

BEFORE THE STATE OF NEW YORK PUBLIC SERVICE COMMISSION

CASE 26559—Rochester Gas & Electric Corporation
and Niagara Mohawk Power
Corporation: Pannell Road to Vorney
and Oswego to Sterling Transmission Facilities.

October, 1974

Prepared Testimony of
Dr. Robert O. Becker
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Q. Would you state your name and business address?

A. Dr. Robert Becker, Veterans Administration Hospital, Syracuse, New York.

Q. Would you summarize your educational and professional background?

A. I am a doctor of medicine, having received my MD degree from New York College of Medicine in 1948. In 1959 I became a Diplomate of the American Board of Orthopaedic Surgery, having completed the necessary advanced training at Downstate Medical Center, SUNY. I have been Chief of Orthopedic Surgery at the VA Hospital, Syracuse, since 1956, and have been Professor of Orthopedic Surgery, SUNY, Upstate Medical Center since 1963. I have been engaged in medical research since 1958 with particular interest in electronic biological control systems. I have published more than 70 scientific papers and given more than 75 presentations at national and international scientific meetings. In 1964 I was awarded the William S. Middleton Award of the Veterans Administration for research in biological solid state physics and biological control systems. I was presented with the Distinguished Alumnus Award from NYU, College of Medicine in 1966. I became a Medical Investigator with the VA in 1972, a position enabling me to devote full time to research.

Q. Are you the director of a research laboratory?

A. Yes. I am the director of the Orthopedic-Biophysics Laboratory at the Syracuse VA Hospital-Upstate Medical Center. The staff varies between 10 and 16 people depending upon such things as the number of students on elective, the number of visiting scientists spending their sabbatical year with us, etc. The present staff includes three Ph.D. biophysicists, one Ph.D. anatomist, two M.D.'s (orthopedic surgeons) and a variety of technical personnel.

Q. What is the purpose of your testimony?

A. I will discuss the medical and biological significance of exposure to low frequency electric and magnetic fields. My testimony will encompass both the published reports and the latest results of our own research. I will testify that an electric field at 60 Hz is a biological stressor. I will discuss the question of medical ethics involved in exposing human beings to electric fields. My testimony will conclude that the transmission line should not be built as proposed.

Q. Would you briefly describe the nature of your research?

A. In brief, our research is aimed at elucidating the details of the control systems that living organisms utilize to direct certain basic life functions such as growth and healing, biological cycles, etc. We have determined that living organisms possess certain electric control systems characterized by the use of very small electrical currents and voltages as control signals. These are derived from certain solid state properties of cells and tissues such as semiconductivity, piezoelectricity, etc. At this time our discoveries are being used to stimulate the healing of non-united fractures and to treat certain types of infectious processes in the human. This work is going on in several medical centers, including Syracuse.

Q. Assuming that the electric field distribution due to the proposed transmission line is approximately as Dr. Marino has calculated, does it present a danger, from a health viewpoint, to either maintenance personnel, persons on the right-of-way, or persons living near the edge of the right-of-way?

A. Utilizing the concept that 1/100 of the dose shown to be not harmful may be considered safe (in this case 1.5 rms-volts/cm) the field strength within the present right-of-way and for a distance out on either side would exceed this level. Maintenance personnel would then be exposed to levels in excess of 1.5 rms-volts/cm for relatively short periods of time. Since our experiments involve long term (30 days) exposure, we cannot say whether or not such short exposures would produce any biological effect. By the same token, we cannot say whether or not any effects from such short time exposures (if they did occur) would be cumulative and eventually become clinically significant. In regard to persons residing near the right-of-way and within the zone of field strength of 1.5 rms-volts/cm or higher, they would run the risk of having some biological effect induced as a result of this exposure. Since the effects we noted experimentally indicated that the field acted as a stressor, I would have to assume that the effects would be harmful. Again in regard to cumulative effects (dose related in this case, i.e., lower field strengths at greater distances with long term exposures) we cannot make any statements at this time.

Q. What is meant by the term "stress" or "stressor"?

A. A non-specific biological stressor is any environmental stimulus which causes systemic stress in an organism. Systemic stress denotes a condition in which, due to function or damage, extensive regions of the body deviate from their normal resting state. This theory is generally accepted as a useful framework to explain some diseases

and to design experiments.

