SESSION VII: Microwave Radiation II

7.6: Bionegative Actions of Microwaves

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SHORTWAVES were introduced in 1926 for biological research and medical treatment, based on observations by *Schereshevsky* and *Whitney* in the U.S.[1], *Esau* and *Pätzold* in Germany[2, 3] and *Stieböck* and *Tomberg* in Austria[2, 11, 9, 13]. Subsequently, microwaves were introduced for research and treatment.

It was found that the *Joule* effect—the thermal action—of a high-frequency capacitive field is more evenly distributed throughout an exposed body, due to the dielectric losses, than in the case of an ordinary diathermy treatment, where the body forms part of the current circuit. Because of the stimulating action of heating biological objects or ailing parts, this improved method of shortwave heating is still in use by the medical profession. The frequency of the field is responsible for the rate of heat developed. Therefore, in objects composed of different layers or structures with differing dielectric constant and electric conductivity, the rate of the developed heat is uneven and inequally distributed. The heat-conduction effect tends to equalize the unevenly distributed temperatures, but going slower than the *Joule* effect, temperature differences in a heterogenous object are inevitable. They depend mainly upon the field intensity, the electrical characteristics and the structural composition of the irradiated object.

It was found that the biological effect or the curing action of a high-frequency capacitive field depends on the applied energy multipled by the time of action; a product called dose. When the dose is small, one can expect a biologically stimulating or curing effect. When the dose is high, relative to a certain threshold depending on the nature of the object, a harmful or destructive effect can result. The former action of the field is often called *bio-positive*, the latter *bionegative*[3].

A number of investigators pretended that besides the thermal positive bio-action, there must be an *electrical* biological action of the capacitive field, because certain cures and biological effects happen at low field intensities and without apparent temperature rise. In most of the investigated cases, cooling was also applied from the outside to eliminate, as they thought, any temperature rise within the object. The idea that some wavelengths—similar to light waves—behave biopositive and others bionegative was also advanced.[8]

However, up to now, no proof exists that short and microwaves at low energies produce any *biopositive* action which could not be traced to the action of the thermal *Joule* effect, when certain aspects of thermal action are—as research work has revealed—examined and taken in account[4, 11, 12, 20, 23].

What was found, in short, is the following:

Besides the thermal effect of high-frequency fields, there is an effect which looks like a non-thermal electrical effect, yet it is an effect based on a thermal action of particular behavior which can not be imitated by other means of heating, like in control tests. This particular effect was called the selective or *specific-thermal* effect. It is based on the foregoing temperature gradients arising from structural differences of a heterogenous biological object when two conditions are present: *(1)*—Marked differences of electrical conductivity and dielectric constant throughout the structure elements, for example, between liquid and solid phase, and *(2)* poor thermal-conductivity behavior, macroscopically, as well as structurally through the interboundaries of particles, layers, etc. When these conditions exist, then brisk temperature gradients with elevated temperature points in discrete areas are possible, which in most instances are very hard to detect or to measure. Cooling from outside cannot eliminate them, because the cooling action in poor thermal conductors is much slower than the temperature producing action of the high-frequency field. Measurements with thermometers or electrical devices show only the averaging temperature rise.[10, 12]

To show the existence of those phenomena, artificially composed objects (phantoms) of heterogenous structure have been used and the rate of temperature rise measured with tiny thermoelectric needles. We used also microscopical objects and emulsions, the microscope featuring a dielectric lens tubing, insulating the observer from the radiation field of the microscopic field-capacitive-electrodes, and thermosensitive dyes introduced in the object to change their color at a predetermined temperature. We could so observe that the highest temperature gradients arise in interboundary space and layers.

To measure the relationship of the biological effect with the dose *(intensity x time)* we use transmitters with pulsed energy output. The pulses are of square or rectangular form, and the ratio between pulse width and off-time is adjustable. The coupling between object electrodes and the transmitter output circuit is by means of a Lecher wire system, or by dipole radiation field. The intensity is adjustable from low values, about 0.1-watt per cm^2 up to 50-watt per cm^2, at wavelengths from 6 meters down to the centimeter region.

Actually, the increased use of microwave transmitters at very high energies, i.e., for radar, poses an interesting health hazard problem due to the destructive[23, 14] or bionegative action of microwave fields. Because of the high dose range—for medical purposes one uses only the low dose range—three kinds of actions and effects should be considered:

(1) Ordinary thermal effects *(Joule)* in more homogenous areas

(2) Specific-thermal effects in heterogenous material or areas due to:
- (a) Irregular absorption which can be inherent to the heterogenous structure of the exposed object, or to irregular field intensity distribution with peaks near metallic objects or dielectrics having resonating qualities, which build up induced fields with enough high-voltage gradients[9, 15].
- (b) Temperature gradients with peaks in some discrete areas of the structure of the exposed object when differences in electric conductivity and dielectric constant in the adjacent areas are present[12, 14, 17, 18, 19]. Low thermo-conductivity helps to build up these phenomena especially in interboundary areas.

