

An Evaluation of Soviet and East European Studies
Relating to the Physiological Effects on
Humans of Nonionizing Electromagnetic Radiation

AN EVALUATION OF SOVIET AND EAST EUROPEAN STUDIES
RELATING TO THE PHYSIOLOGICAL EFFECTS ON
HUMANS OF NONIONIZING ELECTROMAGNETIC RADIATION

Final Technical Report
for
Contract XG-3957

CENTRAL INTELLIGENCE AGENCY

Received 4/15/76

CONTENTS

ANALYSIS, CONCLUSIONS, AND RECOMMENDATIONS.....	1
INTRODUCTION.....	1
METHODOLOGY.....	1
RESULTS AND CONCLUSIONS.....	2
Engineering and Scientific Competence.....	2
Standards of Writing and Publishing.....	3
General Overview of the Reported Biological Effects.....	4
Possible Evidence of Censorship.....	6
Possible Military and Political Functions of Research in Biological Effects of Electro- magnetic Radiation in the USSR.....	7
Philosophical Differences in Public and Occu- pational Health, Scientific Research, and Medical Practice Between the USSR and Western Countries.....	8
Status of Research in the United States Rela- tive to Work Reported from the USSR.....	9
RECOMMENDATIONS.....	10
BIBLIOGRAPHY.....	12
APPENDICES.....	14

APPENDICES

- A REVIEW OF EAST EUROPEAN STUDIES ON THE BIOLOGICAL EFFECTS OF ELECTROMAGNETIC RADIATION (Pazderova, Czerski, et al.)
- B REVIEW OF "MICROWAVE RADIATION: ITS BIOLOGICAL EFFECT AND IMPACT ON HEALTH IN INHABITED LOCALITIES" (Shandala et al.)
- C REVIEW OF "PATHOLOGICAL EFFECTS OF RADIO WAVES" (Tolgskaya and Gordon)
- D REVIEW OF "APPARATUS FOR THE TREATMENT OF NEUROPSYCHIC AND SOMATIC DISEASES WITH HEAT, LIGHT, SOUND, AND VHF ELECTROMAGNETIC RADIATION" (Rabichev et al., U.S. Patent)
- E REVIEW OF "CENTRAL MECHANISM OF ACTION OF ELECTROMAGNETIC FIELDS" (Sudakov and Antimoniy)
- F REVIEW OF "PROTECTION FROM THE EFFECT OF RADIO WAVES" (Kulikovskaya)
- G REVIEW OF "ELECTROMAGNETIC SIGNALLING IN ANIMATE NATURE" (Presman)
- H REVIEW OF "ELECTROMAGNETIC RADIATION SAFETY" (Krylor and Yuchenkova)
- I REVIEW OF "CHANGES IN PERMEABILITY OF HISTO-HEMATIC BARRIERS UNDER THE EFFECT OF MICROWAVES" (Polyashchuk)

ANALYSIS, CONCLUSIONS, AND RECOMMENDATIONS

Introduction

The objective of this research was to gather, review, and assess the relevant literature published in the USSR and other East European countries (Poland and Czechoslovakia) concerning the biological effects of nonionizing electromagnetic radiation. The publications reviewed were predominantly English translations of Soviet and East European open literature.

Methodology

The initial approach adopted for this study was to read translated articles, evaluate them for scientific competence and validity of conclusions, and prepare a compendium of results in biological effects of microwaves. This compendium was to be used for evaluating the quality and emphasis of research being conducted in the Soviet Union and East European countries. This approach was found to be unproductive. Many of the articles were merely abstracts that did not contain details of the experimental method, number of subjects, or analytical approach used in the study. Also, many of the complete articles examined did not describe adequately the experimental method; indeed, on the basis of Western scientific standards of experimental design and reporting, these articles would be considered unfit for publication. We concluded that the Soviet literature on the biological effects of electromagnetic radiation could not be evaluated in terms of Western standards of scientific research and publishing.

Therefore, an alternative approach to this study was adopted. This approach was to take representative individual articles--usually comprehensive reviews or books--and subject them to intensive and detailed analysis. The scope of the analysis varied somewhat with the articles or books examined, but the overall objective was to glean as much information as possible about the attitude of the Soviets toward microwave research. Factors considered in the analysis and review included distribution of topics, emphasis of research, philosophical approach and scientific competence, goals of the Soviet government as suggested by research emphasis, and possible evidence of censorship in research areas considered to be important.

Nine detailed reviews are presented in the appendices to this report. These reviews cover various aspects of Soviet and East European studies on the biological effects of electromagnetic radiation. In addition to these publications, we examined a number of other articles, both in Soviet and Western literature, but did not write formal, detailed reviews

of them. These publications are referred to in various parts of this report. Among them are two books, The Influence of Microwave Radiation on the Organism of Man and Animals, by I. R. Petrov,¹ and Biological Effects of Radiofrequency Electromagnetic Fields, edited by Z. V. Gordon.² These books originally were to be reviewed in detail, but the time set aside for review subsequently was allocated to examination of other articles so as to make the subject area of the reviews more comprehensive.

The Bibliography lists both articles and books that were not reviewed in detail and those that were; the latter are asterisked in the text.

Results and Conclusions

Engineering and Scientific Competence

The achievements of the Russians in space flight and in development of nuclear weapons are adequate testimonials to their general engineering capability. In the field of electromagnetic radiation, review of the book Protection from the Effect of Radio Waves, by Ye. L. Kulikovskaya,^{3*} shows that the author has thorough competence and knowledge by Western standards but that her knowledge is not more advanced than that of researchers in the United States. Discussions with scientific observers who have traveled in the Soviet Union confirm the quality and competence of Soviet equipment and personnel.

Scientific, as opposed to technical, competence appears to be deficient in much of the work. The problem appears to center greatly on inadequate attention to experimental design and inadequate selection of controls. The Soviet researchers also tend either to disregard the significance of an effect found or to discuss the significance in terms that Western scientists would regard as irrelevant. Three examples are:

(1) An article entitled "Hygiene and Physiology of Military Labor" by F. A. Kolesnic and N. A. Komogortseva⁴ presents the results of studies of blood sulfhydryl (SH) groups in people exposed to "SF" (SHF?) radiation generators. Kolesnic and Komogortseva found that the blood SH level was reduced in exposed subjects, relative to controls. The article gives very few details about the subjects tested or how the subjects and controls were selected; moreover, the radiation exposure levels are not specified. The introduction contains some discussion of the significance of blood SH level, but the authors treat the finding, as related to the microwave radiation, merely as an "effect" that did not need to have any demonstrable causal relationship to the radiation. The article would be unacceptable in a Western scientific journal.

(2) The book by Tolgskaya and Gordon^{5*} describes methods for exposing rates to microwave radiation. Animals were

exposed to the beam in multiple cages in a room that did not appear to have radiation-absorbing material on the walls. The description of dosimetry is very casual, and the text does not contain any discussion of possible variations in dose among the animals exposed together. The authors do not seem to have considered the notion that individual animals may have received different doses, although, in other parts of the text, they do show that they have technical knowledge about physical principles of electromagnetic radiation.

(3) An article by Ye. A. Lobanova,⁶ entitled "Investigations on the Susceptibility of Animals to Microwave Irradiation Following Treatment with Pharmacologic Agents," contains no description of the exposure system used or the method of dosimetry. Clinical observations of rats during exposure are presented, and the author states that the animals died under the beam. The susceptibility of the rats to the radiation was measured in terms of mean survival time. This paper is one of the better ones: Doses of the pharmacologic agents are specified, and the mean survival times are given in a number of cases. The numbers of animals per group are specified once or twice. Much of the discussion concerns the effects on the nervous system of the agents, and Lobanova does attempt to relate effects found to physiological mechanisms of heat exchange and metabolism in the rats.

The information given above indicates that, in Soviet articles on biological effects of electromagnetic radiation, the technical competence of the work is probably adequate but the scientific validity of most studies should be considered suspect. We define technical competence as the correctness of the experimental observations--i.e., the blood SH level in the work by Kolesnik and Komogortseva was probably lower in the subjects studied than in the controls. We define scientific validity as the correctness of the conclusion concerning causal relationships--i.e., the authors cannot necessarily conclude that exposure to microwaves causes depression of blood SH levels, nor can they conclude that the result, if true, is caused by any particular physiological mechanism.

Standards of Writing and Publishing

The quality of the organization and writing of scientific papers varied considerably. Among the works reviewed in detail, those by Sudakov and Antimoniy^{7*} and Presman^{8*} were the best, and the book by Tolgskaya and Gordon^{5*} was the worst. The article by Lobanova,⁶ probably would have been rejected by a Western editor for poor quality of writing, regardless of the scientific merit of the findings. Although in some of the detailed reviews, the poor quality of translation is noted (e.g., the book by Kulikovskaya^{3*}), the translations generally are adequate. The principal problem in badly written work is the author's failure to organize the material in a clear, coherent style.

An interesting finding is the tendency of some Soviet authors to plagiarize Western sources of data. The practice is not universal (Sudakov and Antimoniya cite Western literature extensively), but the origin of Soviet work in the field of biological effects of microwaves should be scrutinized carefully in assessing quality of research.

The poor quality of writing and the evidence of tendency to plagiarize suggest that Soviet scientists may be under considerable pressure to produce articles, the number of publications rather than the quality of research being a criterion of accomplishment. This tendency may exist not merely in academic institutions but also in many ordinary research and testing establishments.

General Overview of the Reported Biological Effects

The studies of biological effects of electromagnetic radiation in the Soviet Union and East European countries are directed toward three visible objectives:

- (1) Determination of hazards to public health and methods for protecting workers occupationally exposed to radio waves.
- (2) Study of the physiological effects of radiation as a question of basic scientific merit.
- (3) Study of electromagnetic radiation as a basic factor in the environment.

These objectives are not always distinct in Soviet publications, but generally the first objective is a major concern of such investigators as Z. V. Gordon, M. S. Tolgskaya, M. G. Shandala; the second objective is represented by K. V. Sudakov and G. D. Antimoniya; and the third objective is studied by A. S. Presman. In addition, very likely a group is concerned with potential military and political applications of electromagnetic radiation effects, but this group is not readily identified from inspection of the Soviet scientific literature.

In the first study area, concerned with public health and occupational disease, many effects have been reported. Shandala et al.^{9*} list reported effects on the central nervous system, cardiovascular effects, effects on hematopoiesis, antibody synthesis, thyroid activity, fertility, stress reaction, and effects on biochemical systems. I. R. Petrov¹ lists similar effects in much more detail and includes also effects on the gastrointestinal tract and the kidneys. The book by Tolgskaya and Gordon^{5*} presents a number of morphological effects of microwaves on the nervous system.

All the effects listed above are reported to occur at power densities of 10 mW/cm² or less. The problem of regional

variations in power density in the work of Tolgskaya and Gordon^{5*} was noted above, but examinations of results at high power densities indicates that the average power level at which the animals were exposed is probably not greatly different from that reported in the book. We could make similar analyses of the probable values of power density (where reported) in other works examined but we assume for review purposes that the Soviets are capable of making a measurement of power flux per se with reasonable accuracy.

The book by I. R. Petrov¹ is perhaps the best comprehensive presentation of the public health and occupational safety aspect of Soviet research on the biological effects of electromagnetic radiation. The book is 226 pages long and is divided into 13 chapters and a bibliography. Various authors wrote separate chapters and portions of chapters, so the writing style is uneven. Many portions of the book are written in such a style that the reader has difficulty distinguishing between opinion and conclusion and between reference citation and new data.

Although we examined the book, we did not do a comprehensive review. Chapters 8 and 9 present a fairly good summary of the beliefs of Soviet clinicians about the neurological and psychological effects of electromagnetic radiation. Chapter 7 describes some of the physiological studies of effects of electromagnetic radiation on healthy human subjects. Also in this chapter is the work of Gusarov¹⁰ with the kinesthetic analyzer and that of Osipov and Kalyadall on skin temperature (cited by Sudakov and Antimoni^{7*}). The chapter is fairly good but adds little to the information already included in Appendix E.

Soviet standards on permissible exposure of humans to electromagnetic radiation are lower than U.S. standards by a factor of 10^3 . Shandala et al.^{9*} recommends further reduction of permissible exposure of the general population (not occupationally exposed to electromagnetic radiation) to $0.5 \mu\text{W}/\text{cm}^2$, a value 20 times lower than that permitted for occupational exposure.

Studies by Pazderova, et al.^{12*} in Czechoslovakia and Czerski, et al.^{13*} in Poland showed no demonstrable effects of electromagnetic radiation on occupationally exposed workers. The standard of permissible exposure in these countries is somewhat lower than that in the United States, but it is higher than that in the USSR. In these studies, the investigators do not consider whether biological effects reported from the Soviet Union are true effects of electromagnetic radiation, but they affirm that the effects are not caused by radiation within the permitted standards of their respective countries.

Taken together, most of the conclusions of the Soviet workers concerning the appropriate standards for exposure to electromagnetic radiation probably can be discounted, partly because of poor experimental design and partly because their claims are not supported by observation in other countries. Whether real biological effects exist at non-thermogenic energy levels remains a moot point; Soviet workers in occupational health have not demonstrated such effects.

Sudakov and Antimoni^{7*} and Presman^{8*} review in detail studies on the basic physiological effects of electromagnetic radiation and on the role of electromagnetic radiation in the environment, respectively. Although Presman and Sudakov and Antimoni^{7*} tend to accept the reported work of others uncritically, their articles give the impression that they are considerably more competent than the occupational health workers. Their conclusions are presented in the detailed reviews in the appendices. In general, although Sudakov and Antimoni^{7*} and Presman quote from the work of the occupational health researchers, these authors are more concerned with physiological mechanisms of action and with physiological adaptation to electromagnetic radiation than with health aspects as such.

The appendices to this report should be consulted for more detailed description and analysis of the Soviet and East European work on the biological effects of electromagnetic radiation.

Possible Evidence of Censorship

The various publications that we reviewed in detail--particularly those of Tolgskaya and Gordon,^{5*} Sudakov and Antimoni^{7*} and Presman^{8*}--were scanned carefully for internal evidence of possible censorship by Soviet authorities of results or procedures that might have military or political significance. In the book by Tolgskaya and Gordon, we carefully examined the authors' completeness and detail in presenting various effects; and, in the works of Sudakov and Antimoni^{7*} and of Presman, we focused on the completeness of the citations to references and checked whether any references in the bibliography were not cited in the text. Neither of these approaches is necessarily reliable, but they do provide possible clues to sections that may have been censored.

The detailed results of the scanning are contained in the appendices. Presman's paper had no evidence of omissions due to censorship. In the book by Tolgskaya and Gordon, we noted a curious feature in the reporting of frequencies of radiation: Radiation in the low, medium, high, and very high frequencies is specified more or less precisely--e.g., 14.8 MHz, 191 MHz. Radiation in one part of the microwave band is specified with the same general precision--i.e., 10 cm, 3 cm. However, radiation at longer and shorter wavelengths is designated by the words "decimeter" and "millimeter." The designation appears

consistently throughout the book and suggests the existence of special concern about these frequency ranges. We noted also that at 191 MHz, which is near the decimeter range, the energy density for lethal effects was exceptionally low. This matter should be investigated further. A table in the detailed review summarizes reported biological effects in relation to frequency and notes where effects reported at one frequency are not mentioned at another. Analysis of this table might reveal further evidence of censorship, although the omissions most likely result from the poor quality of writing rather than from the action of censors.

In our review of the work of Sudakov and Antimoni, ^{7*} we noted that, among 224 items in the bibliography, 11 of the references listed were not cited in the text. Ten of the 11 appear to have been omitted through oversight or editorial revision by the authors. However, one of the references, an article by I. N. Zenina entitled "Effect of Pulsed Superhigh-Frequency Electromagnetic Fields on the Central Nervous System after Single and Prolonged Exposures," may have been deleted from the text intentionally. The article appeared originally in O biologicheskoy deystvii elektromagnitnykh poley radiochastot, Moscow, 1964, pp. 26-32. This article should be translated and examined.

Possible Military and Political Functions of Research in Biological Effects of Electromagnetic Radiation in the USSR

This section is necessarily somewhat speculative, but we believe we should comment on possible military and political aspects of research on electromagnetic radiation.