Q. Would you explain the distinction between the terms “acute” and “chronic” as they are used medically?

A. Acute refers to a short term exposure, generally less than one day and chronic refers to long term exposure, more than a day.

Q. Does the proposed safety level of 1.5 rms-volts/cm mean that maintenance personnel should not service the proposed transmission line?

A. No, except for the possibility of cumulative effects.

Q. In your research, do you use animals?

A. Yes, animals are used for preliminary studies and for some studies in which large numbers of individuals are required.

Q. In your research, do you use human beings as subjects?

A. Yes, humans are presently used in our studies on stimulating bone growth and retarding infectious processes.

Q. Would you briefly describe the precautions taken when humans are involved as subjects?

A. In the case of human experimentation, the present regulations require that any proposed study be reviewed in detail by a committee of experts including medical and scientific personnel (it is further recommended that representatives of the clergy, psychological sciences, and laymen be included on the committee). It is the responsibility of the committee to balance risks against gains of any given experiment. In regard to risk, the nature of experimental medicine is such that the possibility that all risks may not be predicted in advance must be entertained. In regards to gain, considerations must be given to gain that may be experienced by the experimental subject (i.e., possible healing of a non-united fracture) and to general human gains in terms of the collection of knowledge that may be of value to others or to general biological understanding. After consideration of these factors, the committee must approve the proposed study. An investigator cannot proceed without such approval. It is most important to note that the key provision of present human experimentation is informed consent. If the committee approves the project, each subject must still be fully apprised of all known possible risks, the possibility of unknown risks and the possible gains (if any) he or she will accrue. Only under these circumstances is human experimentation medically proper.

Q. Would it be considered medically unethical to apply small electric currents to humans for research purposes without securing their permission?

A. Yes, it would be considered unethical in my opinion.

Q. Would it be considered medically unethical to apply 60 hz electric fields to humans without securing their permission?

A. Yes, it would be considered unethical in my opinion, if the field strengths exceeded that to which we are exposed in the normal course of everyday living (i.e., normal household ambient levels). In that case human experimentation committee approval and informed consent would be required.

Q. Dr. Marino has discussed piezoelectric effects as a possible mechanism of action of 60 hz electric fields on animals; are there any other biological mechanisms that would enable 60 hz electric fields to have an effect on living organisms?

A. As I indicated previously, we have, over the past 15 years, obtained evidences for the existence of electronic biological control systems based upon solid state properties of living materials. We know, for example, that injuries result in specific electrical phenomena at the site of injury and that these (very minute in amount) electrical parameters in turn cause the cells at the injured site to multiply and heal the injury. This function is controlled by an overall biological control system which is associated with, but separable from, the central nervous system. Our evidence indicates that this control system is based upon specific cells (the perineural cells) and that it transmits information by means of the actual flow of small direct electrical currents, generated by solid state properties of these cells. It may be likened to an analog computer system while the nervous system itself is similar to a digital computer. This direct current system controls growth and healing, as previously noted and in addition, we believe it may be related to the perception of pain. There is evidence that biological cycles of behavior in all organs are linked to the same cyclic pattern in the normal environmental electrical and magnetic fields. The properties of this direct current system are such that it would be influenced by such cyclic changes in these environmental fields. It is believed that this system may provide the necessary linkage mechanism between the normal variations in these geophysical parameters and the normal biological cyclic rhythms. Changes beyond the normal variations in all environmental parameters (temperature, pressure and other physical variables, as well as social, psychological, etc.), if persistent for any prolonged period are stressful to living organisms. Such stress is reflected in increased production of hormones such as cortisone, in increases in blood pressure and other metabolic changes. If exposure to stressful situations is prolonged, the organism enters a physiological state characterized by Dr. Hans Selye (Stress, Acta Inc., Montreal, 1950) as the stress adaptation syndrome or the general adaptation syndrome. This is accompanied by many metabolic and functional changes which are deleterious to health. Therefore exposure to electric fields differing in frequency and/or in magnitude from the normal earth's field may produce biological effects by (1) inducing small electrical fields within the tissues that could interfere with normal healing and growth processes by presenting abnormal signals to the cells (under certain circumstances such induced currents may be beneficial, i.e., in stimulating the healing of non-united fractures) and (2) by interfering with the normal biological cyclic

rhythm through interaction with the electric system linking organisms to the geophysical environment. This latter effect would be evidenced as a response to stress and with prolonged exposure as the stress adaptation syndrome.