(3) Electrical effects:
- (a) Orientation effects, like the pearl-chain effect[5, 6, 7, 8, 23, 16], which occur in emulsions, when the two components, which may be solid in liquid or liquid in liquid, show different electrical characteristics. One of the components, particles or liquid droplets, when free to move and not hindered by *Brownian* motion aligns in a pearl-chain-like formation.
- (b) Frequency dependent voltage and dielectric phenomena, which are connected to the known physical effects of *Wien* and *Debye*, involving molecular resonance anomalous dispersion and relaxation[2, 4, 10, 17, 23]. Generally, they occur at wavelengths below 300 Mc and to be biologically important, higher voltage gradients at pulsed energies are required.

Energetically, the pearl-chain effect occurs only at very low energies. because the *Joule* effect hinders the free motion of the aligning particles or droplets. This effect has been observed actually only in experiments under the microscope, and recently rediscovered by *Heller* and by *Herrick* (Mayo Clinic). It is a frequency-independent effect and may be observed also at alternating frequencies[6]. We observed it in polymeric emulsions where it can be used to influence the polymerization process under appropriated conditions[23].

Our investigations also disclosed that low-intensity fields yield specific-thermal effects when the field has tendency to concentrate on some areas or when the exposed object possesses areas of high absorption. In the human body, for example, these are the eyes and the testicles. Here, locally-caused high-temperature peaks may be induced without any feeling of general heat.

The exposure to high-frequency fields is naturally not limited to capacitive fields. Coil fields, especially flat coil fields, and then dipoles with concentrating reflectors can produce harmful, destructive effects. To avoid them one has to avoid exposure to fields whose average dose exceeds certain safety values. These safety values should not be generalized, as the actual tendency shows, but adapted to any of the field patterns in use.

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 and Schwarzenberg;* 1935.
4 Saidman-Meyer, J., "Les Ondes Courtes en Therapeutique," *Paris, Doin;* 1951.
5 Krasny-Ergen, W., "Mechanische Wirkungen der Kurzwellen," Acta of 1, *Internat. Congress of Shortwaves in Vienna*, pp. 180-184; 1937.
6 Blüh, O., "Einige Bei der Untersuchung von Kolloiden im Wechselfeld Auftretende Erscheinungen," Koll.-Z.37,267; 1925.
7 Muth, E., "Ueber die Erscheinung der Perschnurkettenbildung von Emulsions-Partikelchen unter Einwirkung eines Wechselfeldes," *Koll.*-Z.41,97; 1927.
8 Denier, A., "Archives d'Electricite Medicale,"; Mars-April 1935.
9 Stieböck, P., Report in *Wr. Kl.Woch*, 27; 1930.
10 Haase-Schliephake, E., "Versuche uber den Einfluss Kurzer Elektrischer Wellen auf das Wachstum von Bakterien", *Strahlentherapie* 40,133; 1931.
11 Groag, P.-Tomberg, V., "Zur Kurzwellentherapie," *Wr.Kl.-Woch*, 30,31; 1933.
12 Groag, P.-Tomberg, V., "Zur Biolog.Wirkung Kurzer Elektr. Wellen," *Wr.Klin.*Wo.9; 1934.
13 Groag, P., "Kurzwellentherapie, eine spezif Warmetherapie." Acta of I, *Internat. Congress of Shortwaves*, Wien; 1937.
14 Heller, R., Lokalisierte Durchwarmung mittels Ultra-Kurzwellen," Z.F.Exp.Med., 83; 1932.
15 Tomberg, V., "Punktwärme-effekte im Kurzwellen Feld," Report in *Wr.-Balneol.Ges.;* 1930.
16 Tomberg, V., "Spezifische Wirkungen Kurzer Elektr.Wellen," Report in Acta, *Ges.f.Kurzwellenforsch*, 21; Nov. 1934.
17 Tomberg, V., "Die Spezif.Biolog.Wirkungen kurzer elektr.Wellen," Report in Acta of *I.Internat.Congress of Radio-Biology*, Venice; 1934.
18 Schweinburg, F., "Uber die Beeinflussung des Wuterregers im Kurzwellenfeld," Acta of *I.Internat.Congress of Shortwaves*, pp. 217, Vienna; 1937.
19 Tomberg, V. "Verteilung,Absorption und Messung der Energie im Kurzwellenfeld," Acta of *I.Internat. Congr. of Shortwaves*, (2 reports), Vienna; 1937.
20 Tomberg, V., "Bases Scientif. et Conceptions Nouvelles de L'utilisation des Ondes Courtes," Acta *Physioth.Rheumat.Belg.*, 4, 109-15; 1947.
21 Tomberg, V., "A Propos des Modalites D'Application de la Therapeutique Par Ondes Courtes," *J. Radiolog.et Electrolog.*, Paris,30,138-40; 1949.
22 De Loz, A., "Influence des Ondes a Haute Frequence sur L'Hypercholesterinemie" *Scalpel;* May, 1951.
23 Tomberg, V., "L'effet Destructif des Micro-ondes en Biologie," Acta of *I. Internat.Congress of Medical Electronics*, Brussels; 1947-Act. *Physioth.Rheum.Belg.*, 6,295-309; 1948.

