American Academy of Environmental Medicine

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January 19, 2012

Decision Proposed Decision of Commissioner Peevy (Mailed 11/22/2011)
BEFORE THE PUBLIC UTILITIES COMMISSION OF THE STATE OF CALIFORNIA
On the proposed decision 11-03-014

Dear Commissioners:

The Board of the American Academy of Environmental Medicine opposes the installation of wireless “smart meters” in homes and schools based on a scientific assessment of the current medical literature (references available on request). Chronic exposure to wireless radiofrequency radiation is a preventable environmental hazard that is sufficiently well documented to warrant immediate preventative public health action.

As representatives of physician specialists in the field of environmental medicine, we have an obligation to urge precaution when sufficient scientific and medical evidence suggests health risks which can potentially affect large populations. The literature raises serious concern regarding the levels of radio frequency (RF - 3KHx – 300 GHx) or extremely low frequency (ELF – 0Hx – 300Hx) exposures produced by “smart meters” to warrant an immediate and complete moratorium on their use and deployment until further study can be performed. The board of the American Board of Environmental Medicine wishes to point out that existing FCC guidelines for RF safety that have been used to justify installation of “smart meters” only look at thermal tissue damage and are obsolete, since many modern studies show metabolic and genomic damage from RF and ELF exposures below the level of intensity which heats tissues. The FCC guidelines are therefore inadequate for use in establishing public health standards. More modern literature shows medically and biologically significant effects of RF and ELF at lower energy densities. These effects accumulate over time, which is an important consideration given the chronic nature of exposure from “smart meters”. The current medical literature raises credible questions about genetic and cellular effects, hormonal effects, male fertility, blood/brain barrier damage and increased risk of certain types of cancers from RF or ELF levels similar to those emitted from “smart meters”. Children are placed at particular risk for altered brain development, and impaired learning and behavior. Further, EMF/RF adds synergistic effects to the damage observed from a range of toxic chemicals. Given the widespread, chronic, and essentially inescapable ELF/RF exposure of everyone living near a “smart meter”, the Board of the American Academy of Environmental Medicine finds it unacceptable from a public health standpoint to implement this technology until these serious medical concerns are resolved. We consider a moratorium on installation of wireless “smart meters” to be an issue of the highest importance.

The Board of the American Academy of Environmental Medicine also wishes to note that the US NIEHS National Toxicology Program in 1999 cited radiofrequency radiation as a potential carcinogen. Existing safety limits for pulsed RF were termed “not protective of public health” by the Radiofrequency Interagency Working Group (a federal interagency working group including the FDA, FCC, OSHA, the EPA and others). Emissions given off by “smart meters” have been *classified by the World Health Organization International Agency for Research on Cancer (IARC) as a Possible Human Carcinogen*.

Hence, we call for:

- An immediate moratorium on “smart meter” installation until these serious public health issues are resolved. Continuing with their installation would be extremely irresponsible.

- Modify the revised proposed decision to include hearings on health impact in the second proceedings, along with cost evaluation and community wide opt-out.

- Provide immediate relief to those requesting it and restore the analog meters.

Members of the Board
American Academy of Environmental Medicine

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American Academy of Environmental Medicine Recommendations Regarding Electromagnetic and Radiofrequency Exposure

Physicians of the American Academy of Environmental Medicine recognize that patients are being adversely impacted by electromagnetic frequency (EMF) and radiofrequency (RF) fields and are becoming more electromagnetically sensitive.

The AAEM recommends that physicians consider patients' total electromagnetic exposure in their diagnosis and treatment, as well as recognition that electromagnetic and radiofrequency field exposure may be an underlying cause of a patient's disease process.

Based on double-blinded, placebo controlled research in humans,[1] medical conditions and disabilities that would more than likely benefit from avoiding electromagnetic and radiofrequency exposure include, but are not limited to:

- Neurological conditions such as paresthesias, somnolence, cephalgia, dizziness, unconsciousness, depression
- Musculoskeletal effects including pain, muscle tightness, spasm, fibrillation
- Heart disease and vascular effects including arrhythmia, tachycardia, flushing, edema
- Pulmonary conditions including chest tightness, dyspnea, decreased pulmonary function
- Gastrointestinal conditions including nausea, belching
- Ocular (burning)
- Oral (pressure in ears, tooth pain)
- Dermal (itching, burning, pain)
- Autonomic nervous system dysfunction (dysautonomia).

Based on numerous studies showing harmful biological effects from EMF and RF exposure, medical conditions and disabilities that would more than likely benefit from avoiding exposure include, but are not limited to:

- Neurodegenerative diseases (Parkinson's Disease, Alzheimer's Disease, and Amyotrophic Lateral Sclerosis. [2-6]
- Neurological conditions (Headaches, depression, sleep disruption, fatigue, dizziness, tremors, autonomic nervous system dysfunction, decreased memory, attention deficit disorder, anxiety, visual disruption). [7-10]
- Fetal abnormalities and pregnancy. [11,12]
- Genetic defects and cancer.[2,3,13-19]
- Liver disease and genitourinary disease.[12,20]

Because Smart Meters produce Radiofrequency emissions, it is recommended that patients with the above conditions and disabilities be accommodated to protect their health. The AAEM recommends: that no Smart Meters be on these patients' homes, that Smart Meters be removed within a reasonable distance of patients' homes depending on the patients' perception and/or symptoms, and that no collection meters be placed near patients' homes depending on patients' perception and/or symptoms.

Submitted by: Amy L. Dean, DO and William J. Rea, MD

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County of Santa Cruz

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Poki Stewart Namkung, M.D., M.P.H.
Health Officer
Public Health Division

Memorandum

Date: January 13, 2012

To: Santa Cruz County Board of Supervisors

From: Poki Stewart Namkung, M.D., M.P.H.
Health Officer

Subject: Health Risks Associated With SmartMeters

Overview

On December 13, 2011, Santa Cruz County Board of Supervisors directed the Public Health Officer to return on January 24, 2012, with an analysis of the research on the health effects of SmartMeters.

Background

In order to analyze the potential health risks associated with SmartMeters, the following questions should be asked:

1) What is the SmartMeter system and what is the potential radiation exposure from the system?
2) What scientific evidence exists about the potential health risks associated with SmartMeters?
3) Are there actions that the public might take to mitigate any potential harm from SmartMeters?

SmartMeters are a new type of electrical meter that will measure consumer energy usage and send the information back to the utility by a wireless signal in the form of pulsed frequencies within the 800 MHz to 2400MHz range, contained in the microwave portion of the electromagnetic spectrum. SmartMeters are considered part of 'smart grid' technology that includes: a) a mesh network or series of pole-mounted wireless antennas at the neighborhood level to collect and transmit wireless information from all SmartMeters in that area back to the utility; b) collector meters, which are a special type of SmartMeter that collects the radiofrequency or microwave radiation signals from many surrounding buildings (500-5000 homes or buildings) and sends the information back to the utility; and c) proposed for the future, a power transmitter to measure the energy use of individual appliances (e.g. washing machines, clothes dryers, dishwasher, etc) and send information via wireless radio frequency signal back to the SmartMeter. The primary rationale for SmartMeters and grid networks is to more accurately monitor and direct energy usage.

The public health issue of concern in regard to SmartMeters is the involuntary exposure of individuals and households to electromagnetic field (EMF) radiation. EMFs are everywhere, coming from both natural and man-made sources. The three broad classes of EMF are:

- extremely low frequency, ELF (from the sun or powerlines)
- radio frequency, RF (from communication devices, wireless devices, and SmartMeters)
- extremely high frequency, known as ionizing radiation (x-rays and gamma rays)

Much of this exposure is beyond our control and is a matter of personal choice; however, public exposure to RF fields is growing exponentially due to the proliferation of cell phones, and wireless fidelity (Wi-Fi) technology. To understand the relationship between EMF from SmartMeters and other sources, it is helpful to view the electromagnetic spectrum:

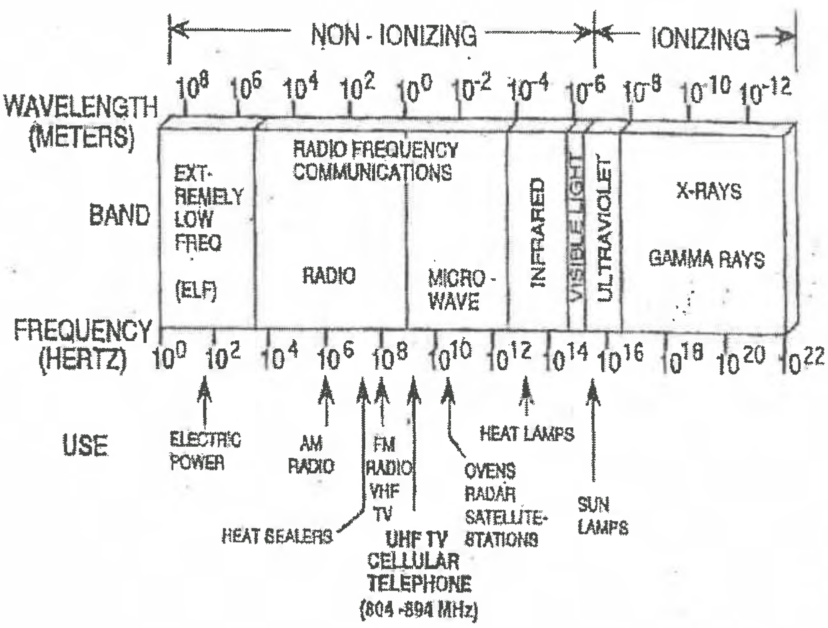

Fig. 1: The electromagnetic spectrum, showing the relations between ELF and RF fields, wavelength and frequency, and the ionizing and non-ionizing portions of the spectrum.

