>2</sup>) intensities exhibited EEG changes. Edelwejn was of the opinion that there is a dramatic response to microwave exposure occurring during the first three years which are accompanied by neurotic symptoms. This three year period is followed by a phase of gradual adaptation. The reappearance of neurologic symptoms occurs after a long period (many years) of exposure to microwaves, even after adaptation has occurred.

Osipov (1965) (20) in a review of neurologic responses to microwave exposure concluded that most subjective symptoms were reversible and that patho-

logical damage to neural structures was insignificant. Only rarely were microwaves found to cause hallucinations, syncope, adynamia and other manifestations of the so-called "diencephalic" syndrome.

Soviet workers have also documented subjective complaints identical to those in Table 3 as a result of exposure to electric and magnetic fields. Vyalov et al. (23) reported characteristic microwave symptoms such as headache, fatigue etc., in workers exposed to 150-1500 oersted magnetic fields. Asanova (24) reported analogous findings for workers exposed to 115-125 microampere fields around hydroelectric stations.

#### *Functional Changes in the CNS*

Many Soviet and Eastern European workers have attempted to identify specific CNS functional responses to microwave exposure. Most Soviet workers are of the opinion that the CNS is the most sensitive of all systems to the effects of microwaves, both at thermogenic and nonthermogenic field intensities. Based primarily upon experimental research, Presman (9) is of the opinion that the hypothalamus is the most sensitive CNS structure to microwave effects which would explain, in his view, the high incidence of blood and humoral changes noted in human subjects exposed to this factor.

Changes in human CNS function have been evaluated on the basis of EEG surveys, reflex tests, and general neurological examinations (Table 5). These changes are reported for a wide range of frequencies and field intensities (thermal and nonthermal). However, functional CNS responses appear to be de-

TABLE 3

*General subjective complaints resulting from exposure to electromagnetic radiation*

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1. Pain in head and eyes
  2. Lacrimation
  3. Weakness, weariness and dizziness
  4. Depression, antisocial tendencies, general irritability
  5. Hypochondria, sense of fear, and general tension
  6. Impairment of memory and general mental function
  7. Adynamia and inability to make decisions
  8. Inhibition of sex life (male)
  9. Scalp sensations and loss of hair
  10. Chest pain and heart palpitation
  11. Dyspepsia, epigastric pain, and loss of appetite
  12. Trembling of eyelids, tongue, and fingers
  13. Asthma
  14. Brittle fingernails
  15. Sensitivity of mechanical stimulation and dermatographism
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