

CASE 26529/26559—Common Record Hearings on the Health and Safety of 765 kV
Transmission Lines

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Amicus Curiae Brief
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POINT 1: The overwhelming weight of the credible scientific evidence shows that the electric field and the magnetic field of the proposed transmission lines will each cause biological effects in the human beings exposed to them.

Introduction

The proposed 765 kV transmission lines would produce electric and magnetic fields in

the air surrounding the energized wires, and the fields would extend outward for many thousands of feet. It is therefore necessary to consider whether the presence of the fields will induce biological changes in the human population, or will influence natural ecological systems. Such questions can be answered only by a review and assessment of the scientific literature, in evidence, which deals with the consequences of exposing biological organisms under controlled laboratory conditions to an electrical environment similar to that which would be created by the proposed transmission lines.

The proposed transmission line would operate at a frequency of 60 hertz (Hz), which is in the extremely low frequency (ELF) portion of the electromagnetic spectrum (generally limited to frequencies less than 100 Hz). An assessment of its impact therefore requires consideration of the scientific literature which describes the observed biological effects due to exposure of ELF electric and magnetic fields. With few exceptions, ELF field biological research did not exist prior to about 1967; since then numerous such studies have appeared. In what follows, the ELF electric and magnetic field reports introduced into evidence are described separately to emphasize that the electric and magnetic field are two different and distinct physical entities, each of which must be considered with regard to the causation of biological effects. Within each group of reports a further distinction is drawn between acute (short-term) and chronic (long-term) exposure, with the dividing point generally assumed to be about three days. ELF electric field exposure was usually accomplished through the medium of air. In some cases an aqueous solution such as seawater or nutrient media was employed. In all instances the electric field listed herein is that to which the test organism was exposed. The epidemiological studies and the reports of ELF field effects on bird orientation and on plant growth are described separately.

Electric Field Effects

1. Acute Exposure

A variety of biological organisms including man have been shown to be sensitive to relatively brief exposure to ELF electric fields. Solov'ev demonstrated that several hours exposure to 5000 volts/cm at 50 Hz was fatal to mice and fruit flies. (Marino 7164*) Lethal consequences have also occurred with bees. (Marino 7161) At 110 volts/cm, the bees began to sting one another to death. Honey and pollen was no longer stored, and all apertures on the hives were closed off by the bees resulting in death of the swarm due to lack of oxygen. (Marino 7162) In other studies, it was found that 30-500 volts/cm at 50 Hz produced changes in metabolic rate and motor activity of bees. (Marino 12316, Exhibit H-6)

The mitotic index of liver and corneal epithelial cells in mice was tripled following application of 200 volts/cm at 50 Hz for four hours. (Marino 7150) ELF electric fields have been shown to affect various forms of animal behavior. Spittka, et al. studied the effect of 500-700 volts/cm at 50 Hz on the drinking behavior of operantly trained rats, and observed a significant decrease in the response rate when the field was applied. (Marino 7162) The operant response rate of rhesus monkeys was increased by 0.0035–0.35 volts/cm at 7–75 Hz. (Marino 7171) Employing classically conditioned cardiac

deceleration techniques, McCleave, et al. showed that eels and salmon were able to perceive 0.0007–0.00007 volts/cm at 60–75 Hz. (Marino 7170) The perception, which occurred only when the field was applied perpendicularly to the body axis, is the most sensitive ELF electric field induced biological effect yet reported. Friend, et al. found that amoebae exhibited changes in shape and orientation within a few minutes of the application of 10 volts/cm at 1-100 Hz. (Marino 7155) Sazonova examined the results elicited by 300–400 volts/cm at 500 Hz on motor performance of rabbits. After cumulative exposure of 18 hours he observed a statistically significant decrease in the rabbits' ability to do work. (Marino 12337)