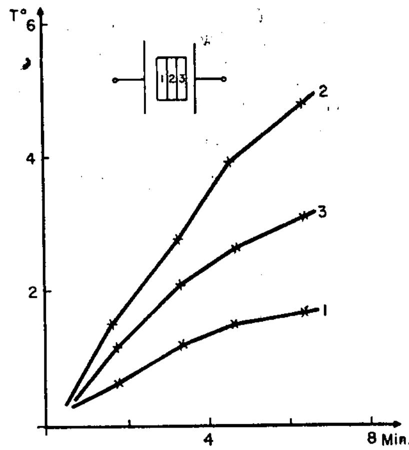

Figure 1—Temperature T in centigrades versus time in min of irradiation at a wavelength of 76 cm. The object is a phantom body consisting of soft bread and wetted with saline. The absorption in center (*2*) is higher than in (*1*) and (*3*).

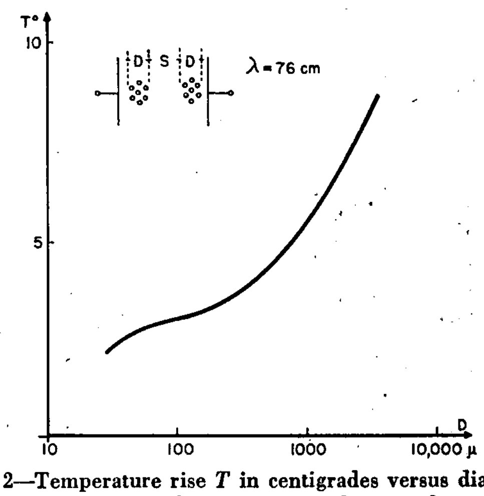

Figure 2—Temperature rise T in centigrades versus diameter D in microns μ in a particle suspension. The particles are plastic spheres (*PVC*) and agglomerated in grapes of D microns di-

Clinic). It is a frequency-independent effect and may be observed also at alternating frequencies[5]. We observed it in polymeric emulsions where it can be used to influence the polymerization process under appropriated conditions[23].

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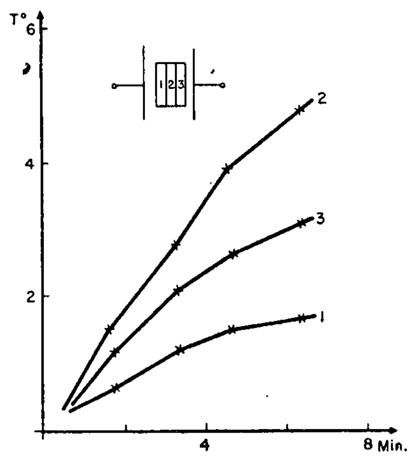

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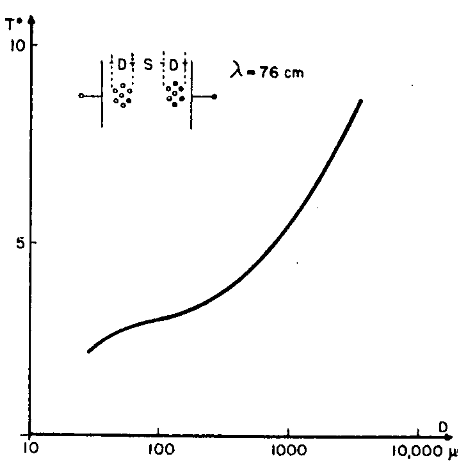

Figure 2—Temperature rise *T* in centigrades versus diameter *D* in microns μ in a particle suspension. The particles are plastic spheres (*PVC*) and agglomerated in grapes of *D* microns diameter. The space between the grapes *S* is about 5.D microns. The particle size is about 5 microns. Irradiation time is 2 minutes; wavelength is 76 cm; observation under the microscope.

SESSION VII: Microwave Radiation II

7.7: Pearl Chain Formation

J. F. Herrick, Rochester, Minn.

DIATHERMY is prescribed clinically for only one reason: To heat. Clinical investigators of outstanding competence have concluded, after extensive and ingenious researches, that all effects of diathermy can be explained by the production of heat within bodily tissues.

Despite this well-established and generally accepted fact, there has been a persistent search for nonthermal effects of high-frequency alternating currents. This unceasing search has resulted in establishment *in vitro* of one definite nonthermal effect which has been observed experimentally, namely, the tendency of microscopic particles, in the presence of alternating electromagnetic fields of low intensity, to become rearranged from a random distribution to an orderly chain formation. This chain formation is strikingly similar to the more familiar alignment of iron filings in a magnetic field. Such chain formations, which are popularly called "pearl chain formations"[1] were reported in the literature more than 30 years ago. Pearl chain formations may be convincingly illustrated microscopically in fat emulsions, in yeast emulsions and in diluted blood on a slide in an electromagnetic field of high frequency. Recently this phenomenon has been studied more extensively. Pearl chain formations have been demonstrated in vitro in other biologic fluids. Illustrations of pearl chain formation in undiluted lymph will be shown.

As yet, no objective clinical investigation of this phenomenon has been attempted, so far as we know.

[1] In the German literature the term is *Perlschnurkettenbildungen.*

Notes