The Federal Communications Commission (FCC) has adopted limits for Maximum Permissable Exposure (MPE) that are based on exposure guidelines published by the National Council on Radiation Protection and Measurements (NCRP). The limits vary with the frequency of the electromagnetic radiation and are expressed in units of microwatts per centimeter squared. A SmartMeter contains two antennas whose combined time-averaged public safety limit of exposure is 655μW/cm² (Sage, 2011). According to the California Council on Science and Technology (CCST) Report (2011), within distances of three to ten feet, SmartMeters would not exceed this limit. However, CCST did not account for the frequency of transmissions, reflection factors, banks of SmartMeters firing simultaneously, and distances closer than three feet. There are numerous situations in which the distance between the SmartMeters and humans is less than three feet on an ongoing basis, e.g. a SmartMeter mounted on the external wall to a bedroom with the bed placed adjacent to that mounting next to the internal wall. That distance is estimated to be one foot. The CCST Report also states that SmartMeters will generally transmit data once every four hours, and once the grid is fully functional, may transmit "more frequently." It has been aptly demonstrated by computer modeling and real measurement of existing meters that SmartMeters emit frequencies almost continuously, day and night, seven days a week. Furthermore, it is not possible to program them to not operate at 100% of a duty cycle (continuously) and therefore it should not be possible to state that SmartMeters do not exceed the time-averaged exposure limit. Additionally, exposure is additive and consumers may have already increased their exposures to radiofrequency radiation in the home through the voluntary use of wireless devices such as cell and cordless phones, personal digital assistants (PDAs), routers for internet access, home security systems, wireless baby surveillance (baby monitors) and other emerging devices. It would be impossible to know how close a consumer might be to their limit, making safety a uncertainty with the installation of a mandatory SmartMeter.

This report will focus on the documented health risks of EMF in general, the relevance of that data to SmartMeters exposure, the established guidelines for RF safety to the public at large, and then provide recommendations to ameliorate the risk to the public's health.

Evidence-based Health Risks of EMFs

There is no scientific literature on the health risks of SmartMeters in particular as they are a new technology. However, there is a large body of research on the health risks of EMFs. Much of the data is concentrated on cell phone usage and as SmartMeters occupy the same energy spectrum as cell phones and depending on conditions, can exceed the whole body radiation exposure of cell phones phones (see Attachment B1, Figure 4). In terms of health risks, the causal factor under study is RF radiation whether it be from cell phones, Wi-Fi routers, cordless phones, or SmartMeters. Therefore all available, peer-reviewed, scientific research data can be extrapolated to apply to SmartMeters, taking into consideration the magnitude and the intensity of the exposure.

Since the mid-1990's the use of cellular and wireless devices has increased exponentially exposing the public to massively increased levels of RF. There is however, debate regarding the health risks posed to the public given these increased levels of radiation. It must be noted that there is little basic science funding for this type of research and it is largely funded by industry. An intriguing divide, noted by Genuis, 2011 is that most research carried out by independent non-government or non-industry affiliated researchers suggests potentially serious effects from many non-ionizing radiation exposures; most research carried out by independent non-government or non-industry affiliated researchers suggests potentially serious effects from many non-ionizing radiation exposures research funded by industry and some governments seems to cast doubt on the potential for harm. Elements of the controversy stem from inability to replicate findings consistently in laboratory animal studies. However, analysis of many of the conflicting studies is not valid as the methodology used is not comparable. Despite this controversy, evidence is accumulating on the results of exposure to RF at non-thermal levels including increased permeability of the blood-brain barrier in the head (Eberhardt, 2008), harmful effects on sperm, double strand breaks in DNA which could lead to cancer genesis (Phillips, 2011), stress gene activation indicating an exposure to a toxin (Blank, 2011), and alterations in brain glucose metabolism (Volkow, 2011).

In terms of meta-analyzed epidemiological studies, all case–control epidemiological studies covering >10 years of cell phone use have reported an increased risk of brain tumors from the use of mobile phones (Hallberg, 2011). Other studies have pointed to an increasing risk of acoustic neuroma, salivary gland tumors, and eye cancer after several years of cell phone use and the tumors occur predominantly on the same side of the head as the phone is used. The analysis of brain cancer statistics since the mid 20th century in several countries reveals that brain tumor formation has a long latency time, an average of over 30 years to develop from initial damage.(Hallberg, 2011). Therefore using studies such as the Interphone Study which looked as shorter latency periods for the development of specific brain cancers will result in inconclusive data.

Another potential health risk related to EMF exposure, whose legitimacy as a phenomen remains contentious, is electromagnetic hypersensitivity (EHS). In the 1950's, various centers in Eastern Europe began to describe and treat thousands of workers, generally employed in jobs involving microwave transmission. The afflicted individuals often presented with symptoms such as headaches, weakness, sleep disturbance, emotional instability, dizziness, memory impairment, fatigue, and heart palpitations. Clinical research to verify the physiological nature of this condition did not begin in earnest until the 1990's and found that the EMF involved was usually within the non-ionizing range of the electromagnetic spectrum. In the early 2000's, estimates of the occurrence of EHS began to swell with studies estimating the prevalence of this condition to be about 1.5% of the population of Sweden (Hilleert et al., 2002), 3.2% in California (Levallios et al., 2002), and 8% in Germany (infas Institut fur angewandte Sozialwissenschaft GmbH, 2003).

In 2004, WHO declared EHS "a phenomenon where individuals experience adverse health effect while using or being in the vicinity of devices emanating electric, magnetic, or electromagnetic fields (EMFs)...Whatever its cause, EHS is a real and sometimes debilitating problem for the affected persons (Mild et al., 2004)."

Currently, research has demonstrated objective evidence to support the EHS diagnosis, defining pathophysiological mechanisms including immune dysregulation in vitro, with increased production of selected cytokines and disruption and dysregulation of catecholamine physiology (Genuis, 2011).

Until recently, the diagnosis of EHS has not received much support from the medical community due to lack of objective evidence. In an effort to determine the legitimacy of EHS as a neurological disorder, however, a collection of scientists and physicians recently conducted a double-blinded research study that concluded that "EMF hypersensitivity can occur as a bona fide environmentally-inducible neurological syndrome (McCarty et al., 2011).

Safety Guidelines

The guidelines currently used by the FCC were adopted in 1996, are thermally based, and are believed to protect against injury that may be caused by acute exposures that result in tissue heating or electric shock. FCC guidelines have a much lower certainty of safety than standards. Meeting the current FCC guidelines only assures that one should not have heat damage from SmartMeter exposure. It says nothing about safety from the risk of many chronic diseases that the public is most concerned about such as cancer, miscarriage, birth defects, semen quality, autoimmune diseases, etc. Therefore, when it comes to nonthermal effects of RF, FCC guidelines are irrelevant and cannot be used for any claims of SmartMeter safety unless heat damage is involved (Li, 2011).

There are no current, relevant public safety standards for pulsed RF involving chronic exposure of the public, nor of sensitive populations, nor of people with metal and medical implants that can be affected both by localized heating and by electromagnetic interference (EMI) for medical wireless implanted devices. Many other countries (9) have significantly lower RF/MW exposure standards ranging from 0.001 to 50 $\mu W/cm^2$ as compared with the US guideline of 200-1000 $\mu W/cm^2$. Note that these recommended levels are considerably lower that the approximately 600 $\mu W/cm^2$. (time-averaged) allowed for the RFR from SmartMeters operating in the low 900 MHz band mandated by the FCC based on only thermal consideration.

In summary, there is no scientific data to determine if there is a safe RF exposure level regarding its non-thermal effects. The question for governmental agencies is that given the uncertainty of safety, the evidence of existing and potential harm, should we err on the side of safety and take the precautionary avoidance measures? The two unique features of SmartMeter exposure are: 1) universal exposure thus far because of mandatory installation ensuring that virtually every household is exposed; 2) involuntary exposure whether one has a SmartMeter on their home or not due to the already ubiquitous saturation of installation in Santa Cruz County. Governmental agencies for protecting public health and safety should be much more vigilant towards involuntary environmental exposures because governmental agencies are the only defense against such involuntary exposure. Examples of actions that the public might take to limit exposure to electromagnetic radiation can be found in Attachment B2.