Naturally, no direct evidence exists of Soviet development of a tactical weapon based on the biological effect of electromagnetic radiation. However, we emphasize the vagueness of specification of frequencies or wavelengths in the decimeter and millimeter bands. The text of the patent for the psychiatric apparatus ^{14*} is also vague on the matter of frequencies. The term "VHF" is used principally, and the word "metric" is used once. Possibly, if a weapon or device is being developed, it may operate in the 150 to 750-MHz region.

The Soviet research also appears to focus on VHF and SHF radiation that is pulse-modulated in frequencies resembling biological rhythms or frequencies--i.e., ~ 0.4 to 100 Hz. The volume of publications in this area, however, is not particularly high. The psychiatric apparatus ^{14*} incorporates such frequencies into its operation. Other studies of this mode of irradiation are cited in the review of Sudakov and Antimoni. ^{7*}

The patent text discusses applications of the psychiatric apparatus ^{14*} in the fields of psychiatry and military medicine. The possibility also exists that this device, or an operationally similar one, could be used to brainwash political dissenters or others.

Sudakov and Antimoniy^{7*} describe primarily the work of experimental physiologists whose research does not appear to be directly connected with military, political, or public health purposes. Presman^{8*} appears to be concerned primarily with determining the overall relationship of radiation to life systems of the planet--again, research that does not appear to have strong military or political significance. The possibility that the Soviet government uses the work of investigators like Presman to plan timing of policy announcements or actions is discussed in the detailed review (Appendix G). The Soviet government very likely would like to advance a philosophy of the meaning and purpose of life that is based on materialistic and rational considerations rather than on appeals to a deity or on supernatural beliefs. On this basis, the government would welcome and support the work of researchers having the competence and scientific stature of Presman for their contributions to the philosophical systems.

The work of the investigators in the public health area is impressively voluminous despite its relative scientific incompetence. The possibility exists that this work is a cover for secret military research. The publications could account for the number of workers and the size of institutions, and the scientific quality of the publications could be a mask to direct attention away from real purposes. We do not know of a direct way to resolve this question.

Moreover, this conclusion may be too cynical. The Soviet government unquestionably is concerned about the health and safety of its people. A more likely explanation is that the Soviet people experience the same problems of coping with and adapting to the modern industrial state as do the English and American people; and the conditions of depersonalization and frustration are the same on both sides of the Iron Curtain. In Western countries, the source of the problem is stated by some psychologists and sociologists to be "The System" or "the rat race," and various public and personal remedies are proposed. In the USSR, such conclusions and solutions would be totally unacceptable, and the Soviet government therefore may be more receptive to the belief that the health of the people is seriously threatened by physical and chemical factors in the environment.

Philosophical Differences in Public and Occupational Health, Scientific Research, and Medical Practice Between the USSR and Western Countries

Zielhuis¹⁵ has analyzed the differences between the United States and the USSR in their approaches to standards for occupational exposure to toxic agents. Although numerous differences exist, the most significant differences are that (1) U.S. standards are based primarily on data from studies of biochemistry and pathology, whereas Soviet standards are based on data from studies of the central nervous system and behavior;

and (2) U.S. standards are made in consideration of the deleterious consequences of the agent, whereas Soviet standards are based on the theory that any deviation is potentially harmful.

Presman's book^{8*} presents differences in philosophy of scientific research; these differences are discussed in the detailed review of this book (see Appendix G). A significant part of the difference is that Soviet scientists readily accept a causal relationship arising from an experimental study without requiring that it be related immediately to the general body of scientific knowledge, whereas Western scientists generally require demonstration of the relationship of a finding to the general body of scientific knowledge as a condition for confirmation. This difference probably leads to Soviet scientists having a somewhat less critical attitude, and accounts in part for some of the discrepancies in findings on biological effects of electromagnetic radiation between the two countries.

The works examined in this project consistently reveal differences in the philosophy of medical practice. The analysis of Zielhuis¹⁵ is abundantly confirmed: Western medicine is primarily pathology oriented, whereas Soviet medicine is primarily function oriented, emphasizing the role of the central nervous system. In the Soviet view, biological effects of electromagnetic radiation arise from stimulation or "irritation" of the nervous system; in the U.S. view, a large part of the body of medical practitioners probably doubts that pathological effects can be induced by any form of nervous system stimulation. In this respect, the Western view most likely is unnecessarily conservative, and a more liberal viewpoint might lead to a better scientific basis for studying the biological effects of electromagnetic radiation.

Finally, fields of research generally tend to be dominated by particular scientific disciplines. In the United States, for example, pathologists dominate the field of carcinogenesis, and chemists dominate the field of toxicology. Regarding research on biological effects of electromagnetic radiation, engineers and physicists clearly dominate in the United States and physicians dominate in the USSR. This difference in field dominance has a powerful effect on the directions of research in the respective countries.

Status of Research in the United States Relative to Work Reported from the USSR

The strong engineering orientation of research on effects of electromagnetic radiation in the United States leads to an emphasis on dosimetry and physical mechanisms. Recent work in these areas has produced results that are relevant to those in published work from the USSR.

In the field of dosimetry, the development of infrared thermography has allowed researchers to study in detail regional differences in radiation intensity within the bodies of exposed animals. In a recent, as yet unpublished study, the carcass of a macaque monkey was exposed to 2.45-GHz microwaves in a multimode, mode-stirred cavity. The head of the monkey showed regions of high energy deposition ("hot spots") in the nasal passages, the back of the eye, the cortex, the hypothalamus, and parts of the medulla and cerebellum. Clearly, radiation intensity is not uniformly distributed, and biological effects reported for a particular organ or part of an organ may result from higher doses than the experimenter believed and reported. In connection with the findings on the regional distribution of dose in the monkey, Tolgskaya and Gordon^{5*} reported pathological findings primarily in the cortex and the hypothalamus of their subjects, and the frequency of exposure was 3 GHz.

In the field of physical mechanisms, work in the United States has shown that electromagnetic radiation can cause optical polarization changes in solutions of macromolecules¹⁶ (the Kerr effect), and, more recently, radiation was shown to cause changes in hydrogen bonding in macromolecules.¹⁷ These effects were demonstrated with fields of 20 and 400 V/cm, respectively, but undoubtedly the effects exist at lower intensities; hence, possible mechanisms exist whereby nonthermal effects can be produced at a cellular level by electromagnetic radiation. An interesting note is that Soviet scientists have postulated such mechanisms to account for nonthermal radiation effects, but the first actual demonstration of such effects comes from the United States. (See also discussion in Appendix F.)

Another notable development in the field of physical mechanisms is the demonstration of the production of acoustic transients in water by pulsed microwaves.¹⁹ This effect can account for the production of RF sound ("pock") as reported by A. Frey and others. Soviet workers have claimed for some time that pulsed microwave radiation is more effective than continuous wave radiation in producing certain biological effects. United States workers have generally discounted this claim on the grounds that only thermal effects are significant. The demonstration of a physical mechanism for production of RF sound also provides support for some of the Soviet claims.

Recommendations

The scientific literature on public and occupational health aspects of electromagnetic radiation in the USSR does not contain scientifically valid data to support the Soviet standards for permissible exposure to the radiation. Many of the studies examined are scientifically unsound by Western standards, and no scientific conclusions could be drawn from them. Nevertheless, it would be a mistake to assume that no biological effects exist simply because scientific proof of them is lacking. We recommend that a modest experimental program be initiated to

repeat selected Russian studies on biological effects of electromagnetic radiation in a scientifically valid manner. The selection should be for reported effects that are technically easy to verify and that would be clearly significant for occupational health and safety--e.g., studies of neurosecretion in the hypothalamus, as reported by Tolgskaya and Gordon.^{5*}

The gaps and omissions of data in Soviet publications suggest censorship or security interest. The survey of the literature should be extended for a detailed examination of the following areas:

- (1) Any radiation studies in the 0.1- to 1-GHz range and in the 30- to 300-GHz range, particularly when the exact frequency is not specified.
- (2) All studies of VHF or SHF radiation that is pulse modulated in the 0.1- to 200-Hz range.

The addition to the above studies, we have selected four articles from the bibliography of the review by Sudakov and Antimoniy^{7*} as being possibly significant and warranting further study. These articles are listed at the end of Appendix E. They should be obtained, translated, and reviewed carefully.

The process of reviewing the Soviet and East European literature should be continued, if only on a limited basis. As a strategy for review, consideration should be given to translating authors and titles for initial review and subsequently the full text only when the reviewer believes that it is warranted. In connection with this review strategy, a citation index should be developed. The index should include author, author's affiliation and background, and subject.

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APPENDICES

The Appendices comprise detailed reviews of articles principally from the Soviet and East European literature. The articles were selected for their relevance to the objectives of this study and, also, for their amenability to critical review. (However, we reviewed the Polyashchuk article partly to demonstrate the difficulties in reviewing a poor paper.)

The four categories we have found useful in analyzing the data are:

- (1) Occupational hygiene
- (2) Military medicine
- (3) Radiation as a component of the environment
- (4) Other work (e.g., basic research, work of isolated groups, diathermy).

Some of the articles in the Appendices fit clearly into one category or another. Thus, under Category 1 are the epidemiological surveys of Czerski et al. and Pazderova et al., the literature review by Shandala et al., and the book by Tolgskaya and Gordon. Category 2 is less well defined. It comprises principally the work relating to potential military or tactical applications, but it also includes that work indicating a superior technical and scientific approach to and understanding of the problem. By this definition, the patent by Rabichev et al. is under this category rather than under Category 4, as is the review by Sudakov and Antimoni. Also included under Category 2 is the book by Kulikovskaya because of the excellence of the technical treatment and because of the author's relationship to the Leningrad "School." Presman's book is an example of material fitting into Category 3. Although the article by Polyashchuk could be interpreted as having potential tactical application, it is included under Category 4 because of its apparent deficiencies.

Appendix A

A REVIEW OF EAST EUROPEAN STUDIES ON THE BIOLOGICAL EFFECTS OF ELECTROMAGNETIC RADIATION

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Literature Reviewed

- J. Pazderova et al. Workers' state of health under long-term exposure to electromagnetic radiation in the VHF band (30-300MHz).
Pracovni Lekarstvi 23 (8), 265-271 (1971).
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I. Theoretical considerations and practical aspects. Aerospace Med. 45 (10), 1137-1142 (1974).
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III. Lens translucency. Aerospace Med. 45 (10), 1145-1148 (1974).
From the Department of Sanitary Inspection, Ministry of Health and Social Welfare; the Institute for Postgraduate Study, Military Medical Academy; and the Military Institute of Hygiene and Epidemiology; Polish People's Republic.

The above-cited papers report the results of two fairly extensive studies, one conducted in Czechoslovakia and the other in Poland, of the health of workers occupationally exposed to electromagnetic radiation from various sources. In both studies, the measured levels of exposure of the subjects were generally within the permissible limits set by government regulation in the respective countries. The objective of both studies was to determine whether any pathological findings in the subjects could be attributed to the permissible-level exposures.

Czechoslovakian Study

The subjects of this study were 58 persons (49 males and 9 females) who were employed as technicians and supervisors at television transmitters. The mean duration of occupational exposure was about seven years. The subjects were hospitalized for five days and given an extensive battery of clinical tests. These tests included cardiovascular examination (pulse rate, blood pressure, and electrocardiogram), hematology (erythrocyte, leucocyte, differential, and platelet counts, blood hemoglobin, and hematocrit), clinical chemistry (plasma cholesterol, SGOT, SGPT, bilirubin, glucose tolerance, and plasma protein analysis),

urinalysis, chest X-ray, gynecological examination of females, ophthalmologic examination, and neurological and psychiatric examination. The tests and examinations were chosen on the basis of various reported effects of electromagnetic radiation, which were cited in the bibliography.

The controls for the study varied. For some tests--e.g., blood pressure or glucose tolerance--the values obtained in the subjects were compared with normal values for the Czechoslovakian population. In other cases, values obtained in the test subjects were compared with those of healthy subjects of equivalent age who were not occupationally exposed to radiation. Different control groups apparently were employed for different tests. The authors acknowledge that the procedure for obtaining controls does not meet ideal specifications, but they state that the expense involved in obtaining proper controls could not be justified. In view of the results obtained, the procedure the authors used for obtaining controls is reasonably valid.

The results were generally negative. No significant differences existed between clinical values obtained in the subjects exposed to VHF radiation and those obtained in the control subjects. The incidence of pathological findings generally was what might be expected in a normal, healthy population. The exposed subjects had slightly higher than normal values of blood hemoglobin and total blood leucocyte counts. The former finding could be attributed to the fact that the subjects lived at somewhat higher altitude than the average population, and the latter result was attributed to minor infections in five of the subjects. Blood cholesterol was slightly elevated, but this finding appeared to be associated with the subjects' being hospitalized; the authors discount it. Plasma protein concentration was higher in the exposed subjects. Although the difference from controls was highly significant, the result was not accompanied by any gross distortion of the distribution pattern of the proteins; and, in the absence of such a distortion, the result has no known pathological significance. Ophthalmological findings were normal for the respective ages of the individual subjects.

The neurological and psychiatric examinations were fairly extensive, including clinical observation of neurovegetative symptoms (e.g., sweating, tremor, or increase in pulse rate during examination), clinical examination and interview, and completion of psychological questionnaires. The authors present an extensive list of findings, but all could be accounted for as being unrelated to radiation exposure or as being the normal incidence for the controls. Moderate, non-dysfunctional neurotic disturbances were found in 39% of the subjects.

The authors conclude that the occupational exposure to VHF electromagnetic radiation at levels not exceeding the permitted levels (10 V/m, 80 V/m hr for an eight-hour shift) causes no significant clinical findings.

Polish Study

The Polish study differed from the Czechoslovakian study in a number of details. First, the radiation was pulsed microwaves in the frequency range used in radiolocation (not otherwise specified) rather than the VHF radiation of the Czechoslovakian study. Second, the subjects were 841 men, 20 to 45 years old, who had been occupationally exposed to the radiation. These men had been referred for clinical examinations by industrial physicians because their fitness for further work under conditions of microwave exposure was questionable. Finally, the scope of the clinical examination was determined by regulations of the Ministry of Health and Social Welfare of the Polish People's Republic, which specify certain clinical conditions and symptoms as medically disqualifying for work under conditions of microwave exposure. The conditions are: organic lesions of the nervous system; evidence of functional neurological disturbance, neurosis, or psychosis; changes in the transparent media of the eye; disorders of the blood-forming system; neoplastic diseases; endocrine disorders; pregnancy; tuberculosis; rheumatoid disease; and heart diseases. The rationale for these various exclusions is based on published reports (cited by reference to reviews) that microwave exposure may adversely affect any or all of these functions. Examination of the titles of the ordinances and regulations indicates that they refer specifically to radiation in the microwave range.

For purposes of analysis, the authors divided the group into two subgroups. One group of 507 persons had been exposed to power densities in excess of 0.2 mW/cm² but not exceeding the allowed maximum of 1 mW/cm². The other group, comprising 334 persons, had been exposed to power densities of less than 0.2 mW/cm². The incidences of clinical signs and symptoms were compared between the two groups and within each group further subdivided by age and by duration of exposure. The authors strongly rejected the use of control groups from the general population or from other sources on the grounds that the examined population was highly selected.

Of the total of 841 subjects, 406 were found to be unfit for further exposure to microwave radiation, according to the standards of the Ministry of Health and Social Welfare. The authors further subdivided the disqualified workers into groups of those disqualified for ophthalmic causes, those disqualified for functional disturbances (neurologic or neurotic, digestive tract and cardiovascular), and those disqualified for other causes. The incidence of disqualification of workers for these broad categories of cause was analyzed by comparison between

the two exposure groups and within each group by comparison with age or duration of exposure.

The relative incidence of any disqualifying condition did not differ between the two exposure groups. Considering the two exposure groups separately, no relationship existed between the incidence of disqualifying conditions and either the age of the worker or the duration of his exposure. The authors conclude that the hazard to personnel from exposure to microwaves is not greater for levels between 0.2 and 1 mW/cm² than for levels less than 0.2 mW/cm². They further propose that the method of survey may be useful for "perfecting" the method for monitoring the health of workers exposed to electromagnetic radiation.

In the second and third papers of the series, the authors analyze the incidence of all functional disturbances and ophthalmological findings, including those that were judged to be of insufficient magnitude to disqualify the subjects from further microwave exposures. The functional disturbances include neurotic and gastrointestinal symptoms and electrocardiographic irregularities. Cases involving organic lesions of the heart or of the gastrointestinal system were excluded from the study, and the gastrointestinal complaints were judged to be related to emotional disturbances.

