See P. 127

Clark see #1695

BIOLOGICAL MICRO WAVE HAZARDS

Victor T. Tomberg
Biophysical Res. Lab.,
New York, N.Y.

Summary.- Short waves and Microwaves are known to produce in high doses destructive biological effects. Physico-chemical and biological studies carried out mostly in the last 30 years showed us what and why this happens. In order to find out how efficiently we can protect us when working with high power transmitters or close to radiating fields we should know what are the biological or physical actions, the effects, the doses and safety levels. This is the purpose of our paper.

Shortwaves were introduced in 1926 as tool for biological research and means for medical treatment (diathermy), based on observations by Shereshewsky and Whitney in the U.S.[1], Esau and Pätzold in Germany[2,3] and Stieböck and Tomberg in Austria[2,3,4,5]. Later on, Microwaves were used for the same purposes, and still are. It was found that the principal biological effect of high frequency fields is heat, the thermal Joule effect, due to absorption and dielectric losses, regardless if the irradiated object is placed between condensor electrodes, in a coil field, or in the beam of a radiating dipole. Diathermy as well as electronic cooking are based on that Joule effect.

Biological objects are not ideal dielectrics. They have a dielectric constant between 1 and 80 according to the content in water, a low electrical conductivity and a bad thermal conductivity. They are, furthermore, of heterogenous structure. The developed heat in such objects depends primarily of the relationship of frequency to dielectric constant and to electrical conductivity. When we keep frequency and field intensity constant, then there is a maximum condition under which the temperature increase is determined. This is the case when $K = \frac{\varepsilon \cdot f}{2}$ where k is the electr.conductivity, ε the dielectric constant and f the frequency. As we shall see later on, this relationship is important to understand a number of biological actions which can not be explained by a general and homogenous thermal action.

It was found that the therapeutical action of high frequency fields, in particular of condensor or dipole fields depends on the biologically stimulating action of heat, as long that developed heat is moderate and does not produce any burns outside or inside a treated body. The stimulating and curing action depends therefore on the applied dose, which is the product of electrical energy multiplied by the time of action. When the dose is high then destructive effects can result which we call bionegative effects. The stimulating effects are called biopositive effects.

It was also found that some biological effects were obtained at very small doses. Control tests by heat applied in a waterbath showed in those cases a different result. A number of researchers[2,3,4] pretended that there must be an electrical action of the Microwave field of non-thermal nature, non depending of the heat developng action of the applied energy, but depending on the applied frequency (like in photoelectrical phenomena). Indeed, such effects are known to exist in physical and chemical experiments studied by Debye, Wien, Falkenhagen, a.o. They are based on moleculair resonance and ionic relaxation in liquids at wavelengths below 300 Mc. They are frequency and voltage dependent. Due to these effects a sudden change of the dielectric constant and of the electrical conductivity takes place.

The question here was and still is, if biological material, like blood and cells, when having a different electrical constant temporarily under the influence of the high frequency field, is behaving biologically in a different way? No positive answer is given as yet.

There is an other electrical effect of non-thermal origine. It is the orientation effect or the so called "pearl-chain" effect. It occurs in emulsions[5,6,7,8] where the two components, which may be solid in liquid or liquid in liquid, have different electrical characteristics. One of the components, particles or liquid droplets, when free to move around and not hindered by Brownian motion, ligns-up in a pearl-chain-like formation. This effect which occurs only in A.C. fields at technical frequencies as well as at high frequencies is frequency independent. In studieing this effect for a great number of biological and non biological material, like red blood cells, plant cells, oil droplets, plastic particles, etc. we found it to be voltage dependent and not energy dependent[7,8]. It is a electro-inductive effect. In order to observe and study it, it is necessary to use fields of low energy because the Joule effect

decreases the tendency to form chains. This,however,does not mean that there is no temperature increase in chain forming media. Any biological effect subsequently observed in such media can not,therefore,be attributed to the orientation phenomenon off hand. It has to be proven that the thermal action which coexists has not been a causative element.

Specific-thermal Effects

When certain aspects of the thermal Joule effect are more closely examined - what we did in our research work - a new thermal action can be found. The resulting effect,called specific-thermal,can not be duplicated by ordinary heating,for example,in a waterbath and is frequency dependent. Hence it is very often mistaken for an electrical effect of non-thermal nature.[13,15,16,17,20,23,24]

This effect is based on the "selective action" concerning field absorption and heat development. When an object of composed texture,like blood or cells,is under the influence of a high frequency field,then the homogeneity of the field is disturbed. Some components of the biological object will concentrate the field more than others. Besides,components of different ε and κ will have a different rate of heating up, because the heating rate depends on these two electrical factors,as we discussed earlier. This means that there will be areas or particles and layers with high temperature peaks or gradients adjacent to those of low temperature peaks or gradients. This is a condition which can not be obtained by ordinary heating. The question now is if this kind of irregular heating pattern subsists or if it can be equalised by inthermal conduction or convection or by cooling from outside. The answer is:no. The reason,as we found,is that biological objects are generally poor thermal conductors and that the generation of heat due to the field is faster than the heat equalisation and cooling-off processus.

In a great number of experiments it was shown that the specific-thermal effect is bio-negative and destructive when higher doses are applied,even when the average temperature rise is tolerable.

Interboundary discontinuities favorise specific-thermal effects. In most instances, high temperature gradients in small discrete areas or particles are hard to detect or to measure. We developed new techniques in using special build Microscopes with non-metallic objectives and stages,transmitters of controlled and adjustable pulse fed through Lecher wires to the microscopic samples, at wavelenghts in the centimeter and meter range. We measure the temperature with tiny differentiating thermocouples and thermosensitive dyes. We use also radiating Dipoles for field absorption experiments.