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Attachment B

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Figure 4 from Hirsch; 2011

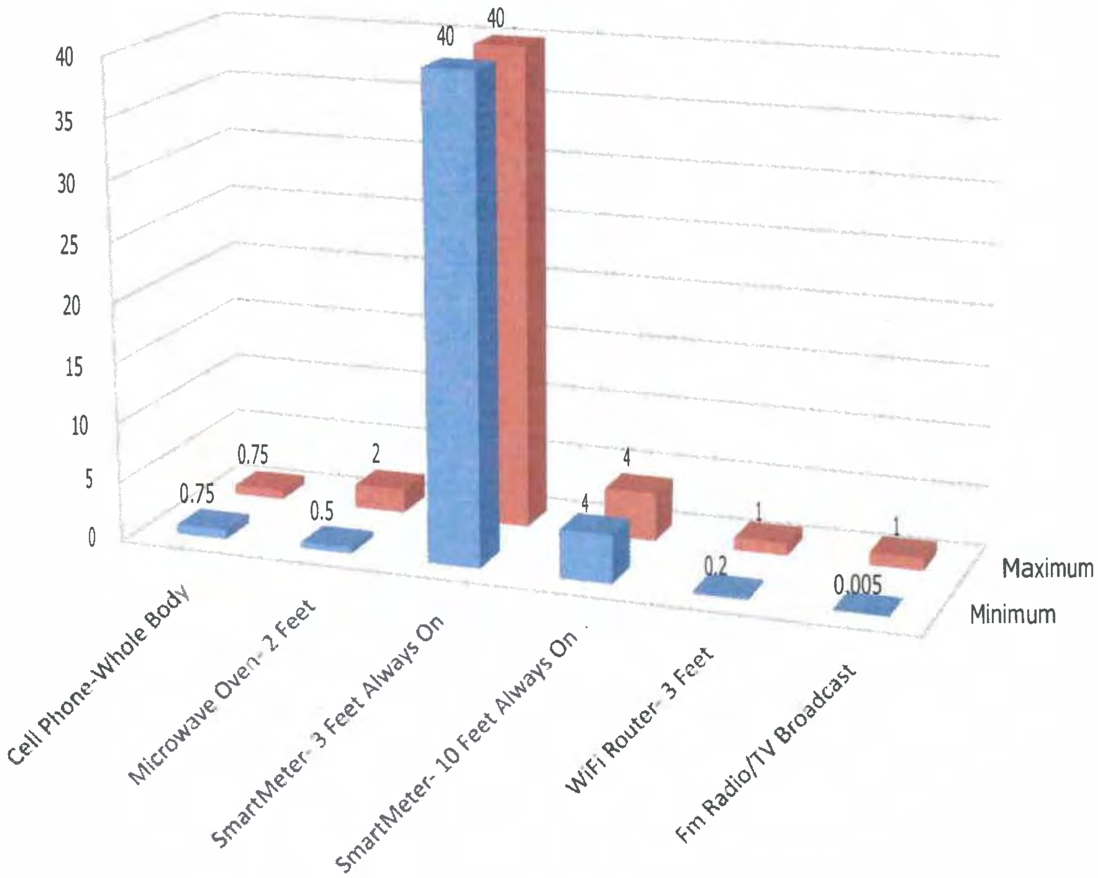

Figure 4. Comparison of Radio-Frequency Levels to the Whole Body from Various Sources in μ W/cm^2 over time [corrected for assumed duty cycle and whole body exposure extrapolated fro m EPRI/CCST SmartMeter estimated levels at 3 feet].

Attachment B2

Examples of strategies to reduce electromagnetic radiation. (Genuis SJ, 2011)

Sources of adverse EMR	Considerations to reduce EMR exposure
Cell phones and cordless phones	• Minimize use of cell and cordless phones and *use* speaker phones when possible • Leave cell or cordless phone away from the body rather than in pocket or attached at the hip.
Wireless internet	• Use wired internet • Turn off the internet router when not in use (e.g. night-time) • Use power line network kits to achieve internet access by using existing wiring and avoiding wireless emissions.
Computers releasing high EMR	• Limit the amount of time spent working on a computer • Avoid setting a laptop computer on the lap • Increase the distance from the transformer. • Stay a reasonable distance away from the computer
Handheld electronics (electric toothbrush, hair dryer, Smart phone, electronic tablets, etc.)	• Limit the use of electronics and/or revert to using power-free devices • Turn devices off before going to sleep • Minimize electronics in bedrooms
Fluorescent lights	• Consider using alternate lighting such as incandescent (Uncertainty exists about the safety of LED lights) • Rely on natural sunlight for reading
Household power	• Measure levels of EMR and modify exposures as possible • Avoid sleeping near sites of elevated EMR • Filters can be used to mitigate dirty power
High voltage power lines substations, transmission towers, and emitters (cell phone tower, radar, etc.)	• Consider relocating to an area not in close proximity to high voltage power lines • Maintain considerable distance from emitters • Consider forms of shielding (shielding paints; grounded metal sheets)
Utility neutral-to-ground bonded to water pipes	• Increase size of neutral-wire to substation and install dielectric coupling in water pipe.

STATE OF MICHIGAN
DEPARTMENT OF ATTORNEY GENERAL

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BILL SCHUETTE
ATTORNEY GENERAL

April 16, 2012

Ms. Mary Jo Kunkle
Executive Secretary
Michigan Public Service Commission
6545 Mercantile Way
Lansing, MI 48911

Dear Ms. Kunkle:

RE: MPSC Case No. U-17000

Pursuant to the Commission's E-Dockets User Manual, I am attaching the Attorney General's Comments Pursuant to the MPSC Order Dated January 12, 2012.

Sincerely,

Donald E. Erickson (P 13212)
Robert P. Reichel (P31878)
Assistant Attorney General
Environment, Natural Resources &
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(517) 373-7540

c: All parties

STATE OF MICHIGAN

BEFORE THE MICHIGAN PUBLIC SERVICE COMMISSION

In the matter, on the Commission's own motion, to review issues bearing on the deployment of smart meters by regulated electric utilities in Michigan. /

MPSC No. U-17000

ATTORNEY GENERAL'S COMMENTS
PURSUANT TO THE MPSC ORDER
DATED JANUARY 12, 2012

In its January 23, 2012 Order, the Michigan Public Service Commission (MPSC or Commission) directed all regulated electric utilities to submit information regarding several topics involving the deployment of "smart meters" Those topics include, but are not limited to: [1]

- The estimated cost of deploying smart meters and any sources of funding.
- An estimate of the savings to be achieved by the deployment of smart meters
- Whether the electric utility intends to allow customers to opt out of having a smart meter; and
- How the electric utility intends to recover the cost of an opt out program if one will exist.

[1] Other topics listed in the Commission's Order including scientific information that bears on the safety of smart meters, and steps each utility intends to take to safeguard the privacy of customer information gathered through smart meters, are the subject of extensive comments filed by other parties in this case, and will not be addressed here. We urge the Commission to carefully consider those comments.

In response to the Order, comments were submitted by several electric utilities. Among those, Detroit Edison Company (Document No.0146) and Consumers Energy Company (Document No. 0148) disclosed the most extensive plans to install smart meters.

The Attorney General respectfully submits that, notwithstanding the comments submitted by Detroit Edison Company (Detroit Edison) and Consumers Energy Company (Consumers), at least two very substantial issues remain that must be further addressed before the MPSC authorizes or approves any further deployment of smart meters by Michigan electric utilities and the recovery from ratepayers of the costs of smart meter deployment. First, there must be a sufficient demonstration that implementation of the smart meter programs will actually produce a net economic benefit to customers. Second, customers must be afforded a meaningful and fair opportunity to opt out of smart meter installation without being penalized by unwarranted and excessive costs.

Inadequate Demonstration of Economic Benefit to Ratepayers

A net economic benefit to electric utility ratepayers from Detroit Edison's and Consumers smart meter programs has yet to be established. In the absence of such demonstrated benefit, the Attorney General has opposed, and will oppose any Commission action that unjustly and unreasonably imposes the costs of such programs upon ratepayers. To a significant extent, the asserted *potential* benefits to utility customers depend upon assumptions that a customer will consider additional "real time" data on electricity usage provided by smart meters, and adjust their electrical consumption to achieve cost savings under variable pricing programs that do not yet exist. (See Edison, Document No. 0146, p 5; and Consumers, Document No. 0148, pp. 6-7). Any assumption that large numbers of residential customers will have the time, ability and motivation to attend to, and act upon daily or even hourly changes in their electrical is questionable.