Of the 841 subjects examined, 33% were found to be free of any functional disturbances, 35% had some neurotic symptoms, 22% had disorders of the digestive tract, and 10% had electrocardiographic irregularities. As in the first study of disqualifying symptoms, the incidence of all symptoms did not differ between the group that had received the higher range of microwave exposure and the one that had received the lower level. Occurrence of electrocardiographic irregularities in both groups was independent of age of the worker or duration of exposure to microwaves. For neurotic and gastrointestinal disturbances, some dependence of incidence of symptoms on age and on duration of occupational exposure was apparent, but the relationship was significant only for age versus incidence in the group receiving the higher range of exposure. In discussing the results, the authors state that, if microwaves exposure were the cause of the functional symptoms, a relationship would be expected between incidence of symptoms and exposure level or duration of occupational exposure. (The incidence of 35% of the subjects having some neurotic symptoms compares well with the 39% incidence found in the Czechoslovakian study.)

For analysis of the ophthalmological findings, the data were grouped under three headings: (1) no opacities present, about 28% of the subjects; (2) single, minute opacities of no significance for visual acuity, about 53% of the subjects; and (3) multiple minute opacities or opacities causing impairment of vision, about 19% of the subjects. Slightly over half of the subjects in the third category were disqualified for further occupational exposure to microwaves. No significant difference

in occurrence of any grade of ophthalmic findings existed between the two exposure groups. The relative number of lens opacities increased with increasing age or duration of occupational exposure, but only the age dependence was significant. The authors state that a study of the incidence of lesions of the retina was not made and should have been included.

Comments

From a methodological viewpoint, the Czechoslovakian study is greatly superior to the Polish study. In the Czechoslovakian study, workers exposed to the VHF radiation were invited to participate in the study, and the description of methods implies that the authors made no conscious selection of subjects. Controls for the study were not ideal but were adequate, considering the generally negative results. In the Polish study, the subjects were workers referred to the health center because of doubts about their fitness to continue in their occupations. This circumstance results in a highly selected population for any kind of survey of health and safety and makes the interpretation of results very problematic, even with the best controls obtainable. The degree of emphasis with which the authors of the Polish study reject the use of unexposed controls suggests that they might have tried to obtain such controls and found that the comparison of the controls with the exposed subjects was embarrassing in some way.

The conclusion of the Czechoslovakian study is that workers occupationally exposed to VHF electromagnetic radiation at or below the intensity levels permitted by government regulation do not develop clinical symptoms in the categories tested. The tests performed cover most of the clinical effects of exposure to electromagnetic radiation that have been reported in Soviet and East European literature. The authors conclude that the safe exposure standards for VHF radiation set by the government are adequate for protection of occupationally exposed workers. They offer no opinion about the likelihood of clinical effects occurring in the categories tested if the exposure level were high enough.

The conclusion of the Polish authors is that symptoms occurring in the workers occupationally exposed to microwaves do not show dependency on intensity or duration of exposure. The authors point out that such a dependency would be expected if microwave exposure were the cause of the symptoms. Although this is probably true, the study does not prove the conclusion that microwave exposure has no clinical effect. Examination of the data shows that, whereas the incidence of effects is truly independent of exposure intensity, it does depend somewhat on duration of exposure. The duration dependency is not statistically significant, but this is not proof that it is nonexistent. The real problem is that the age of the worker and the duration of his exposure are mutually correlated; hence, correlating incidence of symptoms with the two parameters

separately is difficult. The authors used a statistical test for dependence of incidence of symptoms on age or exposure duration that is unfamiliar to the reviewer, but the test is evidently a modification of analysis of covariance that can be applied to enumeration data. The reviewer would prefer to use rank difference correlations to attempt to separate the effects of age and duration of exposure, but the data are not available in the study for such an analysis.

In the Czechoslovakian study, the investigations were based on clinical and experimental effects of electromagnetic radiation reported in the Soviet and East European scientific literature, but the article gives no particular evidence that the findings are incorporated into specific health regulations for workers. In the Polish study, the investigations were based on the same general kinds of findings in the scientific literature, but the results appear to have been accepted on faith by the Ministry of Health and Social Welfare and incorporated into relatively rigid standards of health for workers occupationally exposed to electromagnetic radiation, in the microwave region at least. The general tone of discussion in the papers implies that the authors of the Polish study believe that the government regulations are excessively strict.

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Appendix B

REVIEW OF "MICROWAVE RADIATION: ITS BIOLOGICAL EFFECT
AND IMPACT ON HEALTH IN INHABITED LOCALITIES"

Appendix B

REVIEW OF "MICROWAVE RADIATION: ITS BIOLOGICAL EFFECT AND IMPACT ON HEALTH IN INHABITED LOCALITIES" (Review of the Literature, 1970-1972)

M. G. Shandala, Yu. D. Dumansky, and V. M. Popovich

The authors of this review are associated with the Kiev Institute of General and Communal Hygiene, Ukrainian SSR Ministry of Health. Shandala's laboratory was one of two in the USSR visited by a group of five U.S. researchers at the end of May 1974. Dumansky was one of three Soviet researchers to visit the United States in February 1975; the other two were Engineer I. P. Los', also from Shandala's laboratory, and T. V. Kalyada, from Leningrad.

The objective of this paper is purportedly to "assess the impact of an SHF field on health in inhabited localities and of establishing safe exposure levels." Thirty-nine references are cited. The main thesis of Shandala, et al. is that chronic exposure to low-intensity SHF energy leads "...above all to functional changes in the nervous system, the circulatory system, and the blood." A considerable number of the references are cited as reporting these effects. The review is not a critical nor even a comparative one, as would be expected in a similar Western review. It is purely a narrative exposition of the stated conclusions of others.

The authors commence their review by pointing out that the increasing use of superhigh frequency (i.e., microwaves, 300 MHz to 300 GHz) energy has imposed on researchers in health sciences the tasks of assessing the impact of SHF radiation on health in inhabited localities and of establishing safe exposure levels. The first four citations concern methods of measuring SHF energy in the vicinity of transmitters and (microwave?) transmission paths ("radio-relay lines"). This is purely technical work requiring no scientific judgment.

Shandala et al. next cite the extensive work done by Soviet researchers on the biological effects of microwaves. They claim that most of the Soviet workers have concentrated on relatively high power flux densities (hundreds of microwatts per square centimeter and above) and that the Soviet observations may not be fully pertinent to question of communal health where power flux densities rarely exceed tens of microwatts per square centimeter. Shandala et al. nevertheless review some of the Soviet work, since "so few studies deal specifically with the intensity range of primary interest"--presumably tens of microwatts per square centimeter and below. We believe Soviet workers have concentrated on "relatively high power densities" because they have observed no effects in the intensity

range of primary interest to Shandala, et al.

Next follows a summary of eight articles describing the effects of microwaves on the nervous system and on neurophysiological function. The conclusions of the cited authors are repeated and obviously are taken as unassailable evidence of the existence of the claimed effects. Shandala et al. cite 11 studies on the health of persons occupationally exposed to microwaves. The prime effects are stated to be on the nervous and cardiovascular systems. People working in a microwave field (no mention of exposure power density) complain often of "a heavy feeling in their heads, headaches, fatigue, drowsiness in the daytime, irritability, poor memory, and a pain in the heart, usually of the aching, stabbing type." These highly subjective indicators are accompanied by what the Soviets believe are more objective symptoms including bright-red, diffuse, persistent dermatographia; hyperhidrosis; and unstable arterial pressure. Considerably less emphasis would be placed on such "signs" by Western clinicians.

The remaining citations concern effects more closely associated with basic science and effects on physiological responses in animals, including hematopoiesis, immunology, endocrine effects, carbohydrate metabolism, and reproductive physiology.

Shandala, et al. preface their summary of the material reviewed by noting that the effect of a high-intensity SHF field on animals and on humans has been researched thoroughly and that the "syndrome" caused by these fields has been termed "radio wave sickness." This is not the picture presented in the Soviet literature as we have understood it. Rather "radio wave sickness" has specifically referred to a nonthermal, low-level, chronic exposure effect on humans. However, Shandala et al. conclude that:

"...it is quite apparent...that even low-intensity SHF energy leads after lengthy exposure to a number of functional changes in the organism's vital activities, and that these changes may sometimes develop into organic diseases.-----On the basis of the experimental research that has been conducted, the authors recommend 0.5 microwatts per square centimeter as the maximum permissible level of SHF energy for dwellings."

Comment

The stature of Shandala and Dumansky in this research field in the USSR would lead the reader to believe that their review would be well conceived and well executed. Unfortunately, this is not the case, at least by Western standards. As in much of the Soviet literature, the conclusions reached are not supported by the data presented. The recommendation for a standard of 0.5 uW/cm² for dwellings has no basis, especially not from the presentation by Shandala, et al. Evidence of

effects at levels of tens of microwatts per square centimeter are, by the authors' own statement, lacking, and Soviet researchers do not claim to see effects until levels of hundreds of microwatts per square centimeter are reached.

Moreover, the authors accept uncritically the claims of the various references cited. After our preliminary review of this article, we intended to request translations of all articles cited by Shandala et al. and to perform our own critical review of these publications. However, because of the nature of the work cited, this was not possible. Table 1 is a breakdown of the source of references cited by Shandala et al. Over one-third of the references cited are from Gigiyena truda i biologicheskoe deystvie elektromagnitnykh voln radiochastot [Industrial Health and the Biological Effect of Radio Frequency Electromagnetic Waves]: Materials of the Fourth All-Union Symposium, October 17-19, 1972. We received copies of these articles but could not apply techniques of critical review to them for the reasons described earlier. Table 2 is a breakdown of the type of references cited. Thirty-four of the 39 references cited are abstracts or brief articles not amenable to critical review and assessment. Two are full-length books--one by Tolgskaya and Gordon, a review of which is presented in Appendix C, and another that is unfamiliar to us. The remaining three references, the Ministry of Health Standard and the two book chapters, do not appear to be particularly valuable in terms of the evidence they present to support a new standard.

We conclude, therefore, that Shandala, et al. have proposed the concept of a new standard on political grounds rather than on scientific grounds. Whether this is the basis for most or all standards in the USSR is a question we cannot answer at present.

Table 1
SOURCES OF REFERENCES CITED

Source	No. of Citations
Industrial Health and the Biological Effect of RF Electromagnetic Waves: Materials of the Fourth All-Union Symposium, October 17- 19, 1972. (Gig. tr. i biolog. deystvi. elek. voln radiochastot)	14
Industrial Health and Occupational Disease (Journal) (Gig. tr. i prof. zaboлев.)	6
Journal of Military Medicine (Voen. Med. Zhurnal)	5
Health (Journal) (Zdorov'ya)	3
Author's abstract of candidate's disserta- tion	3
Miscellaneous (other journals, books, standard, etc.)	8
	—
Total references cited	39

Table 2
TYPE OF REFERENCES CITED

<u>Type of Reference</u>	<u>No.</u>
Abstracts or short (1- to 5-page articles	34
Full-length books	2
Ministry of Health Standard	1
Book chapter (10 pages)	1
Book chapter (length not specified) .	1
	39

Appendix C

COMPREHENSIVE REVIEW OF PATHOLOGICAL EFFECTS OF RADIO WAVES

Appendix C

COMPREHENSIVE REVIEW OF PATHOLOGICAL EFFECTS OF RADIO WAVES

M. S. Tolgskaya and Z. V. Gordon, authors; Basil Haigh, translator; Consultants Bureau, New York and London, 1973
(Original pub., Moscow, 1971)

General Overview

This book is both a review of previous studies on the biological effects of radio waves and a presentation of new studies. The style of writing and the manner of citing references often make determination of what is review of past findings and what is new work difficult. As far as possible, we have attempted to identify and report on new work. The book covers virtually the entire frequency spectrum of radio waves and includes studies both at high intensity, and at low intensity, in the region of so-called nonthermal effects. However, the greater part of each section deals with the effects of microwaves. We have reviewed all parts of the book for what information they may contain, placing the strongest emphasis on the chapter covering low-intensity microwaves.

The new material in the book concerns the results of studies on a total of 646 animals. The bulk of the effort in the studies appears to have involved histopathological examination of various organs and tissues. The studies were fairly extensive, and many of the ones on the nervous system required serial sectioning and special staining methods. The numbers of animals in particular parts of the studies usually are not specified, so assessing the amount of effort represented by the book is difficult.

The book begins with an introductory chapter discussing the physics of radio waves, the background of the problem of biological effects, and the methods used in exposure of the animals. The animals used in the study were rabbits, rats, and mice. The animal is rarely specified in any individual part of the book, but rats appear to have been used in most of the studies. For exposure at frequencies below the microwave band (300 MHz, by the authors' definition), animals were stated to have been placed in cavity resonators (although this could not be the case for the 500-kHz frequency used); for microwave exposure, animals were irradiated from external sources. The animals were exposed in multiply compartmented cages, and judging by the photographs, sometimes several animals were exposed in the same compartment. The photographs of microwave exposure facilities do not show use of microwave-absorbent materials on the walls or interior furnishings of the room.

Following the introductory chapter is a section of several chapters on the effects of high-intensity radio waves. The frequencies range from so-called "millimeter" (~ 100 GHz) waves down to 500 kHz. However, the chapter on effects of microwaves is about five times longer than the combined total of those on effects of other frequencies. The intensities in the microwave band ranged from 20 to 140 mW/cm², but most of the studies seem to have been done at 100 mW/cm².

Following the section on high-intensity radio waves is another section on the effects of low-intensity radio waves. The frequencies were the same as those for high-intensity radio waves, and the exposure intensities in the microwave band were generally around 10 mW/cm², which the authors regard as the threshold for thermal effects. The section on low-intensity radio waves is more than twice as long as the section on high-intensity waves; and, in the low-intensity section the chapter on microwave effects is four times longer than the total length of the chapters on other frequencies. In the chapter on microwave effects, the report on effects in the centimeter region amounts to about 80% of the total, with millimeter and decimeter regions making up the rest.

In-depth reviews of the section on high-intensity and low-intensity radio waves are presented next.

Table 1 presents a summary list of all pathological findings in animals subjected to prolonged or repeated exposure to low-intensity radio waves at the various frequencies. For each frequency band, the pathological findings reported for the band are noted by the symbols Y, present; N, not present; O, not mentioned.

Section I - Physiological and Morphological Changes in Animals Exposed to Radio Waves of High Intensity

1. Frequencies of exposure ranged from 500 kHz to millimeter waves. In the microwave region, the field intensities ranged from 20 to 140 mW/cm². In the lower frequency range, the intensities ranged from 350 to 9000 V/m, with lower numbers corresponding to shorter wavelengths. These exposure fields are described as "high intensity" and, except for the 500 kHz frequency, were capable of causing death of the animals, with clinical signs of hyperthermia in several minutes to several hours.

2. Temperature rises (up to 42 to 45°C) were reported in the animals, but temperatures were not recorded systematically. Judgment of a thermal effect seem to have been made in most cases by clinical observation of the animals. The clinical picture of hyperthermia is described in a series of stages: (a) orienting reaction; (b) arousal and appearance of a slight erythema of the paws, tail, and ears; (c) development

Table 1

SUMMARY OF OCCURRENCE OF PATHOLOGICAL FINDINGS IN ANIMAL
EXPOSED REPEATEDLY TO RADIO WAVES OF LOW INTENSITY

Y, Present; N, Not Present; O, Not Mentioned

Effect	100 GHZ			10 GHZ		3 GHZ		0.5-1 GHZ		69-191 MHz		14.8 MHz		500 kHz
	mm	3 cm	10 cm	dm	ultrashort	short	short	short	short	short	short	short	short	
Physical hyperthermia	Y	N	N	N	N	N	N	N	N	N	N	N	N	N
Clinical hyperthermia	N	N	N	N	N	N	N	N	N	N	N	N	N	N
Growth retardation	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	N
Hypotension	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Brain														
Degeneration of apical dendrites in cortex	Y	O	Y	Y	Y	Y	Y	O	O	O	O	O	O	N
Degeneration of axosomatic synapses	O	O	Y	O	O	O	O	O	O	O	O	O	O	Y
Stimulation of hypothalamic neurosecretion	O	O	Y	O	O	O	O	O	O	O	O	O	O	O
Cytopathology of cortical neurons	Y	O	O	O	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Peripheral nervous system														
Changes in sensory field of skin	Y	O	Y	N	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Changes in sensory field of viscera	N	O	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Cytopathology in neurons of spinal sensory ganglia	Y	O	Y	O	O	O	O	O	O	O	O	O	O	O
Cytopathology of neurons of autonomic ganglia	O	O	N	O	O	O	O	O	O	O	O	O	O	O
Conditioned reflex disturbance	O	O	Y	O	Y	Y	Y	Y	Y	Y	Y	Y	Y	O

Effect	~100 GHZ		10 GHZ		3 GHZ		~0.5-1 GHz		69-191 MHz		14.8 MHz	
	mm	3 cm	10 cm	3 cm	10 cm	dm	ultrashort	short	500 kHz			
Brain cont'd....												
Decrease of ribo- nucleoprotein	Y	0	0	0	0	N	0	0	0			
content of skin												
Proliferation of microglia and R. E. cells	Y	0	0	0	0	Y	Y	Y	Y			
Histopathology of myocardial fibers	0	0	0	0	0	Y	Y	Y	Y			
Histopathology of hepatocytes and renal tubule cells	0	0	0	0	0	0	Y	Y	Y			
Histopathology of spermatogenic epithelium	Y	0	0	0	Y	Y	Y	Y	Y			

of a marked hyperemia of the paws, tail, and ears, followed by depression; (d) state of recumbency--with occasional clonic convulsions and pareses--and development of edema of the head and genitalia; and (e) copious discharge of blood-stained fluid from the nose and mouth.