Q. Do the results of your research on electric field exposure at 60 hz as described by Dr. Marino indicate that the rats were subject to biological stress?

A. The condition of the rats at the end of 30 days exposure was consistent with chronic exposure to an environmental stressor. Chronic stress has been linked to cardiac (hypertension), renal (nephritis), gastro-intestinal (ulcers) and nervous (psychoses) diseases. There is some evidence that arthritis, particularly rheumatoid type and certain vascular diseases such as periarteritis nodosa may be also related. In addition, chronic stress results in exacerbation of any pre-existing pathological processes. There is extensive literature in this field and since there are several phases of response to stress, depending upon the length of exposure, I have limited my response to chronic stress situations.

Q. Could people sustain the same effects as the rats, if comparably exposed?

A. Yes. I know of no significant difference between rats and men in terms of their reaction to stress.

Q. Are you familiar with the Navy research project known as Sanguine?

A. Yes.

Q. Would you please describe that project and your involvement in it, if any?

A. Project Sanguine proposes to construct a very large antenna array, buried in the ground which would produce signals perceivable by submarines around the world. The system would function with a carrier frequency of 45 or 75 hz. Because of possible environmental and health related effects, the Navy commissioned a biological study program involving about 24 different projects in many institutions. These projects included a search for the possible effects of both electrical and magnetic fields on a variety of systems including soil ecology, bird migration, embryonic development, physiological and psychological variables in man, nerve function, etc. A committee was appointed to review and evaluate the results of these experiments and I was selected to be a member thereof. The first committee meeting was held last December to evaluate the results of the first year of experimentation. The committee has been reappointed for this year and I am again a member.

Q. You have described an extensive program aimed at determining the impact of the fields associated with the Sanguine antenna. How does the strength of the Sanguine fields compare with that of the proposed 765 kV transmission line?

A. The expected Sanguine electric field directly above the antenna is 0.0007 volts/cm

(Fact Sheet for the Sanguine System, Final Environmental Impact Statement for Research Development, Test and Evaluation, Dept. of Navy, April, 1972). The Sanguine field is therefore much smaller than that associated with the proposed transmission line.

Q. Does your research involve magnetic fields?

A. Yes. I have used magnetic fields primarily as a tool to probe the workings of the direct current control system.

Q. Have you published in this area?

A. I have reported effects of external magnetic fields upon the peripheral nerve electrical potentials (Becker, *Science*, 134, 101 (1961) and upon the electroencephalogram from the brain in animals (Becker, *Proc XI Int. Cong. Radiol.*, 1753 (1966). In conjunction with Dr. Howard Friedman, I have investigated and reported on interactions between changes in the earth's natural magnetic field (magnetic storms) and human behavior (Becker, *Nature*, 200, 626 (1963), and, Becker, *Nature*, 205, 1050 (1965). We have also reported on the effects of low strength magnetic fields modulated at 0.1 and 0.2 hz on reaction times in human volunteers (Becker, *Nature*, 213, 949 (1967)). I was asked to review the literature on the biological effects of magnetic fields in 1963 for publication (Becker, *Med. Elect. Biol. Eng.*, 1, 293 (1963). This was done to provide a baseline for the experimental interest in this area that was on the increase at that time. Most recently, I have been consulted by the AEC on possible hazards associated with the ultra-high strength fields necessary for fusion reactors.