The absence of sufficient economic justification for Detroit Edison's smart meter program was emphatically recognized by the Court of Appeals in the consolidated appeals by the Attorney General and the Association of Businesses Advocating Tariff Equity from the Commission's January 11, 2010 Order in Case No. U-15768, *In re Application of Det Edison Co* (Michigan Court of Appeals Nos. 296374, 296379, slip opinion, pp. 7-9, April 10, 2012):

> We agree with appellants that the PSC erred in approving funding for Detroit Edison's advanced metering infrastructure (AMI) program. The PSC describes AMI as "an information gathering technology that allows Detroit Edison to collect real-time energy consumption data from its customers." As ABATE explains, "[t]he so-called 'smart meters' allow the utility to remotely monitor and shut-off electricity to customers that have these meters installed." According to ABATE, the intention appears to be to "allow customers to access real time energy consumption data and make alterations in their energy consumption patterns in order to reduce their own costs and to reduce the demands placed upon the system at time of system peak." However, appellants have established that the PSC's decision to approve the nearly $37 million rate increase to fund the program was unreasonable because it was not supported by "competent, material and substantial evidence on the whole record." *In re Consumers Energy Co*, 279 Mich App at 188; MCL 24.306.
>
> What the record does reveal is that AMI is a pilot program that even Robert Ozar, Manager of the Energy Efficiency Section in the Electric Reliability Division of the PSC, concedes "is as yet commercially untested and highly capital intensive, resulting in the potential for significant economic risk and substantial rate impact." At best, the

> actual evidence presented by Detroit Edison to support the rate increase was aspirational testimony describing the AMI program in optimistic, but speculative terms. *What the record sadly lacks is a discussion of competing considerations regarding the program or the necessity of the program and its costs as related to any net benefit to customers.*
>
> * * *
>
> Moreover, we will not rubber stamp a decision permitting such a substantial expenditure—a cost to be borne by the citizens of this state—that is not properly supported. Were we to do so, we would abdicate our judicial review obligations. Again, *the PSC may allow recovery of a utility's costs only when the utility proves recovery of costs is just and reasonable.* On the record before the PSC and, perforce, before us, the PSC's decision was erroneous. Accordingly, *we remand this matter for the PSC to conduct a full hearing on the AMI program*, during which it shall consider, among other relevant matters, evidence related to the benefits, usefulness, and potential burdens of the AMI, specific information gleaned from pilot phases of the program regarding costs, operations, and customer response and impact, an assessment of similar programs initiated here or in other states, risks associated with AMI, and projected effects on rates. In other words, a real record, with solid evidence, should support whatever decision the PSC makes upon remand.
> [Slip Op. pp. 7-9, (Emphasis added, footnote omitted)]

Opt-Out Provisions

Given the questionable benefit of smart meter program to customers, as well as the extensive public concern about the effect and potential intrusiveness of smart meter infrastructure acknowledged in the Commission's January 12, 2012 Order in this matter, the Commission appropriately directed Michigan's electrical utilities deploying or proposing to deploy smart meters to provide information about their plans for allowing customers to opt out of having a smart meter, and how they intend to recover the cost of such an opt-out program.

The Attorney General respectfully submits that utility customers should be given a meaningful choice of whether to have smart meters installed and operated on their property. An "opt-out" program that requires those customers who opt out to pay an unwarranted economic penalty for doing so does not afford customers such a meaningful choice.

The information provided by Detroit Edison, and Consumers in response to the Commission's Order does not sufficiently establish that they intend to offer customers a fair choice of whether to accept smart meters on their property. Detroit Edison's response on this subject is based upon the assertion that "Edison's AMI [Advanced Meter Infrastructure] program is beneficial for all customers." (Document No. 0148, p. 7). Proceeding from the unsubstantiated assertion, Detroit Edison apparently proposes to impose what it broadly describes as "all incremental costs" solely upon customers who choose not to accept installation of smart meters. (Document 0148, pp. 8-9). Consumers' submission similarly states that while it proposes to provide customers with the option to retain their existing meter equipment, it apparently intends to subject customers making such a choice to additional charges, including charges for "maintaining ready testing and billing traditional meters". (Document No. 0146, pp. 16-17). While neither Detroit Edison nor Consumers provide details regarding their opt-out proposals and associated charges, both of their comments suggest that they intend to effectively penalize customers who choose to opt-out of smart meters. Presumably, under the utilities proposals, customers who opt-out of smart meters would be required to pay rates covering *both* the costs of the smart meter program, and expansively defined incremental costs "of retaining traditional meters. These proposals raise substantial questions as to whether their respective customers would, in fact, be afforded a fair and meaningful choice to "opt-out".

Another argument which may be important for the Commission to consider is whether a financial incentive to homeowners who allow smart meters to be installed in their home might be an alternative approach to a rate increase if a homeowner refuses to permit a smart meter to be installed.

Respectively submitted,

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>> JANET NEWTON: Yes I am. I'm speaking on behalf of the EMR Policy Institute; we're a national advocacy organization established in 2003. We educate policymakers on the need for sound policy that protects public health regarding electromagnetic radiation, EMR. Since 1997 we continue to challenge U.S. safety policy on EMR and radio frequency, RF, radiation exposures, by submitting official comment to key federal agencies, such as the NAS, FCC, FDA, GAO, NIOSH and now the DOJ.

We have taken three cases to the U.S. Supreme Court challenging the FCC's RF safety policy as inadequate to protect all the members of the public. In each case the court denied cert. Since 1997 the FCC has resisted all calls to address these inadequacies. Our comment today addresses Web information services and equipment and furniture. Hopefully giving background information, so that for the regulatory assessment needed if DOJ revises its regulations.

DOJ must ensure not only that equipment and furniture used in programs and services provided by public entities and public accommodations are accessible to individuals with vision, hearing and speech disabilities. It must also ensure that individuals with implanted medical devices, IMDs, or with the EMR functional impairments of electro hypersensitivity and radio frequency sickness are not injured in their daily living. And that they continue to have access to Web information and services through hard wired communications equipment.

Currently there are three federal mandates to promote wireless technologies that can injure people with IMDs or with EMR functional impairments. These are wireless broadband, wireless smart grid and smart meters, and unlicensed commercial use of TV white spaces spectrum.

The 2008 NAS report, "Identification of Research Needs Relating to Adverse Health Effects of Wireless Communication," explicitly identifies the holes in the RF research record. These are lacks of models of several heights of men, women and children of various ages for exposure to various wireless communications devices such as cell phones, wireless PCs and bay stations.

The need to characterize complex radiation from bay station antennas for the highest reradiated power conditions conducted during peak hours of the day at locations close to the antennas as well as at ground. And the recognition of population subgroups with specific sensitivities, in order to quantify the radiation absorption close to metal and glasses and various medical prostheses such as hearing aids, cochlear implants and cardiac pacemakers.

The FCC focus on interference in safety continues to protect devices rather than people, as noted in the 2009 announcement of its TV white spaces initiative. It says to build on a proven concept, the safe employment of new intelligent devices in the unused spectrum that exists between TV channels without causing undue interference to adjacent users. FCC's adjacent users refers to commercial communications devices, not to IMDs or individuals with EMR functional impairments.

The IEEE developed the existing FCC safety limits in 1992. They do not sufficiently protect the able-bodied, let alone the disabled. EPA's 19-3 comment on FCC's RF safety regulations emphasizes that the IEEE's 1992 standard is based on a thermal effect of RF radiation and by extension is protective of effects arising from a thermal mechanism. Therefore, the generalization that 1992 IEEE guidelines protect human beings from harm by any mechanism is not justified.

IEEE standard does not recognize any population subgroup, variation, and sensitivity to RF radiation such as infants, aged, ill and disabled, persons dependent on medication, persons in adverse environmental conditions, all those that are more at risk than others.

FCC's RF limits certainly do not protect those with IMDs or who require critical care equipment that can malfunction in the presence of wireless signals from outside sources. Such malfunctions can be fatal. They do not protect individuals with EMR functional impairment. No federal agency keeps track of cumulative wireless radiation levels, nor identifies critical levels in locations where individuals with IMDs may be at risk. Nor require signage to identify wireless environments so that individuals with EMR functional impairment can avoid these locations.

The most seriously threatened are the NIH estimated 20 million Americans with IMDs. This is eight to 10 percent of Americans. Smart meters and wireless broadband present the most serious threat because of their ubiquitous deployment throughout the public's living and working environments.

We request that a result of this proceeding will be DOJ recognition of wireless exposure as an accessibility and civil rights issue for individuals with IMDs or with the EMR functional impairment. We request that ADA divisions take action on universal design measures in relation to that recognition, such as to require hard wired rather than wireless Internet connections in public buildings such as schools and libraries.

To require smart grids, smart meter options that employ land line data transmission rather than wireless transmitting meters. And to require signage in public accommodations such as hospitals, stores, hotels, restaurants, airports, and public transportation facilities alerting the public to the presence of wireless communication systems. Thank you.

>> JOHN L. WODATCH: Thank you very much. We appreciate your testimony today.

Romero-Sierra to J. Beal
8/7/73

DIVISION OF MECHANICAL ENGINEERING

DIVISION DE GÉNIE MÉCANIQUE

CANADA

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LTR-CS-98

ENVIRONMENTAL POLLUTION BY MICROWAVE RADIATION - A POTENTIAL THREAT TO HUMAN HEALTH

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PREFACE

This report concerns work that is part of a program of research on the effects of electromagnetic fields on living tissue conducted in collaboration with the Department of Anatomy, Queen's University, Kingston, Ontario, Canada.

ABSTRACT

Due to the ever-growing application of microwave devices in ind.ustry, research, for military purposes, and domestic appliances (encouraged in part by the advent of economic solid state microwave devices) microwave background radiation may increase to a dangerous level in the near future. This presents a potential threat to human health and measures must be taken to control the proliferation of these devices and their applications.