3. The pathological effects reportedly fall into three general classes:

- (a) Hemorrhage--Hyperemia, perivascular edema, and multiple small perivascular hemorrhages occurring in brain, liver, lungs, myocardium, testes, and intestinal mucosa.
- (b) Histological effects--Cloudy swelling of cytoplasm, cytoplasmic shrinkage, formation of vacuoles, unevenness of staining, disappearance of cytoplasmic structures, fatty degeneration, decrease of ribonucleo-protein (RNP), occasional karyocytolysis. Changes were found in the skin, brain, myocardium, testes, liver, and convoluted tubules of the kidney.
- (c) Neurological effects--Degeneration of nerve fibers and fibrils in the sensory fields of the skin and viscera. The changes are described as argyrophilia, formation of pools and beaded structures in the axoplasm, and fragmentation of fibers.

When animals died, the authors made no attempt to relate the pathological findings to the immediate cause of death. Some of the changes were associated with duration of exposure rather than with intensity. At the highest intensities, at which the animals survived only a few minutes, the changes were sometimes less severe than at lower intensity exposures of longer duration. Only qualitative statements of severity of pathological change are given.

4. Mortality was reported for exposure at all frequencies except 500 kHz. Exposure times for 50% mortality ranged from 5 minutes at ultrashort (~ 80 MHz) (sic) wavelengths (5000 V/m) to 180 minutes at millimeter wavelengths (100 mW/cm²). The description of the experiments is sketchy, but, from text references, mortality appears to have been observed under the beam. For comparison, the calculated energy density of the field in ergs/cm³ was given for all the wavelengths used. The data are too sketchy to make strongly positive statements, but a region of strong sensitivity to lethal effects may exist in the range from 150 to 450 MHz.

5. The exposure time for death of 50% of the animals, LD₅₀, was given by Tolgskaya and Gordon as 900 seconds (15 minutes) for 10-cm (3-GHz) waves, and 6,600 seconds (110 minutes) for 3-cm (10-GHz) waves. These data allow an approximate comparison

with results of a recent rat lethality investigation* at 2.45 and 7.44 GHz. The LD₅₀ values in this investigation were related to the exposure intensity P in mW/cm² by the following hyperbolic expression:

$$LD_{50} \times (P - D) = K$$

where D is a constant representing the asymptotic value of exposure intensity corresponding to infinite exposure time (i.e., $P \geq D$), and K is an experimentally derived constant.

The values of D and K for exposure at 2.45 GHz were determined to be 126 mW/cm² and 44,350 mW-sec/cm², respectively. According to this finding, 100 mW/cm² values of P reported by Tolgskaya and Gordon should be nonlethal. However, assuming that Polson et al.'s values of D and K are correct and applicable to exposure durations of 900 seconds, and that the effects at 2.45 GHz are approximately comparable to those at 3 GHz, we can calculate the value of P that Tolgskaya and Gordon might have used. This calculated value is 175 mW/cm²-- i.e., higher than the 100 mW/cm² that they reported using. Alternatively, assuming that the exposure intensity reported by Tolgskaya and Gordon is correct, we can calculate the value of D that would be appropriate to their results. This value is 50 mW/cm², as compared with 126 mW/cm² determined in Polson et al.'s study.

For exposure at 7.44 GHz, Polson, et al.'s values of D and K were 131 mW/cm² and 90,944 mW-sec/cm², respectively. Again, assuming that this frequency is approximately equivalent to the 10 GHz used by Tolgskaya and Gordon, we calculated the corresponding values of P and D as before and obtained 145 mW/cm² for P (as compared with the 100 mW/cm² that they reported using) and 86 mW/cm² for D (as compared with 131 mW/cm²).

Considering the differences in experimental design, exposure configuration, and scope of the work in Polson, et al.'s investigation compared with that of Tolgskaya and Gordon, the differences in exposure intensity or physical parameters of lethality appear to be rather modest.

6. When the exposure was of sufficient duration and intensity to cause death of the animals, the pathological findings were generally similar at all wavelengths. A notable exception is that irradiation with so-called decimeter waves did not produce pathological changes in the skin of the animals or in the nerve fibrils of the sensory field of the skin. Irradiation with shorter (10 cm) or longer (70 to 190 MHz) wavelengths did produce such changes. The authors offer no comment on the apparent difference between decimeter waves and 190-MHz waves. Irradiation with so-called millimeter waves produced more extensive damage to the skin than to internal organs; but, with sufficiently long (3 hours) exposure,

*P. Polson, D.C.L. Jones, A. Karp, and J. S. Krebs; DAAK02-73-C-0453.

pathological changes occurred in the viscera that were qualitatively similar to those reported at other wavelengths. Irradiation with millimeter waves at lower intensities (40 mW/cm^2 , duration not specified) produced changes in the sensory nerve fibrils of the skin but not of the viscera. In this case, however, cytoplasmic swelling occurred in the nerve cells of the spinal sensory ganglia. The authors attribute this effect to "reflex" action arising from the sensory field of the skin.

Section II - Physiological and Morphological Changes in Animals After Prolonged and Repeated Exposures to Low-Intensity Radio Waves of Different Frequencies

1. An introductory chapter summarizes some of the physical and physiological observations in animals exposed repeatedly to radio waves of low intensity. The chapter appears to be a review, but it is loosely organized, and specific references to cited work not always are given. Some of the points may be commented on specifically:

- (a) The authors define a thermal effect as the presence of a temperature response in a human or animal subject. A list of threshold field intensities for thermal effects at various frequencies is given (Table 3, p. 55). The thresholds vary from 7 mW/cm^2 for millimeter waves to $8,000 \text{ V/m}$ for medium waves (500 kHz). The energy density, in ergs/cm^3 , is given for the thermal-effect thresholds at all frequencies. The energy density for the thermal-effect threshold at 191 MHz (157 cm) is about 200 times smaller than that at 3 GHz (10 cm). Thus, a region of sensitive response might be in the region of 191 MHz (cf, this report, p.). Exposures of animals were generally at or slightly below the thresholds mentioned in the table.
- (b) Table 2 (pp. 55-56) lists some of the physiological effects of long-term exposure to electromagnetic radiation. Frequency, intensity, duration of exposure, and experimental procedures are not given, but the implication is that the effects are non-thermal in the sense that the authors use. The table apparently was compiled from the work of a number of people. Although these researchers are mentioned in the text, no references are given. The table indicates the range of effects expected by Soviet researchers as a result of exposure to radio waves. Among 21 effects cited, 7 refer to the central nervous system (including the vague "disturbance of conditioned reflex activity"), 6 are concerned with biochemical effects, and 3 or 4 are concerned with hormonal effects. There is specific mention of cataract of the eye as an effect.

- (c) Two specific effects mentioned in Table 2 are treated in further detail--retardation of growth and depression of blood pressure. Retardation of growth was measured by body weight differences between control and exposed subjects. Reduction of blood pressure was seen at all frequencies, and retardation of growth was seen at all frequencies except medium (500 kHz). The blood pressure effect was frequently biphasic, with an initial rise of blood pressure, followed by a depression, both relative to controls.

2. The first, and longest, chapter summarizes the effects of prolonged and repeated exposure to microwaves of low intensity. The studies were done at various wavelengths--decimeter, 10 cm, 3 cm, and millimeter. In designating decimeter and millimeter, the authors consistently and carefully avoid any mention of exact wavelength anywhere in the book. This practice may be contrasted with the relatively exact specification of other wavelengths and frequencies.

For the 3- and 10-cm waves, exposure was given at 4 to 10 mW/cm², 30 minutes daily, for between 6 weeks and 10 months. Exposures were sometimes CW and sometimes pulsed, and the description of individual studies does not always indicate which was used. Claims occasionally are made (e.g., p. 71, line 11 et seq.) that pulsed waves are somewhat more effective than CW in producing biological effects, but these statements always seem to rest on subjective judgments about histological results.

Animals exposed to 35 to 40 sessions (6 to 7 weeks) of 3- or 10-cm microwaves showed no hyperthermia, no retardation of growth, no vascular effects, and only scattered marginal histopathological effects. What effects were observed disappeared within 3 weeks after cessation of irradiation. The condition of the animals was described as "health."

When the irradiation was extended to 10 months, the animals had lowered blood pressure, disturbance of conditioned reflex activity, and "imbalance" between the fundamental nervous processes of the central nervous system. A special study of the histology of the central nervous system revealed that the apical dendrites of neurons in the surface of the cerebral cortex showed structural degeneration of spines at the tips of the dendrites, leading to degeneration of axo-dendritic synapses. The earliest changes were visible after 35 to 40 irradiation sessions, and, as the number of sessions increased, the degeneration became more extensive, with disappearance of the dendritic spines, formation of beading and spherical swelling on the dendrites, and extension of the degeneration toward the main cell body. The changes were essentially focal in character, and many neurons showed no degenerative changes at all. The authors associate the degenerative changes in the dendrites with the disturbance of

conditioned reflex activity. The degeneration was reversible and disappeared within 3 to 4 weeks after cessation of irradiation; conditioned reflex activity returned at about the same time.

The authors point out that similar changes in the central nervous system have been found after the administration of harmful chemicals such as arsenic, lead, or aniline.

In addition to the studies of axo-dendritic synapses of the cortex, the authors also studied axo-somatic synapses. They found thickening and filling of the terminal bouton ring of the axon, with resulting asynapsia. This effect was also focal in character and reversible on cessation of irradiation.

In the peripheral nerve net, the authors found changes in the sensory nerve fibers of the skin and viscera, with the appearance of increased argyrophilia, swelling, thickening, and pooling of axoplasm, and "tortuosity" of nerve fibers. Nerve cells of spinal sensory ganglia showed cytoplasmic swelling, tigrolysis in the center of the cell, ectopia of the nucleus, and occasional karyocytolysis. Nerve cells of the autonomic ganglia were unaffected. The changes were focal in character, as they were in the central nervous system. The changes in the peripheral nerve fibers and cells are similar to those reported after single sessions of high-intensity radiation.

The change in conditioned reflex activity is associated by the authors with changes in axo-dendritic and axo-somatic synapses in the cerebral cortex. To account for changes in blood pressure, the authors studied the neurosecretory processes in the cells of the anterior hypothalamus and along the hypothalamo-hypophyseal tract. The study was essentially a histological investigation of the presence and apparent number of neurosecretory granules, using a special histological stain (aldehyde-fuchsin/methylene blue) that shows presence of secretory (Gomori-positive) granules in the cells of the hypothalamus and the posterior pituitary. The study involved 40 albino rats exposed to 10-cm waves of up to 10 mW/cm². Serial sections of the diencephalon and pituitary were examined for number of Gomori-positive granules at various times after beginning of irradiation.

During the first 8 weeks of irradiation, the animals showed a great increase in neurosecretory activity, demonstrated by the large number of Gomori-positive granules in most cells as compared with controls. During the same period, the blood pressure rose to 113% of control values. During the period of 8 through 14 weeks of irradiation, the blood pressure remained elevated, the relative number of secretory granules in the hypothalamic cells decreased, and there was histological evidence of active absorption of the neurosecretory material into the blood. During the period of 14 through 20 weeks of irradiation, the neurosecretory activity of the cells resembled

that in control animals, and the blood pressure fell to normal. During the period of 20 through 26 weeks after irradiation, the content of Gomori-positive granules in the cells was reduced greatly, many of the neurons appeared reduced in size, and there was some evidence of vacuolation and karyocytolysis in some of the cells. The blood pressure during this period was 85 to 86% of control. Both blood pressure and histology returned to normal within 4 to 8 weeks after cessation of irradiation.

The authors attribute the changes in neurosecretory function and blood pressure to a stimulation of secretory function in the early stages of irradiation. As irradiation continues, the secretory function and the blood pressure return to normal, and then become depressed. The authors interpret the depression as an exhaustion of function as a result of prolonged stimulation. They draw parallels with the stress reaction of Selye and seem to regard the microwave effect as a "general irritant" rather than a specific stimulus. Changes in ascorbic acid content of adrenals were found, corresponding to changes in neurosecretory activity.

In the late stages of irradiation, changes occurred in the testes. Findings included degeneration and desquamation of the spermatogenic epithelium of some of the tubules. These changes had no effect on fertility.

3. A briefer section of the chapter deals with the effects of millimeter waves. Animals were exposed for 1 hour daily for up to 10 months at 10 mW/cm². Rectal temperature increased slightly (0.3°C), but no clinical signs of hyperthermia were evident. Reduced growth rate and hypotension also were found.

The authors report that neurons of the cerebral cortex showed the same degenerative changes in the structure of the apical dendrites as reported above for 10-cm waves. No mention is made of either axosomatic synapses in the cortex or of studies of neurosecretory function. Nerve fibers in the sensory fields of the skin showed changes similar to those caused by the 3- and 10-cm waves, sensory fibers of the viscera were unaffected, and neurons of the spinal sensory ganglia showed swelling, tigrolysis, and ectopia of the nuclei. The effects on the peripheral nervous system were similar to those reported after a single session of high-intensity irradiation.

Miscellaneous other effects reported were the following:

- (a) Cortical neurons--Shrinking, dark-staining of cytoplasm.
- (b) Hypothalamic neurons--Cytoplasmic swelling, vacuolation, decrease in ribonucleoprotein (RNP).
- (c) Skin--Decrease in RNP.
- (d) Testes--Decrease in RNP content of spermatogenic epithelium, cytoplasmic vacuolation, nuclear pyknosis,

desquamation of spermatogenic epithelium into the tubular lumen; no decrease in fertility.

- (e) Other--Proliferation of microglia of brain and reticulo-endothelial cells of the liver.

4. The third section of the chapter deals with the effects of decimeter waves. The exposure was at 10 mW/cm², 1 hour daily, for 10 months (220 sessions). No hyperthermia was evident, but growth was retarded, and hypotension developed. The animals showed degeneration of apical dendrites of cortical neurons similar to that reported above. Changes in axo-somatic synapses were not mentioned, nor were changes in neurosecretory function, but cytoplasmic swelling was seen in some cells of the hypothalamus. Changes were observed in nerve fibers of sensory fields of the viscera (argyrophilia, tortuosity, fragmentation, and appearance of beads and pools of axoplasm), but no changes were found in sensory nerve fibers of the skin, and the RNP content of the skin was not reduced.

Other effects reported were:

- (a) Myocardium--Swelling, irregular staining, and hemogenization of individual muscle fibers.
- (b) Testes--Desquamation of spermatogenic epithelium of individual tubules of the testes; no effect on fertility.
- (c) Viscera--Reduced RNP content in cells of the bronchial and gastrointestinal epithelia.
- (d) Other--Increased proliferation of microglia of the brain and of reticuloendothelial cells of the liver.

5. Three additional chapters deal with effects of radio wave bands designated as "ultrashort," "short," and "medium." The actual frequencies and intensities were: 191 MHz, 10 to 20 V/m; 155 MHz, 25 to 50 V/m; 69.7 MHz, 150 V/m; 14.8 MHz, 2250 V/m; and 500 kHz, 1800 V/m, 50*A/m. The daily period of exposure was not stated, and the overall duration of the study was 1.5 to 5 months for the first three frequencies, 5 months for the fourth, and 10 months for the last (500 kHz).