There are five controlled laboratory studies which treat the interaction of ELF electric fields and human subjects. In each instance alterations in human reaction time performance were reported. Johansson, et al. exposed subjects in toto to about. 1000 volts/cm at 50 Hz for 75 minutes. The results suggested a decrease in performance. (Michaelson 3726; Marino, Ca., 3846–0012*) Also employing full body exposure at the same frequency, but at field strengths ten times less intense, Haifa reported that after three hours he observed an improvement in performance which he attributed to a nonspecific stimulatory effect. Hamer and Konig both utilized extremely weak ELF electric fields (0.01–0.04 volts/cm), and both showed that such fields affect human beings. Konig observed decreased performance at three hertz as compared to the field-free situation. (Marino 7150) Hamer reported a decrease in performance at the higher frequency as compared to the lower frequency studied. (Marino 7149) Parsinger, et al. looked for changes in the reaction time of 70 subjects as consequence of 0.003–0.03 volts/cm at 3–10 Hz, applied for 40 minutes. Mean reaction times were not affected, however significant sex, intensity, and frequency interactions were seen in the amount of reaction time variability. (Marino, Ca., 3346-0012)

Two animal studies described direct effects of brief ELF electric field exposure on the central nervous system. Gann, in work performed for the Electric Power Research institute (EPRI), subjected dogs to a small controlled hemorrhage and examined the effect of 150 volts/cm at 60 Hz for five hours on the physiological compensatory control mechanism invoked by hemorrhage. Blood pressure and heart rate were found to be significantly different in the exposed dogs indicating a central nervous system disturbance which resulted in an inability to employ effective compensatory cardiovascular mechanisms in response to the hemorrhage. (Marino 12311) It was concluded:

The unexpected finding of these changes suggests strongly that dynamic effects resulting from exposure to electric fields may not be particularly subtle at all, but may be quite easy to detect. In addition to the findings with respect to magnitudes of change, the variability in the heart rates of exposed subjects was also significantly greater than that in unexposed subjects, suggesting that the observations made by Soviet workers on conscious human beings exposed to high voltage electric fields may be present in anesthetized dogs. These results are clearly preliminary but also clearly demand further exploration.

Lott and McCain applied an inhomogeneous field of 0.4 volts/cm maximum at 640 Hz to

anesthetized rats. Recording from implanted microelectrodes, they measured a significant increase in hypothalamic activity during the one hour exposure period. (Marino 7160)

Short-term *in vitro* studies have disclosed ELF electric field induced alterations in calcium release (Marino 12312) and biochemical function (Marino 7172). In the former study, exposure of brain tissue from chicks and cats to 0.05–1.0 volts/cm at 1–75 Hz for 20 minutes significantly reduced the release of calcium from both tissues to the surrounding medium. In the latter study, 1.55 volts/cm at 60 Hz caused complete loss of biochemical function in brain mitochondria after 40 minutes.

2. Chronic Exposure

Behavior was the most frequently studied biological parameter in the acute exposure experiments, whereas in the chronic exposure experiments growth or some physiological aspect of a developing biological system was studied more often.

Utilizing the most intense ELF electric field yet employed in controlled animal research, Knickerbocker, et al. intermittently applied to mice a vertical field of 1600 volts/cm at 60 Hz. The field was applied to male mice only, for 6.5 hours/day, 5 days/week, for a duration of 10.5 months. During the non-exposure periods the mice were mated with non-exposed females and the offspring were reared in a field-free region.

It was found that the male progenies but not the female progenies of the exposed males were smaller in weight when compared at 30, 60 and 87 days postpartum to male and female progenies respectively, of the control males. (Marino 7178)

Marino, et al. have confirmed and extended Knickerbocker's results in experiments involving the continuous exposure of three successive generations of mice to a 60 Hz electric field. (Marino 7191 f) Initially, male and female mice were split into horizontal, vertical and control groups. Mice in the horizontal group were allowed to mate, gestate, deliver, and rear their offspring in a horizontal field of 100 volts/cm. At maturity, randomly selected individuals from the first generation were similarly allowed to mate, gestate, deliver, and rear their offspring while being continuously exposed. Randomly selected individuals from the second generation were mated to produce the third and final generation. A parallel procedure was followed for the vertical group wherein three generations were produced in a vertical electric field of 150 volts/cm, and for the control group wherein three generations were produced in the ambient electric field. In the first and second generation, males and females reared in both the horizontal and vertical electric field were significantly smaller than the comparable control group when compared at 33 days after birth. In the third generation, the males exposed in the vertical field exhibited depressed body weights at 35 days after birth. (Exhibits E and G)

Aberrant growth responses following chronic exposure have been reported in rats, flatworms, and slime mold. McElhaney and Stalnaker intermittently applied 70 volts/cm at 3 and 30 Hz to the immobilized but intact femurs of rats. Most of the exposed rats developed bone tumors, whereas no tumors were seen in the control rats. (Marino