Power density, the presently accepted index of health hazard, is reviewed. Electric and magnetic field vectors are recommended in its place as meaningful parameters in the evaluation of non-ionizing radiation hazards.

A brief discussion on "weak interactions" between microwave radiation and biological systems is presented.

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1.0 INTRODUCTION

It is only in recent years that man has become fully aware of the potential hazards created by his own generated pollution of the environment. Not only is he starting, to, gain full significance of its effects on his health but also on the complex chain of events that characterize natural ecosystems of which he is a small part.

Pollutants in general can be divided into two main groups according to their origin:

1. Man-made pollutants
1. Naturally occurring pollutants .

We are mainly concerned here with what we believe will be a major problem to mankind in the near future -that of microwave pollution of the environment by man-made microwave sources.

2. 0 MICROW AVE SOURCES

The term microwave refers to wavelength. The term is used to describe that portion of the electromagnetic spectrum ranging from about 30 centimeters to about 3 millimeters (i.e., from 1 GHz to 100 GHz in frequency terms, see Figure 1).

Microwaves are widely used. Some typical applications include:

1. Tracking and Navigation (radar installations).
2. Communications, i.e., telephone and television transmission (ground and satellite installations).
3. Research, i.e. , radioastronomy, spectroscopy, MW electron accelerators
4. Industrial appliances, i.e. , MWovens, freeze dryers, sterilizers, etc .
5. Domestic appliances, i.e. , MW ovens.

Since most of the above uses require very expensive MW power devices such as klystrons and magnetrons, only industrial, military and research establishments can operate these costly installations. However, the advent of radically new types of MW generators[1] introduced during the past few years will most probably dramatically change this state of affairs. The new MW generators are of the solid-state type and are considerably cheaper than MW tubes. They include:

1. Gunn oscillators
2. Limited space-charge accumulation diodes (L. S. A.)
3. Read diodes
4. Impatt diodes

These devices are practically battery operated and their cost is expected to drop to a few dollars per unit in the next few years. They are reliable and though their power output is at present limited to less than 1 watt in most cases, it is only a matter of time before solid state MW- technology will have advanced to much higher power MW devices.

From a cost point of view it is easy to foresee the many different domestic and other applications[2] that could be found for MW, so it may be anticipated that MW devices will become widely used in the near future. The uncontrolled proliferation of MW devices would considerably increase the ambient level of MW radiation in a highly complex and unpredictable fashion.

Since the object of this paper is to bring attention to the potential threat that uncontrolled and irresponsible use of these devices could place on human beings, animals and vegetation, we mention in passing a few of the possible major contributors to the MW radiation background:

1. Domestic and private uses of MW devices, i.e. , MW ovens, etc.
2. Use in cars of collision avoidance radar systems, etc .
3. Traffic signalling systems
4. Utility poles
5. Extensive ground communications where the need of closely spaced repeaters is required due to MW attenuation
6. Large scale satellite-earth communications.

3.0 BIOLOGICAL CONSIDERATIONS OF MICROWAVE RADIATION

In view of the lack of knowledge on the biological effects of microwave radiation, the following actions are required:

1. A systematic study of the biologic al effects of MW radiation must be initiated, and
2. The maximum permissible MW radiation levels for occupational workers and public in general must be determined.

Extensive but somewhat inconclusive and controversial studies have been conducted in both areas. An excellent source of references up to 1965 is given by Pressman[3]. Since then, many other publications on this subject have appeared including our own contributions[4-23].

The interaction of microwaves with living systems13 is a subject of extreme complexity, as depicted by the block diagram of Figure 2. .In this diagram an arbitrary division has been made between wave and non-wave effects in order to point out some of the wave effects common , to all electromagnetic radiation. Some of these interactions can be correlated with the biological effects elicited. However, a considerable amount of work has yet to be done in this field to elucidate the subtleties that would lead to an understanding of the observed effects at very low radiation levels.

In the study of the effects of MW on living systems consideration must be given to (i) energy level of radiation and (ii) exposure time.

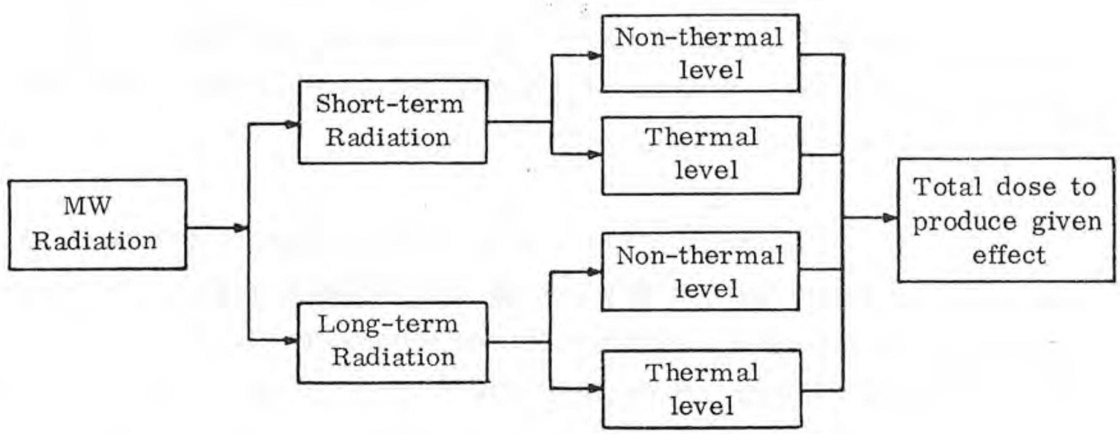
Radiation levels can be divided into two categories:

1. Thermal
2. Non-thermal.

This division requires some clarification. Irradiation intensities below 10 mW /cm2 are considered athermal (non-thermal) for both pulsed and CW beams, either with general or local irradiation of humans and animals. At a power level of 10 m W /cm2 , the energy transformed into heat in the body is roughly equal to the heat loss per square centimeter of body surface of humans and warm-blooded animals under normal environmental conditions.

Further, effects related to exposure time can be divided into two categories: (i) short-term and (ii) long-term.

Exposure time and energy level of radiation together with the observed biological effects are three of the factors which determine the maximum permissible radiation levels, as shown by the following block diagram.



Because of the dramatic effects produced by thermal MW levels resulting in permanent damage and/or death of the biological specimen under irradiation, the short-term thermal level combination has been the most fruitful area of experimentation. Little work has been done on the short-term non-thermal and long-term non-thermal modes of MW radiation.

Since it is reasonably easy to detect and monitor high radiation levels we emphasize the importance of the last two irradiation modes . From these we consider the long term non-thermal combination as being of the utmost importance in the near future because of the doubt we have expressed concerning the uncontrolled proliferation of MW devices .

With this in mlnd a systematic investigation should be undertaken to determine the "safe" levels of exposure for man, animals, plants and various other organisms.

4.0 SAFETY LEVELS

International accord has not been achieved as yet on safe exposure levels in the short and long-terms. Microwave radiation exposure levels for safe whole body radiation ranged from 100 cW/cm^2, originally established in the USA, to 10 $\mu W/cm^2$ established by the USSR, for exposure durations of one day. Recently 10 mW/cm^2 has been accepted in the USA as a safe level for a period of 0.1 h.[24,25].

The latter is a lower limit for thermal effects to take place and therefore does not take into account biological effects likely to occur at the non-thermal level. However, recent reports in the Russian literature describe harmful effects arising from MW radiation of low intensity on people living and working near radar installations. This confirms our own experimental findings in another area.

We mention in passing that although natural MW sources have received practically no attention, such natural pollutants may prove to be of utmost importance in the future.

The status quo of safety levels established by different countries is an indication of the lack of knowledge of the extent of biological effects. The presently accepted safety levels in several countries are summarised in Table I.

All the safety levels are given in terms of MW power (flux levels). Furthermore, and this is not apparent from Table I, these standards have been established by assuming plane waves of linear polarization travelling in free-space reaching points of interest located in the far zone of the radiating element, and far from any disturbing component -- including the biological specimen itself.

In addition, normal incidence of the wave on the specimen is usually assumed together with the fact that the size of the object is much larger than the wavelength of the incident radiation.

Also, standard environmental conditions of temperature, humidity and pressure are postulated and no previous history of the biological system is taken into consideration. In other words the system is assumed to be "normal".

These are indeed very strong assumptions that raise questions as to the validity of the nowadays commonly accepted standards of safe exposure.