Changes similar to those described for microwaves were found in the nerve fibers of sensory fields of the skin and viscera. For the frequency range 191 to 14.8 MHz, the skin and visceral fibers were about equally affected, and the potency of the radiation declined with decreasing frequency. For the 500-kHz irradiation, the visceral fibers appeared to be affected more than those of skin, and the authors comment that the morphological changes appeared to be more severe than those with shorter waves.

For the frequencies of 191 to 14.8 MHz, hypotension, changes

*Possibly a misprint in the original text or translation. This value may be 5 A/m.

in electrical activity of the brain, and changes in conditioned reflex activity are reported. No mention is made of degeneration of axo-dendritic or axo-somatic synapses in the brain or of changes in neurosecretory function, but histological changes in the cell bodies of cortical and hypothalamic neurons are described. For the frequency 500 kHz, no mention is made in the text about hypotension or disturbance of conditioned reflexes, but Table 5 (p.) shows that blood pressure decreased by 12% after exposure at 5 A/m, 500 kHz, for 30 weeks. Moreover, the text mentions finding degenerative changes in axo-somatic synapses in the hypothalamus.

Comments

Of all the material presented in the book, the evidence of effects of microwaves on the neurosecretory activity of the hypothalamus is the most impressive. The data in the text are largely histological observations, which are difficult to quantify. Nevertheless, good histologists and good pathologists can make reasonably reliable subjective observations that show relative changes and trends. Changes in ascorbic acid content of adrenals were noted, which corresponded to changes in neurosecretory levels.

Some of the other observations in the animals--e.g., desquamation of the spermatogenic epithelium of the testes--might be secondary effects arising from the effect of changes in neurosecretion on the anterior pituitary. In Table 2, p. of the text, the authors note that exposure to non-thermal levels of microwaves produced disturbances of estrous cycle and lowered fertility in female rats. These effects also could arise from disturbances in pituitary function.

It is entirely plausible that, if the disturbance in neurosecretory function of the hypothalamus is real, chronic exposure to microwave could produce disturbances in mood and behavior of animal and human subjects, as has been reported.

The text gives more evidence of histological changes in axo-dendritic and axo-somatic synapses in the brain, but these data are less impressive. Part of the reason is that the association between such changes and changes in physiological function is somewhat nebulous. The authors report that the changes in synapses are associated with functional changes in the central nervous system. The functional changes are described as (1) "weakening of excitation and increase in limiting inhibition in the CNS," determined by studies of conditioned reflex activity; and (2) "lowering of excitation and weakening of fundamental nervous processes," determined by "strong acoustic stimulation of rats particularly sensitive to ringing of a bell." The second functional change suggests that rats may become less sensitive to audiogenic seizure after exposure to microwaves, but the description of the first functional change conveys no information.

Repeating some of the studies of neurosecretory function and hormonal and endocrine changes following exposure to microwaves would be desirable.

APPENDIX D

REVIEW OF

"APPARATUS FOR THE TREATMENT OF NEUROPSYCHIC AND SOMATIC DISEASES
WITH HEAT, LIGHT, SOUND, AND VHF ELECTROMAGNETIC RADIATION"

APPENDIX D

REVIEW OF

"APPARATUS FOR THE TREATMENT OF NEUROPSYCHIC AND SOMATIC DISEASES WITH HEAT, LIGHT, SOUND, AND VHF ELECTROMAGNETIC RADIATION"

U.S. Patent No. 3,773,049; filed November 13, 1970, issued November 20, 1973.

Primary examiner: William E. Kamm
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Inventors: L. Y. Rabichev, V. F. Vasiliev, A. S. Putilin,
T. G. Ilina, P. V. Raku, and L. P. Kernitsky, all
of Kishinev, Moldavian Republic, USSR

This apparatus consists of one or more lights, a source of sound, a source of radiant heat, and a source of VHF electromagnetic radiation. All these elements are connected to an electrical switching arrangement that delivers the stimuli from these sources to the subject in the form of rhythmic pulses at a repetition rate of 10 to 100 per second.* In the first version, pulse repetition was provided by a mechanical chopper connected to a constant-speed electric motor. In the final version, the pulse repetition is controlled by an electronic timer using a cold cathode thyatron.

In the final version of the invention, the light source has two green incandescent lamps installed at the eye level of the subject at a distance of 40 to 50 cm. The lamps are symmetric with respect to the subject's sagittal sinus plane. The sound source is a small loudspeaker placed 40 to 50 cm from the subject (location not specified). The sound from the speaker is an imitation of the noise of falling raindrops or surf. The VHF electromagnetic field generator is an oscillator that delivers its load to two electrodes (design not specified) mounted at the level of the carotid sinuses of the subject and 3 to 4 cm from the surface of the skin of the subject's neck. The heat source consists of a thermal electric element, thermal insulation, and a blower. The blower is the element connected to the pulse switching, and the diagram implies that the instrument blows rhythmic pulses of hot air on the skin of the subject's face.

The intensities of stimulus from each source can be controlled independently, and each source can be switched off completely; however, the diagram indicates that all the sources are pulsed simultaneously by the same electronic timer. The frequency of the VHF radiation is not specified, except that the claim at one point refers to "metric waves range."

*However, see next page.

Subjects are exposed in the apparatus in repeated sessions of 30 to 60 minutes each. Intensities of sound, light, and heat radiation are selected "to suit the particular patient." Intensity of the VHF radiation is not specified, but the patent recommends that the VHF exposure be limited to 10 minutes in the first session and increased in 5-minute increments in succeeding sessions up to a maximum of 30 minutes per session.

The apparatus is recommended for treatment of a number of neurotic and psychosomatic conditions, including hypertension, insomnia, ulcer, stammering, asthma, "tonic disease" (muscular tension?), intestinal dyskinesia, and cardioneurosis. The inventors claim that the apparatus has been used on 300 patients suffering from such complaints, and no harmful complications have occurred. However, the applicants do not state how effective the treatment was. The other proposed applications are for treatment of athletes about to enter a crucial sports contest and for treatment of combat fatigue in soldiers in line units and field military hospitals.

Some discrepancy exists in the statements about pulse frequency. In the description of the motor-driven pulsator (column 3, line 38), 60 pulses per minute is specified, whereas in the description of electronic pulsator (column 4, line 15), 10 to 100 pulses per second is specified; and in the description of the treatment session (column 6, line 55), 20 to 40 pulses per minute is specified. From all aspects of the description, most likely 10 to 100 pulses per minute was the statement intended for the specification of the electronic pulsator. The pulse duration for the mechanical pulsator is given as 0.15 second; for the electronic pulsator, the pulse width is not specified. The patent recommends a pulse rate of 20 to 40 per minute for the first treatment session, and a progressively decreasing rate in later sessions.

The theory of operation, as explained in the patent, is that the rhythm of superposed stimuli is synchronized with the activities of the thalamus opticus neural formations. The monotonous rhythm causes focuses of "inhibition," which spread over the cortical field and eventually cause natural sleep. The inhibition process is manifested in a slower pulse, lower skin temperature and blood pressure, and relaxation of skeletal muscles. The development of inhibition is gradual over a number of sessions. The patent implies that the inhibition will develop regardless of whether the subject resists it or not, but the language is unclear on this point.

In operation, the apparatus appears to function by inducing some type of hypnotic state in the subject or a state similar to that produced in transcendental meditation. The physiological effects (blood pressure, etc.) are similar to those produced during the practice of meditation. The results are credible, but no indication is given of how well the apparatus would work if the VHF radiation were omitted. The intended

purpose of the apparatus appears to be to apply stimuli simultaneously through as many sensory channels as possible, and the VHF may have been added without testing for its overall contribution to the stimulus effect.

The patent gives a brief reference to the possibility that, once "inhibition" has been induced, suggestive and rhythm therapy can be introduced simultaneously to increase the treatment effect. Moreover, the inventors describe the apparatus as "humane." The possibility thus exists that the apparatus is being considered for its brainwashing potential.

L. Ya. Rabichev, the first listed applicant, is the author of an article entitled "electrosleep treatment of stuttering in children" that appears in the book Electrosleep in Practical Medicine, V. M. Banskchikov, Ed., Moscow, 1972. A copy of the book was not available for examination, but a review was presented in Neuroelectric News Vol. 4, No. 3, July, 1974. The titles of articles in the book show a fairly heavy emphasis on psychiatric applications of electrosleep.

Appendix E

REVIEW OF "CENTRAL MECHANISM OF ACTION
OF ELECTROMAGNETIC FIELDS"

Appendix E

CENTRAL MECHANISM OF ACTION OF ELECTROMAGNETIC FIELDS
BY K. V. SUDAKOV AND G. D. ANTIMONIY. USPEKHI FIZIOLOGICHESKIKH
NAUK, NO. 2, 1973, 101-135, MOSCOW.

This report is a review of the effects of electromagnetic fields (EMF) on the neurophysiology and behavior of animals and humans. The translated report consists of 43 typewritten pages, and contains 224 references to literature published both in the Soviet Union and the western countries. By ordinary standards of Soviet scientific literature which we have seen, the report is exceptionally well organized and well written, and there are almost no discontinuities or nonsequiturs in the presentation. The literature coverage is extensive, and, with few exceptions, all points made by the authors are carefully documented.

The authors belong to the school of thought that accepts as an uncontestable fact the premise that electromagnetic fields have direct effects (i.e., non-thermal) upon the nervous systems of animals. As a result, they tend sometimes to disregard cautious reservations expressed by original authors about the validity or implications of their work, and an original author's tentative "may" or "might" becomes a more positive "is" in the review. The review makes no reference to questions of safety or permissible standards of human exposure, and is ultimately concerned primarily with the neurophysiological mechanisms of behavioral effects induced by electromagnetic fields. The term "electromagnetic field," as used by the authors, includes everything from fixed magnetic or electric fields to superhigh-frequency (SHF) radio waves. In many cases, the frequency and nature of the fields are specified in the text, but the authors consider that there is no essential difference in biological effects, and results of experiments with diverse frequencies are cited together to make a point.

The review is divided into two main sections. The first section, entitled, "Biological Aspects of the Effect of EMF on the Central Nervous System of Animals and Man," opens with a subsection on the role of natural electromagnetic fields in evolution. The discussion is largely philosophical or speculative, and the 15 references cited are all from the USSR. The next subsection deals with the effects of "natural EMF" (= magnetic field) on animals and men. The bulk of the evidence is concerned with various studies on the apparent correlation of incidence of such things as mental hospital admissions.

cardiovascular disease, and automobile accidents with the timing and intensity of solar flares. The works cited include three studies in the USSR on conditioned activity of animals during magnetic storms and one study on the incidence of neurological disorders in people living in the region of the Kursk magnetic anomaly. Of a total of 21 references cited, 14 are from the USSR, three are from Germany, two from the USA, and one each from Poland and Spain. The third subsection deals with the possibility of electric field interaction between individual neurons of the central nervous system (CNS) (ephaptic interaction). The discussion is largely philosophical, and somewhat inconclusive. Of 23 references cited, eight are from the USSR and 15 are from the USA.

The fourth subsection deals with the evidence for the sensing or experiencing of EMF by living organisms. The evidence for sensation comes from two sources: reports by humans of subjective experience on exposure to EMF (e.g., Frey's "pock") and evidence that EMF can be used as a signal in the formation of conditioned reflexes. For subjective human experience of EMF, a total of nine references are cited, of which six are from the USA and one each are from Germany, Czechoslovakia, and the USSR. In seven of the non-USSR references, the subjects reported auditory, visual, or kinesthetic sensation. The Soviet reference reported that the exposure of the head to "impulse" EMF at the frequency of the alpha rhythm produced disagreeable sensations. The nature of these sensations was not described, either in the review or in the original article. The original article, #109 in the review, was by M. Khvedelidze, S. Dumbadze, V. Aprionidze, M. Sokolova, B. Zhorzholiani, and Kh. Gagva, entitled, "Mechanism of Transformation of Electrical and Magnetic Fields in the Nervous System," and appeared in the collection Problemy nevrokibernetiki (Problems of Neurocybernetics), Izd-vo, Rostovsk. un-ta, 1969, pp. 137-140. The authors of this article do not appear in any of the other publications cited, and the reference is cited only once in the text. It is recommended that this article be given further examination.

For the sensation of EMF as a conditionable signal, a total of 14 references are cited, of which 11 are from the USSR and three are from the USA. The Soviet work cited dates from 1952 to 1972.

The fifth subsection deals with the effect of EMF on behavior and conditioned activity of animals and people. The first paragraph deals with natural (instinctive) behavior of animals, and contains seven references, of which four are from the USA, two from Germany, and one from the USSR. Following this is a lengthy description of American studies of effect of exposure of heads of monkeys to UHF EMF. Then there

is a series of Soviet works (12 references) on the disturbances in conditioned reflexes caused by exposure of animals to EMF. Frequencies range from a steady magnetic field to SHF fields. Various effects are reported. The most common general effect appears to be some loss of ability to discriminate between signals, such that error rate increases and response to the conditioned stimulus tends to disappear. Conditioned reflex performance is restored after cessation of exposure. Different kinds of conditioned behavior may vary in their sensitivity to EMF. Two Soviet studies are then cited to show that irradiation of rats in utero results in irreversible impairment of ability to form conditioned reflexes in the animals after weaning. Another Soviet study is then cited and described in detail, showing that mice trained for sustained swimming in a special tank suffered loss of ability to sustain swimming after exposure to UHF fields. The description implied that after exposure the animals forgot or lost the adaptive skill in long-time swimming acquired during previous training. Another study is described, showing that exposure to "low frequency" intensive EMF decreases the response rate of rats in a Skinner box. This is one of the few studies that is unreferenced. It is paired with an American study showing that exposure of monkeys to EMR causes the monkeys to lose the (trained) ability to judge short time intervals accurately.

The authors of the review express the opinion that exposure of animals to EMF results in disruptions of "adaptive" behavior in animals.

A series of studies of effects of exposure to EMF on man are cited. The studies are of two types: (1) experimental exposure of human subjects in test situations, and (2) clinical studies of people subjected to occupational exposure to EMR. Nine references are cited in the first type of study, of which five are from the USSR, two from the USA, and one each from Italy and Czechoslovakia. Five of these studies deal with performance of motor or simple intellectual or judgmental tasks during exposure and three claim that the threshold of sensitivity to electrocutaneous stimulation rises after exposure to UHF or SHF fields. For the second type of study (clinical observations), nine references are cited, of which eight are from the USSR and one from Italy.

The second major division of the review, entitled, "Neuro-physiological Mechanisms of Action of EMF," is divided into three major subsections. The first subsection, dealing with the bioelectric (electroencephalographic, EEG) activity of the brain during exposure to EMF, contains 44 references, of which 33 are from the USSR, six from the USA, three from Czechoslovakia, and one each from Poland and Italy. Various effects are described, most of which are difficult to evaluate. The authors acknowledge that the EEG response to EMF is probably polymorphic. Among the effects on EEG mentioned are: production of high-amplitude slow waves (mentioned six times in the text),

"desynchronization" of the EEG(three times), depression of amplitude and frequency (two times), sensitization of the brain to epileptic discharge (two times), and shifts in constant potential of the cortex (one time). Studies are also cited on the effect of EMF on the evoked electrical activity of the brain arising from external stimuli, e.g., light flashes or sounds. Primary and secondary responses to flashes of light are reported to be facilitated in certain regions of the brain by exposure to EMF, while response to sound is less affected. In these studies, 11 references are cited, all from the USSR.

The second subsection is entitled, "Morphological and Functional Changes in the CNS upon Exposure to EMF," and presents a brief list of biochemical, physiological, and morphological effects of exposure. Of 21 references cited, 17 are from the USSR and four are from the USA. Biochemical results include studies of the ammonia-glutamine-glutamic acid systems, oxidative metabolism, and cholinesterase content. Physiological results include studies of drinking behavior of animals toward solutions containing particular salts. Morphological results include the study by Tolgskaya and Gordon (reported in detail in Appendix C) concerning axo-dendritic and axo-somatic changes in neuron synapses in the cortex. The review does not mention the extensive study also reported by Tolgskaya and Gordon concerning changes in neurosecretory function in the hypothalamus. The general impression created by this subsection is that the authors may have included it as a courtesy, so as not to offend important and possibly influential scientists in the USSR.

The third, and final, subsection is entitled, "Selective Action of EMF on Structures of the Central Nervous System." In it, the authors of the review develop their major thesis, that behavioral effects of EMF are caused by selective, direct action of the EMF on the limbic system of the CNS, in particular, the hippocampus. Sixty-eight references are cited in this section, of which 39 are from the USSR, 28 from the USA, and one from France.