Results and Conclusions

It is known that high intensity fields like in Radars may produce burns when the intensity exceeds safety levels. Actually this safety level of 10 mW per square centimeter was proposed having in mind that the principal hazard is being burned due to thermal action of the field and that the electrical effects are,percentually to the applied energy,insignificant. It is not taken in consideration that:

1. specific-thermal effects exist which may be dangerous at this same low safety level
2. electrical fields can be reflected and concentrated 10 or hundert times and more,due to environmental factors of metallic objects,water droplets,etc.
3. electrical biological effects depend on Voltage gradients and not on applied intensities in Watt per cm^2.

Therefore,further studies of biological effects are justified and extended to investigations concerning the ionizing effect of high Voltage gradients which we found evident.

Here are some biological effects which have been found in earlier research.

The Iontophoresis rate is several times increased when simultaneously a condensor field is applied. This is due to the specific-thermal action of the H.F.field.

The Sedimentation rate of blood and other suspended particles in a liquid is changed. This is a combined electrical and specific-thermal effect.

The growth of Microbes,Germs and Cells is stimulated. This is due to the specific-thermal action of H.F.fields at low doses.

The growth of Microbes,Germs and Cells is inhibited and a killing action is produced at temperatures which under ordinary circonstances favorise the growth. This is due to the specific-thermal action of the H.F. field.

Certain wavelengths show a bio-positive,others a bio-negative behavior in experiments where temperature rise is a important biological factor. This is due to the fact that the energy absorption at different wavelnegths has not been kept constant. Hence the temperatures obtained belong either to the stimulating or to the inhibitive biological range.

References

1. McLennan,R., "The heating effect of Short Radio Waves," Arch.Phys.Ther. 143; 1931.
2. Kowarschik,J.,"Kurzwellentherapie," Wien,Springer;1950.
3. Liebesny,P.,"Kurz-und Ultrakurzwellen,"Wien,Urban & Schwarzenberg;1935.
4. Saidman-Meyer,J., "Les Ondes Courtes en Therapeutique," Paris,Doin;1951.
5. Krasny-Ergen,W.,"Mechanische Wirkungen der Kurzwellen," Mittelungen des I.Internat.Congress of Short Waves," Vienna,pp.180; 1937
6. Blüh,O., "Einige bei der Untersuchung von Kollofden im Wechselfeld auftretende Erscheinungen," Koll.-Z.37,267; 1925.
7. Muth,E.,"Ueber die Erscheinung der Perlschnurkettenbildung von Emulsions-Partikelchen unter Einwirkung eines Wechselfeldes,"Koll.-Z.41,97;1927.
8. Denier,A., "Archives d'Electricité Médicale," Mars-April 1935.
9. Stiebőck,P., Report in Wr.Klin.Woch. 27; 1930.
10. Haase-Schliephake,E.,"Versuche über den Einfluss Kurzer Elektrischer Wellen auf das Wachstum von Bakterien, Strahlentherapie 40,133;1931.
11. Groag,P. - Tomberg,V.,"Zur Kurzwellentherapie," Wr.Klin.Woch.,30/31; 1933
12. Groag,P.-Tomberg,V.,"Zur Biologischen Wirkung Kurzer Elektrischer Wellen," Wr.Klin.Woch. 9; 1934.
13. Groag,P.," Kurzwellentherapie,eine spezifische Wärmetherapie." Berichte of I.Internat.Congress of Short Waves,Wien; 1937.
14. Heller,R.,"Lokalisierte Durchwärmung mittels Ultra-Kurzwellen," Z.f.Exp.Med.,83;1932.
15. Tomberg,V.,"Punktwärme-Effekte im Kurzwellenfeld," Report in Wr.Balneolog.Ges.1930.
16. Tomberg,V.," Spezifische Wirkungen Kurzer Elektrischer Wellen,"Report in Acta of Ges.f.Kurzwellenforschung, Wien,21 Nov.,1934.
17. Tomberg,V.,"Die Spezifisch Biologischen Wirkungen Kurzer Elektrischer Wellen," Report in Acta of I Intern. Congress of Radio-Biology,Venice;1934.
18. Schweinburg,F.," Uber die Beeinflussung des Wuterregers im Kurzwellenfeld,"Acta-Berichte of I.Internat. Congress of Shortwaves,p.217;Vienna, 1937.
19. Tomberg,V.," Verteilung,Absorption und Messung der Energie im Kurzwellenfeld," Berichte of I.Internat. Congress of Short Waves,Vienna,1937
20. Tomberg,V.,"Bases Scientifiques et Conceptions Nouvelles de l'Utilisation des Ondes Courtes," Acta Physio-Ther.Rheumat.Belgica,4,109-15;1947
21. Tomberg,V.,"A Propos des Modalités d' Application de la Thérapeutique par Ondes Courtes," J.d'Electrologie et Radiologie,Paris,30,138-40; 1949
22. De Loz,A.," Influence des Ondes à Haute Frequence sur l'Hypercholesterinemie" Scalpell; May 1951.
23. Tomberg,V.," L'Effet Destructif des Micro-Ondes en Biologie," Acta of I.Internat.Congress of Medical Electronics,Brussels,1947 and Acta Physiother.Rheumat.Belgica.,6,295-309, 1948.
24. Tomberg,V."Bionegative Actions of Microwaves," Digest of12th Annual Conference on Electrical Techniques in Medecine and Biology,Philadelphia 10-12Nov.1959