5.0 QUANTIFICATION OF M!CROWAVE FIELDS

Power density (Real part of Poynting's vector) has traditionally been used as a parameter of the biological effects associated with a microwave field. Safety standards for levels of exposure have been set based on this concept. The usual procedure is to calculate the power density from the microwave source in the far zone (in free space) where the plane wave approximation is valid

Country	Radiation Level	Period	Remarks
USA and Western European Countries	10 mW/cm^2	0.1 h	
USSR	10 $\mu W/cm^2$	Working day*	
	10-100 $\mu W/cm^2$	2 h/day	Obligatory use of protective glasses
	1000 $\mu W/cm^2$	15-20 m/day	" " " "
Czechoslovakia	25 $\mu W/cm^2$	Working day	Occupational workers, CW
	10 $\mu W/cm^2$	Working day	" " , Pulsed
	2.5 $\mu W/cm^2$	Continuous**	Other workers, CW
	1.0 $\mu W/cm^2$	Continuous	" " , Pulsed

* 8 h/day
** 24 h/day

TABLE I : MAXIMUM MEAN VALUES OF SAFE MICROWAVE IRRADIATION ACCEPTED IN CERTAIN COUNTRIES and set an upper limit to this level as biologically significant for a given biosystem of known electromagnetic characteristics. In this approach the following is further assumed:

1. The object under illumination is semi-infinite in size.
2. The illuminated object and radiating element are far from any reflecting surfaces .
3. No reflection of radiation takes place from the illuminated object in the direction of the radiating element.
4. The radiation field is not affected by the object under illumination .

The above implies that no Electromagnetic Interference (EMI) takes place and that resonance effects are neglected.

It is not difficult to see that none of the above premise are satisfied. Firstly, the energy absorbed by an object is dependent upon its shape and physical dimensions[25], particularly when the wavelength of the incident radiation is of the same order of magnitude as the dimensions of the object itself. Secondly, the object (biosystem) creates a strong disturbance of the field. Thirdly, unless the object is completely transparent or a perfect absorber of microwaves, a standing. wave (SW) will be formed between the radiating element and the illuminated object. Fourthly, objects (including radiating elements) interact with partially reflecting surfaces such as walls , ground, etc. Thus complicated Interference Patterns (IP) arise in most cases.

Even in the far zone of a radiating element (where $D \geq n \frac{a^2}{\lambda}$ with > 1) power density measurements performed in the absence of the object are of very limited value. The situation is worsened because illumination takes place very often in the intermediate and near zones of radiating elements where complex multipath fields (MF) occur and where plane wave approximations are invalidated. For instance, wave-fronts due to cracks, slots, etc. , would be of spherical or cylindrical form for which certain parts of the body (or the body as a whole) cylindrically, or spherically shaped would respond differently from the case where the wavefront is a plane wave. Thus, in most cases information at a given point of the amplitude of the components and phase of the magnetic (electric) field gives no information regarding the electric (magnetic) field at that point.

The alternative of calculating the power density inside the illuminated object as representative of the biological effects induced by the radiation (apart from practical difficulties) is even more complicated and ambiguous. A simple fact will clarify the difficulties. For instance, once the wave front has reached the object of interest the transmitted electric and ~ magnetic fields are out of phase by an angle ϕ which depends upon the properties of the medium and the frequency of the imposed radiation. Because of this phase the power density concept loses its meaning since the maxima and minima of E and H does not take place at the same time and so E/H varies widely in time and from point to point at a given time.

Assuming that the fields inside the object are given by:

$$\underline{E} = E_o \; e^{-\beta \underline{n}.x} \; e^{i\,(\alpha \underline{n}.\underline{x} - \omega t)} \quad \ldots.(1)$$

$$\underline{H} = \underline{H}_o \; e^{-\beta n.x} \; e^{i\,(\alpha \underline{n}.\underline{x} - \omega t)} \quad \ldots.(2)$$

it is easy to show that for a conducting medium[26] (i.e., biological tissues and fluids)

$$\underline{H}_o = \sqrt{\frac{\varepsilon}{\mu}} \left[1 + \left(\frac{4\pi\sigma}{\omega\varepsilon}\right)^2\right]^{1/4} e^{i\phi} \; (\underline{n} \times \underline{E}_o) \quad \ldots.(3)$$

where ϕ (phase angle) = $1/2 \tan^{-1}\left(\frac{4\pi\sigma}{\omega\varepsilon}\right)$ ....(4)

Equation 3 simply means that $\underline{H}$ lags $\underline{E}$ in time by the phase angle ϕ.

In addition the ratio H_o/E_o is given by[26]

$$\frac{H_o}{E_o} = \sqrt{\frac{\varepsilon}{\mu}} \left[1 + \left(\frac{4\pi\sigma}{\omega\varepsilon}\right)^2\right]^{1/4} \quad \ldots.(5)$$

which indicates that as σ increases the field energy is mainly magnetic in nature .

Due to the phase angle between the fields it is possible to have zero instantaneous power density (i. e ., one of the fields being zero at some instance of time) and arbitrarily large electric (magnetic) energy density, and electric (magnetic) field strength.

A. further complication arises from the fact that the ratio £/H varies along the path of the electromagnetic wave (£MW} due to the different absorption coefficients of the medium for electric and magnetic fields. For example, if one deals with a medium of high electrical conductivity the field will be magnetic itl nature due to the absorption of the electric field as the wave penetrates into the system. Conversely, in a medium of low electrical conductivity and high magnetic susceptibility the field will be predominantly electric .

To appreciate the intrinsic ambiguity of power density measurements in relation to biological effects, consider the following. In the near zone of a radiating element (few wavelengths from the source) the time-averaged power density is zero (energy bouncing back and forth) , yet the electric and magnetic fields associated with the wave may be arbitrarily large (and therefore their energy densities). In some regions near the antenna only a magnetic field exists with no electric field present. There,the power density is zero, but the magnetic energy density may be arbitrarily large.

The standing wave formed by two single plane waves travelling in opposite directions but of the same linear polarization and amplitude has a zero time-average power density. However, the magnetic and electric energy densities associated with the standing wave may be as high as four times that of the original waves at some points.

Once the fictitious nature of power density has been established it remains to decide what quantities are meaningful for quantifying MW fields in relation to their biological effects. In this regard energy density (electric U_E , magnetic U_M , and Total U), the strength and orientation .of the fields (electric and magnetic) and their squared magnitudes (E^2, and H^2) are likely candidates[13].

It is not an easy task to determine which of these parameters is more meaningful from the biological standpoint due to the fact that some biologic al effects are known to depend on the square of the electric and/or magnetic field intensities. Others are determined by the strength and orientation of the fields. Examples of the first kind are those effects depending on energy absorption (electric, magnetic, or both). It will be noted that energy density is proportional to the square of the field intensity where the proportionality factor is the real part of the complex dielectric and/or magnetic permeability. On the other hand some effects fall in the second category such as some magnetomechanical and electromechanical phenomena, field forces on charged particles (Lorentz force) , orientation effects, pearl chain formation, etc .

We believe that the field vectors (strength and orientation of E, and H) are more fundamental parameters than their corresponding squared magnitudes or energy densities because ultimately all biological effects (thermal, or non-thermal) are directly related to them.

The properties of an anisotropic medium with respect to an Electromagnetic Wave (EMW) are defined by the two tensors $\in_{ik}$ (ω) and μ_{ik} (ω) which give the relation between the inductions and the fields:

$$D_i = \epsilon_{ik}(\omega) E_k \quad \text{and} \quad B_i = \mu_{ik}(\omega) H_k \qquad \ldots\ldots(6)$$

where both ϵ_{ik} and μ_{ik} are symmetrical tensors.

For a transparent anisotropic medium, the internal Electromagnetic Energy (EME) per unit volume (energy density) is[27]

$$\bar{U} = \frac{1}{16\pi}\left[\frac{d}{d\omega}(\omega\epsilon_{ik}) E^*_i E_k + \frac{d}{d\omega}(\omega\mu_{ik}) H^*_i H_k\right] \qquad \ldots\ldots(7)$$

For the case where absorption of the EME takes place (i.e., electric losses), we have[27]

$$\frac{i\omega}{8\pi}\left[(\epsilon^*_{ik} - \epsilon_{ki})\ E_i\ E^*_k + (\mu^*_{ik} - \mu_{ki})\ H_i K_k^*\right] \qquad \ldots.(8)$$

These expressions are greatly simplified for the case of an isotropic medium.

In the case of an isotropic transparent dispersive medium the energy density becomes[27]

$$\bar{U} = \frac{1}{16\pi}\left[\frac{d}{d\omega}\ (\omega\epsilon)\ \underline{E}.\underline{E}^* + \frac{d}{d\omega}\ (\omega\mu)\ \underline{H}.\underline{H}^*\right] \qquad \ldots.(9)$$

where ϵ and μ are functions of ω, i.e., $\epsilon(\omega)$, and $\mu(\omega)$

Equation (8) can be further simplified for a non-dispersive medium to give

$$\bar{U} = \frac{1}{8\pi}\left[\epsilon\ \underline{E}^2 + \mu\ \underline{H}^2\right] \qquad \ldots.(10)$$

In the case where absorption of electromagnetic energy takes place the losses are given by

$$\frac{\omega}{4\pi}\left[\epsilon''\ \overline{\underline{E}}^2 + \mu''\ \overline{\underline{H}}^2\right] \qquad \ldots.(11)$$

where an accounting of the law of increase of entropy yields

$\epsilon''(\omega) > 0$ and $\mu''(\omega) > 0$ except for $\omega = 0$ for all substances at all

frequencies. ϵ'' and μ'' are the imaginary part of the complex dielectric ϵ and magnetic permeability

$$\epsilon = \epsilon' + i\ \epsilon''$$
$$\mu = \mu' + i\ \mu''$$

6.0 PERMISSIBLE LEVELS

I

Permissible levels are based on the appearance of some biological effect. Because heat is usually involved in the interaction of a MW field with the biosample, effects we.re first observed at MW levels that produced a measurable increase in the temperature of the specimens. Western countries based their maximum permissible levels on this level. Tissue and biological fluids being lossy materials of relative high electrical conductivity, high Ohmic losses occur in them which are proportional to σE^2. Thus the effect of an electric field (or its magnitude squared) has predominance over the magnetic field.