The general structure of the argument for the significance of the limbic system for behavioral effects of EMF is as follows:

1. Electric current used to induce electroanesthesia initially excites the limbic structures, chiefly the hippocampus (Ref. 1, Abramov, 1969).
2. A 39-MHz EMF with a 50 Hz modulating frequency and a 30-400 V/m intensity stimulates isolated convulsive activity in the limbic structures (mostly hippocampus). Exposure times were several seconds to two hours. With longer exposure times, the convulsive activity spreads to the cortex (unreferenced, probably authors' own work).

3. Amnestic effects of electroconvulsive shock are also associated with function of the hippocampus. Stimulation of the hippocampus by electrical or chemical means results in isolated convulsive electrical discharges in the hippocampus, similar to those found after EMF exposure (11 references: one Soviet, ten American; date of Soviet reference: 1970).
4. An experiment is described in detail, in which rats were trained to discriminate between, and respond differently to, situations where the experimental chamber was black or white. After 5-15 minutes exposure (39 MHz, modulating frequency 50 Hz, field intensity 100-120 V/m), the rats apparently lost the ability to make the black/white discrimination. The consequent disruption of behavior led the animals to approach the food container whereupon an electric shock would result (Antimoni, 1972).
5. Behavior studies after excision or placement of lesions in the hippocampus indicate that animals lose ability to make discriminations, in a manner analogous to the results of the experiments described in (4) above (12 references: four Soviet, eight American).
6. Another behavior study shows that it is difficult to extinguish previously formed conditioned food reflexes in rats during exposure to EMF (Antimoni and Sudakov, 1972). In comparison, studies by Swanson and Isaacson (American, 1969) show that hippocampectomized rats acquire motor reflexes when reinforcement is vague.
7. The hypothesis advanced by the authors is that EMF exert a selective stimulating effect on the limbic structures, chiefly the hippocampus, and that this stimulation leads to loss of ability to make certain types of discrimination and to disruption of the mechanism of formation of negative emotional states.

General Comment

It was noted previously that the organization and presentation of the material is very good, even by Western standards. In the evaluation of the material presented, however, it was also noted that the authors tend to accept an overly optimistic interpretation of the validity of experimental results that agree with their viewpoint about the effects of EMF on behavior or neurophysiology. For instance, the descriptions of the effect of EMF on conditioned behavior (derived exclusively from Soviet work) indicate a very profound and extensive disturbance of well established behavior patterns. Further, the disturbance in EEG pattern in the hippocampus resulting from exposure does correspond to that induced by spreading depression in the hippocampus. However, the effects

lesions or spreading depression in the hippocampus on conditioned behavior often appear to be somewhat vague, and require sophisticated experimental procedures to detect. The extent of disturbance of conditioned behavior from exposure to EMF (as described by the authors) appears to be much greater than that from hippocampal dysfunction. A curious fact in connection with the question of hippocampal function in relationship to effects of EMF on behavior is the following: the total number of references cited on electrophysiological and behavioral functions of the hippocampus was 40; of these, 16 came from literature in the USSR, and 24 from the USA.

On an overall basis the most significant sections are probably those dealing with the sensing of EMF by living organisms and the effect of EMF on the behavior and conditioned activity of animals and men. Mention was made previously of an article by Khvedelidze and co-workers on the effect of EMF pulsed at alpha-rhythm frequency. In addition to this, two other articles are of sufficient interest to be investigated further. They are:

D. V. Gusarov, "Study of the Kinesthetic Analyzer in Persons Subjected to Superhigh-Frequency Electromagnetic Radiation," in the book, Medikobiologicheskiye problemy SVCh-izlucheniya (Biomedical Problems of Superhigh-Frequency Radiation), Leningrad, 1966, pp. 145-199.

D. V. Gusarov, "Effect of a Superhigh-Frequency Field on the Physiological Condition of Experimental Animals," Voyen.-med. zh. (Journal of Military Medicine) 1971, 3, pp. 61-66.

Bibliography

The bibliography in this document lists 224 references. It is arranged such that publications from the USSR are listed first, in (Cyrillic) alphabetical order of the names of the senior authors, followed by publications from other countries, listed in (Roman) alphabetical order of the names of the senior authors. The distribution of references is as follows:

USSR (including pubs. in non-Soviet literature)	137
USA (including pubs. in Soviet literature)	70
Germany	6
Czechoslovakia	4
Belgium	2
Italy	2
Poland	1
France	1
Spain	1

A total of 328 citations to the bibliography are given in the text of the review, 218 to Soviet literature, and 110 to non-Soviet literature. Among the items in the bibliography, there are six Soviet and five American publications listed but not cited anywhere in the text. The reference numbers are (USSR) 19, 33, 49, 75, 99, and 123; (non-USSR) 130, 144, 181, 186, and 208. Of the non-USSR references, numbers 130 and 144 were probably omitted by oversight or typographical error, 181 and 186 were probably either oversight or refer to topics which the authors may have omitted in the final draft of the manuscript, and 208 was probably a supplementary reference to a topic discussed in the text. Of the uncited USSR references, 19, 33, 75, 99, and 123 were probably omitted by oversight or typographical error. Number 49, I. N. Zenina, "Effect of Pulsed Superhigh-Frequency Electromagnetic Fields on the Central Nervous System after Single and Prolonged Exposures," may have been omitted by oversight or may have been deleted intentionally. The title suggests that the reference should be examined further. The reference appears in 0 biologicheskoy deystvii elektromagnitnykh poley radiochastot, Moscow, 1964, pp. 26-32.

Special Topics

Citations in the text of the review were scrutinized for reference to two topics of special interest: studies on human subjects and studies using low frequency or high frequency modulated in a low-frequency mode. The reference so identified are listed in Tables B-1 and B-2, respectively.

Some of the low-frequency work was done on humans, so there is some overlap between the tables. Also note that a few of the studies refer to electric or magnetic fields only; these are marked where they could be identified from the text of the review. The abbreviation "S & A" in the tables means "Sudakov and Antimoni, " and refers to the review.

For 224 references listed, a total of 45, or 20%, refer to human subjects. A number of these, e.g., those referring to the effect of natural magnetic fields on human behavior, are of little or no interest to the present study, but are included in the table for the sake of completeness. For most of the studies cited in the review, some indication is given of the range of frequency of the work, although the specification is sometimes vague, e.g., "decimeter," or "UHF." Frequencies listed in Table B-2 as "unstated" are usually specified in the text as "low." Two of the instances of low frequencies mentioned in the review were not given specific reference numbers. They may have been unpublished work by the authors of the review.

Summary

A review article by K. V. Sudakov and D. G. Antimoni, entitled "Central Mechanism of Action of Electromagnetic Fields,"

has been examined in detail for content, position of the authors on the subject and content and distribution of the bibliography. The authors appear to accept the liberal interpretation that EMF have a direct (non-thermal) effect on the central nervous system (CNS), but appear to be unconcerned with questions of public health and safe exposure standards. The material reviewed contains a large number of studies of the putative effects of electric, magnetic, and electromagnetic fields on behavior and neurophysiology, many of them accepted rather uncritically by the authors. The most significant sections are those dealing with the sensation or experience of EMF by living organisms, and the effects of EMF on the behavior of organisms; these sections appear to contain a comprehensive summary of the available work in the field. The bibliography has been analyzed for number and distribution of references cited, and special tabulations in two possible areas of interest have been made. Four items in the bibliography are recommended for additional review. These items are:

- (1) M. Khvedelidze, S. Dumbadze, V. Aprionidze, V. Sokolova, B. Zhorzholiani, and Kh. Gagva, "Mechanism of Transformation of Electrical and Magnetic Fields in the Nervous System," Problemy neyrokibernetiki, Izd-vo, Rostovsk, un-ta, 1969, pp. 137-140.
- (2) D. V. Gusarov, "Study of the Kinesthetic Analyzer in Persons Subjected to Superhigh-Frequency Electromagnetic Radiation," in the book Medikobiologicheskiye problemy SVCh-izlucheniya, Leningrad, 1966, pp. 145-199.
- (3) D. V. Gusarov, "Effect of a Superhigh-Frequency Field on the Physiological Condition of Experimental Animals," Voyen. med. zh., 1971, 3, pp. 61-66.
- (4) I. N. Zenina, "Effect of Pulsed Superhigh-Frequency Electromagnetic Fields on the Central Nervous System after Single and Prolonged Exposures," in the book O biologicheskoy deystvii elektromagnitnykh pol radiochastot, Moscow, 1964, pp. 26-32.

Table E-1

STUDIES CITED BY SUDAKOV AND ANTIMONIY (S & A)
INVOLVING NEUROLOGICAL AND BEHAVIORAL EFFECTS OF HUMAN SUBJECTS
EXPOSED TO ELECTRIC, MAGNETIC, OR ELECTROMAGNETIC FIELDS

Type of Effect	Number of References (S & A Citation Nos.)
Effect of natural magnetic fields on human behavior	USSR: 6(22, 79, 80, 86, 101, 104) USA: 2(158,* 159) Belgium: 2(140,141) Germany: 1(150) Poland: 1(135)
Sensation or experience of EMF by human subjects	USSR: 4(76, 83, 85, 109) USA: 6(156, 157, 178, 195, 215, 216) Germany: 1(207) Czechoslovakia: 1(198)
Effect of EMF on human behavior	USSR: 5(8,+ 9,+ 41, 56, 200) USA: 3(160,+ 170,**178)
Clinical observations on humans subjected to occupational exposure	USSR: 8(31, 34, 39, 46, 71, 81a, 96, 106) Italy: 1(146)
Effect of EMF on the threshold of electrocutaneous stimulation	USSR: 1(50) Italy: 1(201) Czechoslovakia: 1(182)
Effect of EMF on human electro- encephalographic patterns	USSR: 4(31a, 34,+ 71, 106) USA: 1(175)

Total number of references, excluding repeats:

USSR	25
USA	11
Germany	2
Italy	2
Belgium	2
Czechoslovakia	2
Poland	<u>1</u>
Total	45

*Misquoted.

+Magnetic field.

**Electric field.

Table E-2

STUDIES CITED BY SUDAKOV AND ANTIMONIY (S & A) INVOLVING LOW FREQUENCY,
LOW-FREQUENCY-MODULATED, OR PULSE-MODULATED LOW FREQUENCY ELECTRIC,
MAGNETIC, OR ELECTROMAGNETIC FIELDS AND THEIR EFFECT
ON BEHAVIOR OR NEUROPHYSIOLOGY

Frequency Hz	Species	Biological Effect	Ref. No.	Country Of Origin	Senior Author And Date
10-55	Human	Sensations of light; visual hallucina- tions	207	Germany	Seidel, 1968
160/100	Human	Sensations of sound	195	USA	Mosnier, 1968
Unstated	Human	Sensations of sound	156-157	USA	Frey, 1962-65
Unstated	Human	Sensations of shock	198	Czechoslova- kia	Novak, 1968
a-rhythm	Human	Disagreeable sensa- tions	109	USSR	Khyedelidze, 1969
200	Human	Conditionable signal	83	USSR	Petrov, 1952
0.01-10*	Human	Conditionable signal	76	USSR	Mikhaylovskiy, 1969
0.1-0.2*	Human	Increase of motor reaction time	160	USA	Friedman, 1967
Unstated+	Human	Increase of motor reaction time	170	USA	Hamer, 1968
8	Human	Desynchronization reaction of EEG	31a	USSR	Volynskiy, 1969
7	Monkey	Disturbance of time judgments	163	USA	Gavalas, 1970
Unstated	Cat	Conditionable signal	17	USSR	Atayev, 1972
50	Cat	Shift in constant potential of sen- sorimotor and visual cortex	18	USSR	Ban'kov, 1971
200-400	Rat	Conditionable signal	43	USSR	Denisov, 1970
50*	Rat	"Disinhibition" of conditioned reflex	29	USSR	Venger, 1968
50	Rat	Disturbance of con- ditioned reflex	15	USSR	Antimoniya, 1972
Unstated	Rat	Disturbance of Skinner-box responses	Not given	USSR (?)	S & A, p. 13; lines 10-13
Unstated	Rat	Blockage of extinc- tion of learned behavior	15a	USSR	Antimoniya, 1972
Unstated*	Rabbit	Circulatory Changes	161	USA	Friedman, 1969
50	Unsta- ted	Isolated electro- convulsive activ- ity in the limbic structures	Not given	USSR (?)	S. & A, p. 22, lines 23-27
Unstated	Unsta- ted	Desynchronization of sensorimotor cortex	135	Poland	Baransky, 1967

*Magnetic Field

+Electric Field

Appendix F

REVIEW OF PROTECTION FROM THE EFFECT OF RADIO WAVES

Appendix F

REVIEW OF PROTECTION FROM THE EFFECT OF RADIO WAVES

Ye. L. Kulikovskaya; translation of Russian-language book, Zashchita ot Deystviya Radiovoln, 1970, Sudostroyeniye, Leningrad; 152 pages)

This book is of interest because we believe it is representative of the quality of research on microwaves being conducted in the Leningrad area. Our other reviews have included articles from Moscow (Tolgskaya and Gordon, Appendix C) and Kiev (Shandala et al., Appendix B), and these should be compared with this review.

The research was performed at the Laboratory of Physical Factors of the State Scientific Research Institute of Labor Hygiene and Occupational Diseases directed by Candidate of Medical Sciences Yu. A. Osipov; in the section for improvement of labor conditions of the TsNIIMF (Central Scientific Research Institute of the Maritime Fleet) under the direction of Candidate of Technical Sciences Ye. P. Zagorskaya, with active assistance of the Electroradionavigation Chamber of the Basin Sanepidstantsiya (Sanitary and Epidemiological Station); and the Division of Labor Safety Procedures of Baltic State Maritime Steam Navigation; and also the Division of Communication and Radio Navigation and the Labor Safety Inspectorate of Black Sea State Maritime Steam Navigation. The book concerns the work conditions of personnel who tune, regulate, test, and operate HF and SHF devices in the shipbuilding industry and the maritime fleet. Its stated purpose is to discuss radiation sources, familiarize the reader with methods of measuring radiation, and present an idea of possible intensities of irradiation during various types of operations and their biological effects.

The 152-page book contains ten chapters and a bibliography. The first three chapters almost exclusively concern engineering considerations and comprise nearly one-half of the book. The chapter titles are:

- * I - "Electromagnetic Field Distribution in Induction and Radiation Zones"
- * II - "Methods of Determining the Intensity of Irradiation by High and Superhigh-Frequency Electromagnetic Waves"
- * III - "Electromagnetic High and Superhigh-Frequency Fields in Work Areas"

Electrical engineering details are treated in an excellent, very comprehensive manner--in strong contrast with most of the other literature we reviewed. Details are given of available power flux density meters in the USSR, and, in addition, similar instrumentation available in the United States, England, and

Germany is discussed. A wealth of detailed information is presented on fields in the radio rooms of ships, including equipment types and layouts, on the decks and superstructures, in the living quarters and service compartments, etc.

The remaining seven chapters are about the same number of pages as the first three chapters and are devoted to describing the biological effects of radio waves and methods of protection against them. These chapter titles are:

- * IV - "Biological Effect of Radio Waves"
- * V - "Protective Measures Against the Effect of Electromagnetic Waves of High-Frequency Industrial Heating Devices"
- * VI - "Protective Measures Against the Effect of Electromagnetic Waves When Manufacturing and Repairing Marine Radios and Radar"
- * VII - "Protective Measures Against the Effect of Electromagnetic Waves When Operating Marine Radios"
- * VIII - "Protection of the Personnel of the Transmitting Centers of Shipping Lines from Radio Wave Irradiation"
- * IX - "Protective Measures Against the Effect of Electromagnetic Waves of Marine Radar"
- * X - "Medical Measures for the Effects of High-Frequency and Superhigh-Frequency Electromagnetic Radiation on the Organism"

The translation available for review was inconsistent in the use of technical terms, and frequently the translators did not choose the English word best expressing the concept or the word most familiar to readers of technical literature in English (e.g., "professional hazard" for "occupational hazard"). Some equations (e.g., on page 134 of the translation, $P_{ave} = P_{pulse} r/F$) simply do not appear correct as written. However, we believe that behind the somewhat clumsy translation and several typographical errors lies an original work with accurate information aptly expressed. Thus, the book essentially comprises an exhaustive study of the subject by an author exhibiting thoroughness and competence by U.S. standards. However, no knowledge, techniques, materials, or other advances over the state of the art in the United States is revealed. In fact, a comparable work published in the United States very likely would cover a frequency range extending to higher frequencies than those mentioned and would discuss more sophisticated field strength- and energy flux-measuring instruments and a wider range of RF-absorbing and -shielding materials.