Q. What is the current state of research in the area of biological effects of magnetic fields?

A. There has been increasing interest in this area over the past 10 years. Two books have been published in the United States (Barnathy, M.F., ed., *Biological Effects of Magnetic Field*, Vol. I. Plenum Press, New York 1964 and Vol. II, Plenum Press, New York 1969 and several volumes in the Soviet Union). Of particular pertinence to the present hearing are several reports of effects produced by very low strength magnetic fields (i.e. from 1 to 10 gauss). The most recent was by Dr. William Keeton (*Proc. Nat. Acad. Sci. U.S.A.* 68, 102, 1971) who was able to show that the homing pigeon utilized the earth's magnetic field for navigation with a sensitivity and precision that our best instruments cannot attain. His observations have recently been corroborated by Wolcott and Green (*Science* 184, 180, 1974) and extended to several other species of birds (Southern, W.E., *Bioscience* 22, 476, 1972 and Wi1tschko, W. in *Animal Orientation and Navigation*, p. 569, Government Printing Office, Washington, D.C. 1972). I believe that this is an instance of these particular animals developing the same system that is present in all animals into a specific sensing mechanism of survival value. Dr. James Hayes has shown that naturally occurring reversals in the earth's magnetic fields in the geological past were accompanied by the extinction of animal species. During reversal periods, the magnetic north and south poles exchange their position. We know only that this is not associated with a drop in the field strength below half normal nor is it

associated with any major increases in field strength. Since no reversals have occurred in the documented past, we cannot speculate on such factors as the appearance of specific frequencies or alterations in the earth's electrostatic field. The point is that such seemingly minor variations in the magnetic field are quite apparently events of major biological magnitude. (Hays and Updyke, *Science* 158, 1001, 1967). Dr. Frank Brown, who is primarily interested in the phenomenon of biological cyclic behavior has shown that it can be influenced by applied magnetic fields as low as 1 gauss. Since the biological cycles have periodicities the same as the natural geomagnetic field cycles, the suspicion is that the biological cycles are driven by the earth's naturally fluctuating geomagnetic cycles (Brown, F. *Nature* 209, 533, 1966, *Encyclopedia Britannica* 292, 1966). The work of Friedman and his colleagues may be relevant to Brown's observations in that he has been able to demonstrate that magnetic fields of 200 gauss strength are definite stressors for the exposed organisms (Friedman, H. and Carey, R. *Physiol. & Behavior* 9, 171, 1972 and *Physiol. & Behavior* 4, 539, 1969). Most recently Dr. Dietrick Beischer of the Navy's Aerospace Medical Research Laboratory has shown effects upon human volunteers of exposure to very low strength (1 gauss) 45 hz magnetic fields. The primary findings were an increase in serum triglycerides observed in two experimental runs (Beischer, D., Navy Aerospace Med. Res. Lab. report #1180, 1973). The Sanguine Biological Study Committee to which these findings were reported was also advised by the responsible Navy personnel that following Dr. Beischer's report, the personnel at the Wisconsin Test Facility (a test antenna similar to the proposed Sanguine Antenna located at the proposed Wisconsin site) were examined and all were found to have elevated serum triglycerides. The mechanism producing this effect is currently under study. The significance of the elevated triglycerides is in the fact that this material is one of the steps involved in fat metabolism and such elevations beyond the normal range are generally believed to indicate an increased risk of arteriosclerotic disease.

Q. Are you an expert on the possibility of interference with cardiac pacemakers by emanations from the line as proposed?

A. No.

Q. Would you recommend construction of the 965 kV line as proposed by the applicant?

A. No, for the reasons that the strength of both the electrical field and magnetic field produced by the line will be in the range possibly productive of biological effects. I believe that chronic exposure of humans to such fields should be viewed as human experimentation, and subjected to the rules previously mentioned. I believe that the most prudent course to follow would be to determine the complete spectrum of biological effects produced by exposure to 60 hz fields. It should then be possible to establish firm levels of permitted exposure both as to field strength and to exposure times.

Q. Do the conclusions you have proffered apply to transmission lines whose voltage is less than 765 kV?

A. Yes, proportionally so.

Q. Would you state for the record whether the conclusions you have reached apply equally to an underground 345 kV line, a 400 kV d-c overhead line and an underground d-c transmission line?

A. Our conclusions do not apply to the d-c case. In the case of the underground 345 kV line, it is my understanding that these lines may be shielded to reduce the ground level electrical and magnetic fields to the ambient level.

Q. Does this conclude your testimony?

A. Yes.