Strong experimental evidence of biological effects produced at much lower MW levels than those set by Western countries forced Eastern countries (where low-level studies were pioneered) to lower 1u those levels by a factor of 1000. In both cases, nevertheless, safety levels are mainly based on short-term irradiation whether or not they are thermal in nature. That is, effects that appear during an irradiation time much shorter than the life span of the system under consideration. It is therefore possible (and almost certain) that lower field levels may induce biological effects in the long term.

It is important to note that the effect that the magnetic field associated with the MW may have in the biological system has received very little consideration.

In the region where the predominant effects are thermal in nature it is obvious that the electric field plays a key role. In this region subtle non-thermal effects may be obscured by the thermal effects. But actually what happens in the non-thermal region ?

How are the electric and magnetic fields related to a specific non-thermal effect and what sort of interaction on a molecular or macroscopic level takes place? A number of theories have appeared in recent years proposing mechanisms whereby low intensity MW fields can affect biological systems, particularly in regard to effects on the central nervous system (CNS) .

Among the more advanced theories are the following:

1. Batteau[28] suggested as a result of his studies on the mechanism of hearing that sensation in the organisms may be caused by the shifting of the transition probability of electrons from an excited state to the ground state in some organic molecules.

2. A suggestion has been put forward by Berg[29] in which membranes and neural tissues may behave as wax electrets .

3. Wei's[30] theory suggests that the neuron has the potential profile and structure of a p-n-p transistor.

4. Based on experimental evidence of electron transfer taking place in biomolecules

(metabolites, hormones, etc.) Szent-Gyorgy[31] proposed a quantum mechanical theory in which the cell is treated as a solid state system in which the different energy levels that are possible can be occupied by valence electrons fusing into common energy bands.

7.0 WEAK INTERACTION

One can extend the Szent-Gyorgy theory to very large aggregations of like and unlike biomacromolecules to form tissue, organs, or even the whole body. Thus one may picture these as giant complex molecules endowed with practically unlimited numbers of quantum energy states approaching a continuous band distribution. Allowed transitions between different energy states probably constitute the rule and not the exception though this is difficult to foresee without detailed knowledge of transition probabilities between states.

The complicated energy spectrum of such a system is due to complex interactions between. different particles, atoms, functional groups, and molecules making up giant molecules. The structure of their energy spectra would probably consist of various quasicontinuous {or continous) bands (more or less separated by better defined quantum states , etc.) This is due to the different vibrational, rotational, spin, and possibly translational quantum states .

In principle, it is then possible for MW radiation to be absorbed by such a system, inducing in turn a change in quantum state; though only through experimentation is it possible to determine what biological effect would result from this type of interaction. The possibility of a cascade mechanism triggered by a MW photon or by photons of lower or higher energy cannot be ruled out.

Thus the possibility of direct interaction between an EM field and a- macroscopic system such as the human body may be significant.

There are other possibilities. The interaction of an external MW field generated by a living system should also be considered. Little is known about the MW spectrum generated by living organisms. We believe that apart from the so-called black body radiation (Planck's distribution) MW radiation may be produced through specific biophysical mechanisms and chemical reactions. If this is so the continuous spectrum should exhibit maxima and/or minima indicating the generation or absorption by the biological system of MW radiation of non-thermal origin. Currently we are conducting experiments along these lines with an X-band correlation radiometer[32].

Subtle biological effects may also be caused by the magnetic field associated with a MW field. The magnetic field, because of its highly pervasive nature, may in principle affect any, or every, cell in the body of a living system .

Pronounced effects are known to be induced by very weak magnetic fields[33] ranging from afraction of a Gauss to several Gauss. This is the same magnitude of intensity as that commonly encountered in MW fields of moderate energy density. Although most of the experiments have been conducted with DC fields there is no reason to believe that similar effects may not be induced by high frequency magnetic fields. It has been long maintained that the effects of a varying magnetic field are due to the induced emf and currents. However, a change in the magnetic field has been shown to produce direct biological effects[34]. Attention should also be given to the possible influence of the magnetic field on unbounded Ni and Fe. These elements appear in body fluids (plasma, intracellular and extracellular fluids, etc.) and in macromolecules containing ferromagnetic elements *(biomagnetite….jb)* such as iron (hemoglobin) where high magnetic fluxes may be induced.

Many other possibilities fall into what may be referred to as weak interactions. One area of investigation might be the effect of an external MW field on the very low magnetic field known to be produced by the heart, brain, and most recently by skeletal muscles[35]. These fields are in the order of 10^{-7} Gauss (one millionth of the earth's steady magnetic field).

Knowledge of weak interaction is sparse because of the minute strength of these interactions. The tendency is to disregard them on the assumption that they are insignificant. However, biology provides an incredible number of cases that prove otherwise.

We believe investigation into some of these interactions may yield useful and interesting information.

8.0 SOME REMARKS ON MICROWAVE DOSIMETRY

Microwave dosimetry as any other type of dosimetry, is a highly complex matter. Determination of electromagnetic fields inside the system under study is not an easy task because these fields are not related in a simple way to the fields that exist at the same point in space in the absence of the object. This means that either probes have to be implanted in the living system or inside a phantom simulating its characteristics and geometry.

To determine tolerances of MW levels in man one obviously must perform measurements on phantoms since no other animal has man's combined properties of size, shape, skin characteristics, ε^*, μ^*, σ, of tissues, etc. However, it is not possible to simulate (not even approximately) any living system. Not only is it necessary to reproduce the electromagnetic parameters but also the thermal characteristics, cooling mechanism (passive and active) etc., of the system.

Implantation of probes per se introduces a number of problems particularly when it is necessary to determine both field strength and field orientation simultaneously. The latter is very important in cases where field orientation is a determining factor in specific interactions. One further complication arises due to physical dimensions of the probes. Recall that the wavelength (in a medium other than free space) is given by $\lambda_0/\sqrt{\varepsilon'\mu'}$ where λ_0 is the free space wavelength. The complication is more apparent in the centimetric and millimetric regions where electrical performance is greatly affected by the physical size and construction of probes.

9.0 CONCLUSIONS

In view of the expected proliferation of MW devices in many different applications, a substantial increase in MW background activity is feared that may endanger human health. On this basis strict control of the use of these devices must be introduced while present safety standards are revised and extensive research is conducted into long term effects of exposure to low intensity MW radiation. In particular, a study of possible accumulative effects of MW radiation (directly or indirectly) through sensitization must be conducted .

The inadequacy of power density as an index of radiation hazard has been discussed. Meaningful parameters are energy densities (electric and magnetic), electric and magnetic field vectors and their squared magnitudes. We suggest the field vectors to be better quantitative measures to relate to biological effects (thermal or athermal) than their squared amplitudes or energy densities.

Systematic investigations of the weak interactions of MW fields with complex biological systems must be conducted together with exploratory experiments to determine the importance of the magnetic field associated with the EM wave.