59

The great amount of information presented and its tediousness of detail reflect the Russian philosophy that humans need protection from radio waves to a much larger degree than is believed necessary in the United States. The discussions relating to shielding and field-strength testing in factories and shipyards and on board ships sometimes appear interminable; but they are interesting because they indicate the Soviet concern that personnel should avoid RF energy fluxes above the microwatt per square centimeter level rather than just those above the milliwatt per square centimeter level.

Although the author does indicate that the subject is controversial, with most of the counter-evidence arising outside the USSR, she restates (Chapter IV) the Russian views concerning "tissue cell irritation" by high-frequency "ion currents" or "ion oscillations"--the nonthermal "specific effect that can directly affect brain centers," and through RF magnetic fields as well as electric. The author seems to believe that so-called nonthermal specific effects can be explained in terms of "point" heating of individual structures, or the microthermal effect, as indicated in the following extract (pages 75 to 76):

"The thermal effect of radio waves is studied experimentally as the thermal reaction of the organism. It must be stated that the data which have been published up to now, especially foreign data, are interpreted differently by the researchers. The fact is that it turns out to be difficult to establish the relation between the increase in body temperature or temperature of the organ and the organism's reaction as a whole to this increase. However, the thermal effect of electromagnetic radio waves in a living organism in the presence of significant irradiation intensities is indisputable, and it is recognized by all researchers.

As for the nonthermal specific effect of radio waves, there is no united opinion with regard to this question. Many researchers consider that the shifts occurring in the organism of people who work under irradiation conditions which cannot be connected with a rise in temperature in the organs and tissues still provide no grounds for thinking in terms of the specific effect of the electromagnetic field, but this is explained by the "point" heating of individual structures or the microthermal effect. That which is called the nonthermal specific factor of the effect of radio waves must, in reality, be accepted as microheating of the tissues not subject to ordinary measurements. Yu. A. Osipov [71] considers that the specific effect (in the sense of juxtaposition with respect to form of energy to thermal), although theoretically possible, still has no convincing physiological confirmation."

This abnegation of convincing physiological confirmation of the specific effect of radio waves differs strongly from the "orthodox" view of the vast majority of Soviet authors.

Such a carefully worded statement and the high engineering competence evidenced in the book, coupled with the Leningrad affiliations of the author, led us to think earlier that differences might exist between researchers in Leningrad--both in technical competence and belief--and those from other areas and organizations. Unfortunately, we have not reviewed any other publications that might confirm this impression. We note, however, that Kulikovskaya conducted this research in the laboratory of Yu. A. Osipov. Osipov is cited occasionally in the literature, but we have not reviewed any of his articles in detail. Some of his work is referenced in the general collection Influence of Microwave Radiation on the Organism of Man and Animals, edited by I. R. Petrov (Meditsina Press, Moscow, 1970). The following is an extract from page 105 of the translation:

"It was also established that at very low intensities ($10-20 \text{ uW/cm}^2$), irradiation of a man's hand increases its skin temperature by as much as 1°C . This effect was observed not only on the irradiated extremity, but also in the opposite one and on the skin of the forehead (Yu. A. Osipov and T. V. Kalyada, 1962; Yu. A. Osipov, 1965). However, E. N. Goncharuk and M. A. Pivovarov (1966) reported that even at PFD of $1-3 \text{ mW/cm}^2$, they had observed similar shifts among 18 subjects even when the radiation exposure was imaginary."

Goncharuk and Pivovarov also appear to be from Leningrad; the above reference is to an article in the Transactions of the Military Medical Academy imeni, S. M. Kirova, Leningrad. The actual title of this article is not given; but, as an example of the general field of work that they might be involved in, Goncharuk and Pivovarov published a paper in 1964 on "The Effect of a SHF Electromagnetic Field on Human Motor Reactions," (III All-Union Conference on Medical Electronics, Moscow).

A further relationship worth noting is that, as long ago as 1962, Osipov published a paper with T. V. Kalyada and Ye. L. Kulikovskaya. This paper was "Observations of Functional Shifts During the Work of Individuals Subjected to Irradiation by EMF of the Centimeter Range," Gigiyena i Sanitaria, No. 6, p. 81. Osipov's work seems to have been slanted toward humans. Equally as important is the fact that Kalyada is a member of his group. Recently (February 1975), three Soviet scientists visited the United States in reciprocation to the OTP/NIEHS visit to the USSR in May/June 1974. The three members of the Soviet group were Dumansky and Los' (from Kiev) and Kalyada (from Leningrad). Our information is that, although Dumansky was nominally leader of the group, the person observed to take the superior role was Kalyada. Finally, Osipov does not appear to have published in the open literature for the last decade.

The assemblage of data on the Leningrad group presented above might be no more than a fortuitous one. However, we have presented it as perhaps being part of a larger picture. We also believe that pursuing a more detailed analysis of publications from the above and related authors would be worthwhile. This would be done best by a citation indexing approach, in conjunction with an author/article title search.

Finally, on the technological side, mention (without reference other than "foreign literature") of the existence of chemical emulsions in which radio waves are converted to chemical energy--as for light waves in photographic emulsions--was noted (in Chapter VI, Paragraph 2, p. 112) with interest; the research uses of such a material could be important. However, we know of no such material in use in the United States at present. Possibly, though, this reference is to liquid crystal materials frequently used for microwave power flux density measurements in Western research, and the English translation is a result of the translators' lack of familiarity with the existence of such materials.

62

Appendix G

REVIEW OF
ELECTROMAGNETIC SIGNALLING IN ANIMATE NATURE

Appendix G

ELECTROMAGNETIC SIGNALLING IN ANIMATE NATURE
BY A. S. PRESMAN. IZDATEL'-STVO SOVIETSKOYE RADIO,
MOSCOW, JANUARY 1974

This work is a brief monograph first published in Moscow in 1974. The translation consists of 68 text pages, divided into seven chapters, and including nine figures, two tables, and a bibliography of 101 items. The tables and figures are numbered sequentially throughout the text, and the references in the bibliography are numbered and listed in the order cited in the text, with one exception.

The text is well organized and well written. It is a popular or semi-popular work, at a level somewhat comparable to Scientific American or Psychology Today. In the author's own view, it is addressed primarily to specialists in radiocommunications, in the hope of arousing their interest in the problems of interaction of electromagnetic radiation and life.

The basic thesis of the author is that all living forms interact with electromagnetic radiation at non-thermal intensity levels, and that this interaction plays an important role in both the evolution of life and the regulation of life processes. The evidence for this thesis consists of a number of experimental studies on the effects--largely behavioral--of electromagnetic-field changes on various animals or other living forms, plus a number of apparently speculative papers on biological phenomena. Like other proponents of this thesis (e.g., K. V. Sudakov and G. D. Antimoni), the author lumps together practically all electromagnetic phenomena, from terrestrial magnetism and atmospheric electricity through hard gamma rays, and considers their effects to be basically similar. A fair number of the studies cited involve very low frequencies, or even nonfluctuating fields. In the text or in the references cited, there is frequently no mention of frequency; among the references cited, there are at least 14 involving static or very-low-frequency fields and at most eight involving radio frequencies, two of which were omitted from citation in the text of the monograph.

The author cites a few studies on the potential health hazards of microwaves, but he is not primarily concerned with health hazards as such. Man-made radio-frequency electromagnetic fields are treated somewhat like a biospheric pollutant, which must necessarily have some effects on all living forms, but to which the living forms will eventually adapt.

The nature of the relationship between electromagnetic fields and life is postulated as follows:

- (1) All living forms receive and respond to all electromagnetic fields.
- (2) All living forms also generate electromagnetic fields.
- (3) The reception and generation of electromagnetic fields functions as information transfer for living systems.
- (4) Natural electromagnetic fields, in their informational role, regulate physiological processes involving rhythmic or periodic activity, e.g., circadian rhythm, migration of animals, and regulation of reproduction.
- (5) Disturbances in the natural electromagnetic field (e.g. magnetic or electric storms) cause behavioral or physiological disturbances. Man-made electromagnetic fields cause similar effects.
- (6) Electromagnetic fields generated by living forms serve internally (by information transfer) to coordinate oscillatory processes, e.g., heart rate, rhythm of locomotion, or propagation rate of neuroelectric pulses.
- (7) Electromagnetic fields generated by living forms serve externally (by information transfer) to coordinate movement of groups of animals (e.g. flocks of birds or schools of fish), to enable separated animals to locate one another (e.g. mating of insects, homing of birds), to coordinate vital activity in social groups (no example cited), and to provide intercommunication among groups, populations, and communities (no example cited).
- (8) The estimated sensitivity for electromagnetic reception by living forms is of the order of 10^{-5} - 10^{-6} V/m, or less.

In the theory, as developed by the author, the receptor system for electromagnetic fields consists of two systems: a central system, which is autooscillating and has high inertia, and a peripheral system, which oscillates to any externally imposed frequency. The central system is the biological clock, which regulates circadian rhythm. It has a natural frequency that corresponds to the diurnal rhythm of natural electromagnetic fields, but when the natural field changes, e.g. in a magnetic storm or when the subject moves to a new location, the central system continues to oscillate at its previous setting, and only slowly readjusts to be in phase with the new diurnal cycle of natural electromagnetic field. The phase difference between the central system and the peripheral system provides migrating birds with a sense of longitude which accounts for their ability to navigate over long distances.

The first chapter of the book is a brief introduction setting forth the scope and purpose of the work. The second chapter is a summary of the evidence for electromagnetic signaling in animate nature. The calculations of electromagnetic intensity requirements for known types of molecular changes are compared with evidence for biological effects at intensity levels several orders of magnitude lower. The conclusion (if one believes that biological evidence) is that effects on life forms cannot result from energy transfer by the electromagnetic field, and hence must be due to information transfer. It can be noted in passing that in Figure 1 in this chapter, the section designations "b" and "c" are reversed from the author's original intent.

The third chapter deals with biological rhythms and their regulation by natural electromagnetic fields. The chapter deals not only with the familiar circadian rhythm, but also other, longer cycles. One series of cycles of biological rhythm is cited, where the periods of the cycle form a geometric progression with the ratio of $\sqrt{2}$. This series is coordinated with a similar cycle of solar activity. Cycles of fertility and seasonal migration of animals are also said to be regulated by natural electromagnetic fields. The geomagnetic basis of navigation of animals is discussed in this chapter.

The fourth chapter deals with the effect of natural electromagnetic disturbances and man-made radio-frequency background on vital activity of organisms. These disturbances are said to result in aberrations in reproductive and survival behavior. This result is cited as the reason for migration of birds: birds fly to regions of relatively low electromagnetic disturbance for mating, nesting, and rearing of young. A series of studies is cited on the correlation of natural electromagnetic disturbances with various indicators of pathological disturbance in man: blood pressure, mental hospital admissions, deaths from cardiovascular disease, leucocyte count and prothrombin index of blood, and electric potential of skin. Finally, evidence is submitted for an association between the advent and proliferation of radio transmitters (about the year 1920) and an increase in height and lowering of age of sexual maturity in the human population.

The fifth chapter deals with the information function of electromagnetic fields within and among organisms. Within the organism electromagnetic fields serve to regulate periodic vital functions; between organisms, they serve to provide communication. An interesting opinion advanced by Presman is that in man the capacity for electromagnetic information transfer between people has been largely lost through replacement by speech and other communication methods. He regards extrasensory perception in man as an atavistic phenomenon, rather than the progression of human evolution.

The sixth chapter deals with the scientific approach that Presman claims is essential to the study of electromagnetic signaling in animate nature. He designates it the cybernetic approach. In this approach, the organism is treated as a black box, the internal organization of which is unknown. Data are gathered on the output from the black box, in relation to a series of (electromagnetic) inputs. The empirical generalizations about this input/output data are then combined with everything else known about the properties and behavior of the system, and a structural-functional scheme for the response to the electromagnetic radiation is deduced. The functional scheme does not have to exist within the framework of physical analogs of the phenomenon in inanimate nature, but cannot be logically contradictory to them. This formulation seems to reflect a fundamental difference in scientific approach between Presman and possibly other Soviet scientists, and the majority of Western scientists. In work of Western scientists, a newly reported phenomenon is often not taken seriously until and unless it can be fitted somewhere into the entire body of already classified knowledge.

A final, short chapter presents a brief summary, reaffirming the need for biologists and radio engineers to cooperate in the study of the relationship of electromagnetic fields and life, and reiterating the statement that the cybernetic approach is the only one suitable for the problem.

The bibliography, as noted above, consists of 101 entries. All but four of the items in the bibliography are actually cited in the text, and for the references not cited (Nos. 54, 58, 59, and 60), inspection of the text suggests that the omission of the citations was due to minor typographical errors in the writing, editing, publishing, or translating of the work. Sixty-seven of the references are Soviet (including Soviet publications in foreign journals and Westerners publishing in Soviet journals), 20 are American or English, nine are German, and the remainder are from miscellaneous countries. Of the Soviet references, eight are citations by Presman of his own previously published work, six deal with radio frequency (including microwaves), eight deal with weak magnetic fields (including terrestrial magnetism), eight deal with biological rhythms, five deal with the relationship of solar activity and life (including effects on terrestrial magnetism), and the remainder cover a variety of topics, e.g., extraterrestrial life, electroaurograms, magnetic dipoles of insects, and the like. The latest publication year for a cited Soviet reference is 1972, and 60 of the 67 references occur between 1964 and 1972, approximately the same number per year.

It is difficult to evaluate a work like this. There is no question about the sincerity of Presman, but from a scientific viewpoint, it is easy to find fault. Presman is sometimes careless with references: he quotes the work of Tolgskaya and Gordon as if it referred to human studies, when, in fact, it does not. He cites correlation studies, e.g., relationship of incidence of fatal coronary infarct to geomagnetic storms, as

if they were rigorously established experimental facts, and he seems quite unaware of the treacherous nature of correlation analysis in establishing causal relationships. He discusses "electromagnetic" communication among insects for mating, and either ignores, or is unaware, of the extensive work on pheromones as sex attractants in insects. The whole process of generating and receiving electromagnetic signals by an organism having no identifiable organ system functionally serving the purpose appears absurd to any scientist trained in the spirit of skepticism. And to the same skeptic, the cybernetic approach to the study of electromagnetic fields and life smacks of teleology and other such disreputable modes of thinking.

Yet, it is evident that the Soviet government takes the work of Presman and others seriously enough to give it reasonable support. Moreover, some of the things he argues for do have some experimental basis in fact. For instance, the navigation of birds (homing of pigeons) is associated in some way with magnetic fields. The existence of correlations between geomagnetic storms and coronary infarcts or mental hospital admissions does not necessarily prove a causal relationship between the two, but the question cannot be thereby dismissed. Finally, the cybernetic approach, which appears unwholesome to scientific tradition, is essentially the approach used by B. F. Skinner in his classical studies on behaviorism. Skinner's work is often criticised on quasi-theological grounds, but it is rarely challenged on grounds of experimental validity. Perhaps the strongest objection to Presman's work is that it seems to lack the rigor of Skinner's work. It assembles in an uncritical way a large number of observations, hypotheses, and speculations, covering a vast range of physical and biological phenomena, joined by a marginally plausible assumption that they are interrelated.

The modern scientific origin of the studies on the association between electromagnetic fields and life appears to be a paper in 1935 by Dull and Dull on the relationship between geomagnetic storms and the increase in death rate [Deutsch. Med. Wochenschr., 61:95 (1935)]. In 1963, Friedman, Becker, and Backman published a paper on the relationship of geomagnetic storms to rate of admission to mental hospitals [Nature, 200:626-628 (1963)], and in the same year Becker published a paper on the relationship of geomagnetic environment to human biology [N.Y. State J. Med., 63:2215-2219 (1963)]. As noted above, the various Soviet references cited by Presman occur mainly from 1964 onward, and there is an average of about six to eight a year, almost evenly distributed over the years. It is possible that the publications of Friedman and Becker were the starting point for the present Soviet studies. Becker is still doing such work. Two papers appear in 1974 (Ann. N.Y. Acad. Sci., 238:236-241 and 238:436-444). The discussion of the papers suggests almost polite disdain or disinterest on the part of the audience, but the work is supported by a grant from the National Institutes of Health.