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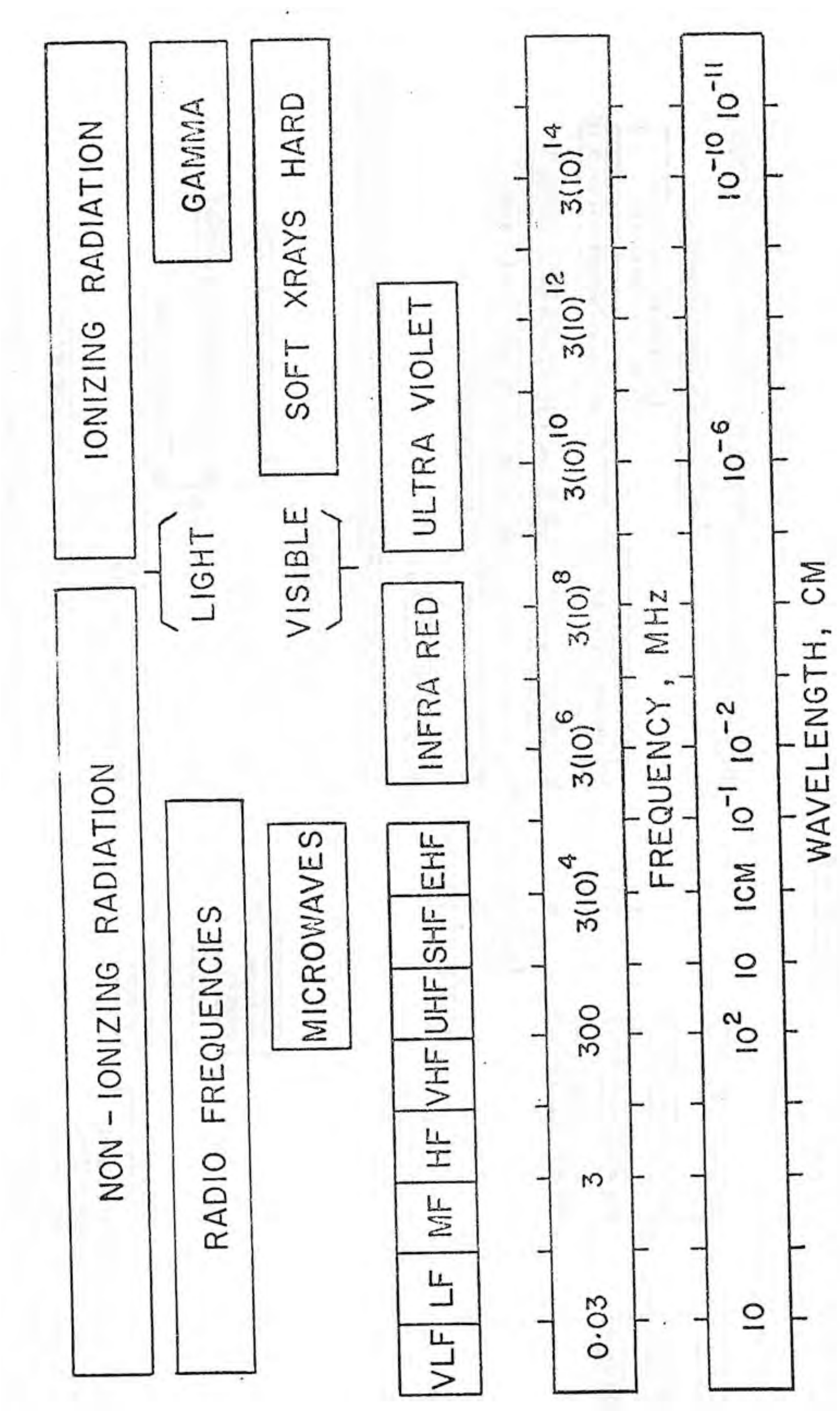
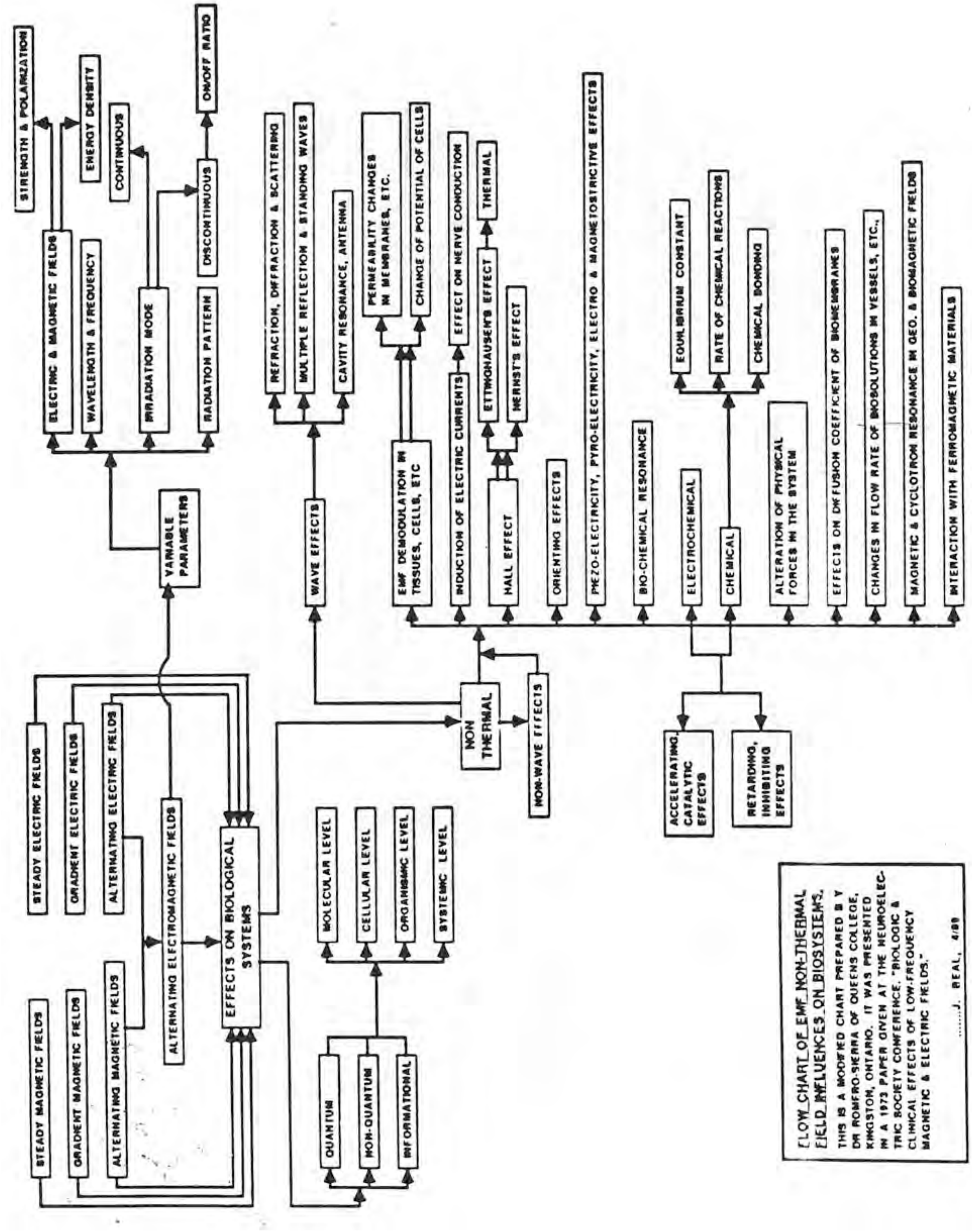


FIG.1: ELECTROMAGNETIC FREQUENCY SPECTRUM


STEADY MAGNETIC FIELDS
GRADIENT MAGNETIC FIELDS
ALTERNATING MAGNETIC FIELDS
ALTERNATING ELECTROMAGNETIC FIELDS
ALTERNATING ELECTRIC FIELDS
GRADIENT ELECTRIC FIELDS
STEADY ELECTRIC FIELDS
EFFECTS ON BIOLOGICAL SYSTEMS
QUANTUM
NON-QUANTUM
INFORMATIONAL
MOLECULAR LEVEL
CELLULAR LEVEL
ORGANISMIC LEVEL
SYSTEMIC LEVEL
VARIABLE PARAMETERS
ELECTRIC & MAGNETIC FIELDS
STRENGTH & POLARIZATION
ENERGY DENSITY
WAVELENGTH & FREQUENCY
IRRADIATION MODE
CONTINUOUS
DISCONTINUOUS
ON/OFF RATIO
RADIATION PATTERN
NON THERMAL
NON-WAVE EFFECTS
WAVE EFFECTS
REFRACTION, DIFFRACTION & SCATTERING
MULTIPLE REFLECTION & STANDING WAVES
CAVITY RESONANCE, ANTENNA
EMF DEMODULATION IN TISSUES, CELLS, ETC
PERMEABILITY CHANGES IN MEMBRANES, ETC.
CHANGE OF POTENTIAL OF CELLS
INDUCTION OF ELECTRIC CURRENTS
EFFECT ON NERVE CONDUCTION
HALL EFFECT
ETTINGHAUSEN'S EFFECT
THERMAL
NERNST'S EFFECT
ORIENTING EFFECTS
PIEZO-ELECTRICITY, PYRO-ELECTRICITY, ELECTRO & MAGNETOSTRICTIVE EFFECTS
BIO-CHEMICAL RESONANCE
ELECTROCHEMICAL
EQUILIBRIUM CONSTANT
RATE OF CHEMICAL REACTIONS
CHEMICAL BONDING
CHEMICAL
ALTERATION OF PHYSICAL FORCES IN THE SYSTEM
EFFECTS ON DIFFUSION COEFFICIENT OF BIOMEMBRANES
CHANGES IN FLOW RATE OF BIOSOLUTIONS IN VESSELS, ETC.,
MAGNETIC & CYCLOTRON RESONANCE IN GEO. & BIOMAGNETIC FIELDS
INTERACTION WITH FERROMAGNETIC MATERIALS
ACCELERATING, CATALYTIC EFFECTS
RETARDING, INHIBITING EFFECTS
FLOW CHART OF EMF NON-THERMAL FIELD INFLUENCES ON BIOSYSTEMS.
THIS IS A MODIFIED CHART PREPARED BY DR ROMERO-SIERRA OF QUEENS COLLEGE, KINGSTON, ONTARIO. IT WAS PRESENTED IN A 1973 PAPER GIVEN AT THE NEUROELECTRIC SOCIETY CONFERENCE: "BIOLOGIC & CLINICAL EFFECTS OF LOW-FREQUENCY MAGNETIC & ELECTRIC FIELDS."
........J. BEAL, 4/89