It is not clear why the Soviet government supports Presman in this work. There is no indication in the work of any possibility of either a system or procedure for modifying or controlling human behavior, or (by the wildest speculation) of an anti-personnel device. For either of these purposes, the book by Presman and the work of other Soviet scientists cited by him would constitute, at best, only a remotely connected type of basic research. One curious possibility concerning a part of the work does, however, occur to this reviewer. If I were an important Soviet official, and if I believed that human behavior is influenced by the cycles of solar activity and geomagnetic storms, I would try to time announcements and actions of the government--particularly aggressive actions in foreign policy--in those predictable phases of solar and geomagnetic activity where the potential opponents of the policy were least able to mass effective opposition. It might be worthwhile to examine a number of actions of the USSR over the last five to seven years and compare their timing with phases of sun-spot activity or geomagnetic disturbances.

Appendix H

REVIEW OF
ELECTROMAGNETIC RADIATION SAFETY

Appendix H

Electromagnetic Radiation Safety

By V. A. Krylov and T. V. Yuchenkova
Moscow, 1974

This is a 192-page book devoted to several important labor-safety problems in Soviet industry that center around a very broad spectrum of electromagnetic radiation, including radiofrequency (nonionizing) radiation, laser emissions, and x-rays (ionizing radiation). It is of particular interest to this study because it has been possible to trace an underlying pattern of exchange of information in the literature from the USA to the USSR and back again, both acknowledged and unacknowledged. This pattern emphasizes the difficulties encountered in attempting to make an assessment of published Soviet literature in the field of biological effects of non-ionizing radiation (and, presumably, many other fields).

The book itself is divided into five chapters, of which the first is concerned with radiofrequency (nonionizing) radiation. The remaining four chapters are devoted to laser emissions, ionizing radiation, occupational diseases, and physiological and economic aspects of providing safety measures. The material shows that the Soviets recognize the importance of underlying electromagnetic principles and apply them correctly, although with slightly different nomenclature than is used in the Western literature.

On pages 26-32 the authors give several tables of dielectric constants, conductivities, reflection factors, and penetration depths for various (unspecified) human and animal tissues. Although the data for relative dielectric constant and conductivity appear to be measured by the Soviet authors, closer inspection indicates the data are more likely to have been taken from an article by Schwan.¹ Schwan's data are a compilation of the results of his work and those of others, and he provides 19 references at the end of his tables. Where Schwan gives a range of values for a parameter, the Soviets have taken a single value from within this range, perhaps by graphical interpolation. Presumptive evidence that this may be so is provided by the fact that the Soviets' Figure 1.15.a ("Dielectric constant of muscle tissue as a function of frequency") is a replot of Schwan's Figure 2.

We additionally draw attention to the fact that the Soviets also make a transcription error in going from Schwan's Table Vb to their Table 1.2 for the value of dielectric constant of blood at 1 and 10 kHz.

The explanation provided by the Soviets (their pp. 26-29) of the nature of the mechanism of interaction of electromagnetic energy with matter seems to be a rewording of Schwan.

Casual reading gives the impression that the Soviet authors actually calculated the data on the depth of penetration in Table 1.4 (page 31). This is not so. This table is a re-ordered version (to avoid charges of plagiarism?) of an earlier table by Presman² (his Table II). Careful scrutiny indicates one transcription error between Krylov and Yuchenkova's table and Presman's table. This is in the translocation of values for brain at 100 and 200 MHz. Presman's values are correct, since penetration depth decreases with increasing frequency. While Krylov and Yuchenkova do not reference the source of their Table 1.4 (thereby heightening the impression that they calculated the values), Presman does. The original source of the table is an article by four U.S. researchers, Fleming, Pinneo, Baus and McAfee.³ Interestingly enough, the values provided by the U.S. authors for brain at 100 and 200 MHz are transposed in the same manner as those of Krylov and Yuchenkova. It is, therefore, more likely that these two Soviet authors plagiarized the U.S. data directly, instead of using Presman's corrected version. Likewise, Fleming et al. provide data on reflection coefficients for a sequence of tissue interfaces (their Table V). This table has been copied, again without acknowledgment, by Krylov and Yuchenkova (their Table 1.3)

The tracing and comparison of some of the extant data on electrical properties of biological tissues which have occurred in this critique have also been of interest in showing the passage of fundamental data from the USA to the USSR and back to the USA again, not infrequently with transcription error, and without proper acknowledgment on the part of the Soviet authors. This plagiarism points up one of the difficulties inherent in attempting to review and criticize the published Soviet literature.

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APPENDIX I

REVIEW OF "CHANGES IN PERMEABILITY OF HISTO-HEMATIC BARRIERS
UNDER THE EFFECT OF MICROWAVES"

APPENDIX I

REVIEW OF "CHANGES IN PERMEABILITY OF HISTO-HEMATIC BARRIERS UNDER THE EFFECT OF MICROWAVES"

L. V. Polyashchuk; Kiev, Doklady Akademii Nauk Ukrainskoy SSR, No. 8, 1972, pp. 754-758; signed to press 9 March 1971, presented by E. B. Babsky, Member Academy of Sciences Ukrainian SSR.

Introduction

This article has been chosen for review because (1) it contains details of research outwardly similar to work currently being conducted in the United States and that we consider may be important and (2) it provides a good example of the problems encountered when an attempt is made to perform a critical review of many of the articles appearing in the Soviet literature.

The translation (JPRS 58203, 12 February 1973) is, unfortunately, of poor quality. This may be due, in part, to the quality of the original article, but it is also due to the apparent unfamiliarity of the translator with this biological area. This unfamiliarity clearly is shown in the use of the term "hemato-encephalic barrier" in the translation instead of the more common "blood-brain barrier."

Summary

The author introduces the article by noting that microwaves are being used more frequently in the treatment of diseases of the nervous system, digestive organs, and serous membranes, as well as for treating various muscle disorders. However, until the present study, the effect of microwaves on the permeability of organisms (sic) has not been studied. Only scattered data exist on the effect of microwaves on the permeability of the ophthalmic barrier (blood-aqueous barrier?). The author, therefore, decided to conduct a study on the effect of microwave exposure at varying powers and durations on the permeability of the blood-brain and hematic barriers (precise definition unspecified) in rabbits.

Ninety-two animals were used in the study. Radioactive phosphorus was injected intraperitoneally into the rabbits. The dose was 45 uCi/kg of animal weight. Sixty minutes after the injection, the rabbits were sacrificed by electric current. (The reason for death by electrocution rather than by other methods is not indicated, nor does the paper specify whether any controls were run to determine the effect of this method of sacrifice itself on the blood-brain barrier.) Samples were taken from the vermis, cerebral hemispheres (no precise indication of sample location), gray and white matter of the cerebrum (again,

no indication of location), optic chiasma, midbrain, colliculi, olfactory bulb, medulla oblongata, epiphysis and hypophysis, cervical, thoracic, and lumbar spinal cord, and from the femoral and thoracic muscles. Radioactivity of tissues was determined by apparatus PP-16.* Microwaves were generated by a Luch-58 apparatus at 2,307 MHz. Three power levels were used--30, 50, and 75 Watts. Two exposure durations, 10 and 20 minutes, were used. A standard diathermy applicator apparently was used to direct microwave energy onto the animal's body, although this is not stated explicitly. The distance from the applicator to the surface of the animal was held constant at between 7 and 8 cm. Power density was measured with a PO-1 apparatus. For examination of the effect of microwaves on the blood-brain barrier, the applicator was directed on the head; it also was directed on a part of the frontal abdominal wall for determination of effects in that region. Finally, the rear limb of the rabbit was exposed to microwaves for determination of the permeability of the blood-tissue barrier in that region.

Unfortunately, the author does not state precisely how many experimental groups or how many animals per group were used. If the reader assumes that all experimental situations are described in the report, Polyashchuk must have used three power levels time two durations times three exposure regions--i.e., 18 exposed groups plus a control group.

The results are presented poorly in the paper. Table I-1 is our compilation of all the values of P³² absorption given in the tables, figures, and text of the translated article. Table I-1 shows that Polyashchuk used seven experimental situations and one control group. The tabulated results indicate a very small standard deviation for all measurements. This result is surprising, since it indicates very little variation in the measurement from animal to animal, as well as excellent reproducibility of measurement in the PP-16 apparatus. (Since a total of 92 rabbits was used in the study, the group size cannot have been overly large, which might have helped reduce the standard deviation.) Because the standard deviations are so small, all the observed changes in permeability under microwave radiation are statistically significant at the 5% level or better. In 49 of the 51 microwave exposure cases, permeability increases over the control values. The only decreases occur in the hypophysis and epiphysis for a "dose" of 75 W for 10 minutes delivered to the head. Surprisingly, a greater "dose" of 50 W for 20 minutes to the head results in the maximum reported P³² percentage of absorption--64.4%--in the hypophysis, despite the reduction reported above.

*We are unfamiliar with this apparatus.

Table I-1

PERCENTAGE OF P³² ABSORPTION CONTROL VALUES AND EXPERIMENTAL RESULTS

Sample	Control	Head Exposure		Epigastric Exposure	Right Hind Appendage Exposure	Head Exposure		
		30 W-10 min	50 W-10 min			75 W-10 min	30 W-20 min	50 W-20 min
Vermis	1.81 ± 0.1		3.21		2.09		2.41 ± 0.2	4.20
Cerebral hemispheres	1.67 ± 0.06	1.68			2.26		2.28 ± 0.2	
Grey matter	1.92 ± 0.1			1.99	1.93		2.31 ± 0.2	
White matter	1.63 ± 0.1				1.85		2.15 ± 0.1	
Four colliculi	1.69 ± 0.1	2.30			1.89		2.47 ± 0.3	3.39
Olfactory bulb	1.96 ± 0.1	2.45		1.56	2.15		2.67 ± 0.2	3.98
Medulla oblongata	3.55 ± 0.2				3.91		3.97 ± 0.4	
Epiphysis	56.59 ± 2.5				67.38	39.29	65.32 ± 0.6	
Hypophysis	45.41 ± 2.4		60.65		52.45	29.30	48.43 ± 0.4	64.37
Optic chiasma	2.17 ± 0.3				2.71		3.34 ± 0.2	
Cervical spinal cord	2.04 ± 0.4			4.91	2.35		2.53 ± 0.3	
Thoracic spinal cord	2.94 ± 0.06			4.51	3.41		3.07 ± 0.3	
Lumbar spinal cord	2.57 ± 0.1			3.25	2.89		2.90 ± 0.1	
Lungs	18.24 ± 0.9			32.89	22.74	23.70	19.09 ± 0.5	
Femoral muscle	2.40 ± 0.008				2.67		2.71 ± 0.2	
Pectoral muscle	8.32 ± 0.7			13.21	9.31		11.11 ± 0.3	
PFD (approximate)	0	150 mW/cm ²	250 mW/cm ²	250 mW/cm ²	250 mW/cm ²	375 mW/cm ²	150 mW/cm ²	250 mW/cm ²
Calculated maximum temperature rise (approximate)	0	1.5°C	2.5°C	2.5°C	2.5°C	3.75°C	3°C	5°C
Dose (joules)	0	18,000	30,000	30,000	30,000	45,000	36,000	60,000

Perhaps the strongest criticism about this work is that it is scientifically unsound. A certain quantity of radioisotope has been injected intraperitoneally into a rabbit. If the radioisotope were to be distributed uniformly, the percentage of uptake measured in all locations would be 100%. (Note that this is our interpretation, since the author gives no definition.) Since the measured values are all low (on the average, 1% to 5%), a major reservoir of high concentration still exists elsewhere in the body, presumably in the peritoneal cavity. Transportation is (assumed) via the blood--hence, "hemato-encephalic" and "histo-hematic" barriers. To reach brain, lung, and muscle, the radioisotope must be taken up by the blood--the true "histo-hematic" barrier--and then by these tissues from the blood. The circulating level of radioactive isotope therefore would be more likely to vary than the tissue levels measured here; and variation in the circulating level most likely would cause variation in the tissue levels. Yet circulating levels were not measured, or at least they were not reported. Thus, we must question the validity and interpretation of the work published in this article.

Critique

The following criticisms can be made about this paper:

(1) The translation is poor; many of the terms apparently are not familiar to the translator, resulting in the use of terms not generally used. For example, hemato-encephalic is used instead of the normal blood-brain barrier; ophthalmic barrier is used instead of the normally employed blood-aqueous barrier; and histo-hematic or, sometimes, hematic barrier is used for what is more normally termed tissue uptake index. This is not a trivial criticism since, from the literature retrieval point of view, this article could be overlooked if an investigator searched the literature using key words such as blood-brain barrier.

(2) Many important definitions (e.g., absorption percentages*) and details of the experiments are lacking. Knowing the precise nature of the dibasic phosphate salt that was used is important because this knowledge might help explain the vast differences in the results for percentages of uptake in the different regions of the brain. For example, the epiphysis and hypophysis stand out as having P^{32} absorption values of 56.6 and 45.5%, respectively, in control animals. These values are extremely high when compared with all other values except those for lungs and muscles (minimum values 1.63% in white matter, maximum value 3.55% in medulla). These large differences are not explained.

*We interpret these absorption percentages to be the measured radioactivity in microcuries per kg as compared with the theoretical dosage of 45 $\mu\text{Ci/kg}$ assuming uniform distribution in the experimental animals.

(3) No explanation is given for the selection of electrocution for sacrificing the animals instead of a more conventional method. Whether this is a possible explanation for the high values for epiphysis and hypophysis uptake is an open question.

(4) The author does not state when the microwave radiation was applied to the experimental animals, nor does he indicate whether the animals received any form of anesthetic before the irradiation. Moreover, the number of animals per group or the number of groups is not specified. "Batches of samples" were taken from different parts of the brain--again, a vague statement with no precise explanation.

(5) The applicator used to irradiate the animals is not described. Because it was kept at a distance of 7 to 8 cm from the animal, the animal was, by definition, in the near field of the applicator, which greatly complicates the dosimetry.

(6) The results are poorly presented. The table we constructed from the data shows that, instead of 13* out of a possible 18 exposed groups, there are only six (see Table I-1). Further, in Table I-1, only 67 of a possible 128 values are given. The obvious questions: How many values were actually measured? If more than 67 were measured, why are they not all given?

(7) Claims that the optimal doses to produce the maximum increase of P^{32} permeability are 50 W and 75 W for 10 minutes of exposure are not justified by the results presented. Clearly, head exposure at 50 W for 20 minutes yields permeability changes that greatly exceed all other changes in Table I-1. However, approximate calculations based on a guess of the applicator size and power density reveal a large temperature rise for this case. This may explain the absence of results for the 75-W, 20-minute head exposure case, which possibly may have proved lethal to many animals, and which may have led to a reluctance to approve the 50-W, 20-minute exposure as the "optimum."

(8) The claims that the reflex character of the effect of the microwaves on other physiological processes has been demonstrated are not supported by the results given. For head exposure at 50 W for 10 minutes, only two values are given with which to compare exposure of the right rear leg at 50 W for 10 minutes. These data clearly are insufficient to substantiate such claims.

(9) Finally, the last two paragraphs of the report are representative of the broad (and unsubstantiated) claims and erroneous generalizations made in many of the papers that we have studied. In this case, the author claims "Our results prove

*Head exposure at 30, 50, and 75 W for 10 and 20 minutes = 6 groups; abdominal exposure for 30, 50, and 75 W for 10 and 20 minutes = 6 groups; right rear leg exposure at 50 W for 10 minutes = 1 group.

that the intensive action of the microwaves lowers the accumulation of P³² in the endocrine glands (epiphysis and hypophysis) but in other areas of the cerebrum the accumulation of P³² increases." Table I-1 shows that, for all cases except the 75-W, 10-minute head exposure, accumulation of P³² increased in the epiphysis and hypophysis. Second, "The obtained results are explained on the basis of the functional level of endocrine glands under the effect of microwaves and by the stress mechanism of this effect." (This statement is meaningless.) "These observations can be used by clinicians in a form of dosage-like prescription with the aim of regulating the permeability of the hemato-encephalic and histo-hematic barriers of medical substances." This statement indicates that the author appreciates the practical significance of regulating the blood-brain and blood-tissue permeabilities to various pharmacological substances; however, to claim that these experiments with an unspecified dibasic phosphate salt permit extrapolation to use of "medical substances" (medications?) in the clinic is hardly justifiable.