7148) In another study, two species of flatworms were sectioned transversely and subjected to 3.1–4.2 volts/cm at 60 Hz applied along the antero-posterior regeneration axis. In a significant number of animals the normal regeneration pattern (head anterior, tail posterior) was altered resulting in bipolarity (the production of a head at both the anterior and posterior surfaces). (Marino 7153) In the experiments on slime mold, the investigatory simultaneously applied 0.007 volts/cm and 2 gauss at 45, 60 and 75 Hz. At all three frequencies they observed delays in the mitotic cycle and retardation in protoplasmic streaming. (Marino 7166)

Different consequences of ELF electric field exposure have been seen in chick growth depending on the strength of the applied field. When day old chicks were exposed continuously for 22 days to 400 to 800 volts/cm at 60 Hz, growth appeared to be affected, and gross motor activity measured after the birds had been removed from the field was reduced relative to that of the control birds. (Marino, Ca., 3846-0011) These observations led to experiments on male and female chicks separately. Female chicks were exposed continuously to 200 or 800 volts/cm for the first 14 days posthatching, and body weights were obtained at 1–8 weeks of age. The mean body weight of the chicks exposed at both field strength was greater than that of the control birds. The results, which were on the order of 5–10 percent, became statistically significant during the second week. Male chicks were then exposed to 400 or 800 volts/cm for the first 20 days posthatching, and body weights were obtained during the exposure period. A significant enhancement in the early growth response was observed. (Marino, Ca., 3846-0012)

Giarola and Krueger observed that one day old chicks exposed to a nonuniform field of maximum value 35 volts/cm exhibited depressed body weights when compared to unexposed chicks. (Marino 7153) The effect became significant after 22 days at 45 Hz and 23 days at 60 Hz. In another study, the same group found that exposure of egg-laying hens to 16 volts/cm at 60 Hz for 16 weeks caused a decrease in egg production during the first half of the test period, but not during the second half. (Marino 7133)

Durfee, et al. studied the influence of electric fields (60–75 Hz, 0.01–0.10 volts/cm) upon the growth rate of chick embryo cells. They found both growth inhibition and growth acceleration, depending on the particular field strength and frequency employed. (Marino 7169)

In vitro observations of the impact of chronically applied ELF electric fields have been made at widely different intensities. Utilizing the most intense fields yet employed in chronic exposure experimentation, Gan and LaFrance found that the threshold of a 100 percent lethal effect on mammalian cells exposed for one week at 60 Hz in cell culture was between 2,000 volts/cm and 6,000 volts/cm. (Marino 7154) At 1,000 volts/cm, a 12 percent increase in the growth of embryonic chick tibiae was seen. (Marino 7157)

Marino, et al. exposed 21–24 day old rats to 150 volts/cm at 60 Hz for one month in ten separate experiments. A variety of statistically significant effects were found including depressed body weight, depressed water consumption, increased adrenal and pituitary weights, and altered serum levels of albumin, hydroxy corticosterone, and glutamic

oxaloacetic transaminase. (Marino 7181) The results indicated that exposure to the ELF electric field produced a physiological stress response. Noval, et al. independently performed similar experiments at much lower field strengths and reached essentially the same conclusion. They exposed 30–35 day old rats to 0.005–1.0 volts/cm at 45 Hz for 30–40 days. The treated rats exhibited depressed body weights, decreased levels of brain choline acetyltransferase activity and elevated levels of liver tryptophan pyrrolase. (Marino 12306)

Mathewson, et al. exposed 49 day old rats for 28 days to 0.02, 0.10, 0.20, 0.50 and 1.0 volts/cm, and reported that they failed to observe effects comparable to those Noval et al. Since, however, the 60 Hz background present at both Mathewson's control and experimental cages was as high as 0.07 volts/cm, it is appropriate to regard the rats exposed to 0.02 volts/cm as part of the control group for the purposes of comparing them jointly to those animals exposed at 0.5–1.0 volts/cm (where at the applied field was sufficiently greater than the background). Under this approach the data of Mathewson, et al. reveal a variety of statistically significant changes including a decrease in blood glucose in three consecutive replicative experiments, and changes in blood hemoglobin and hematocrit (red blood cell count) in two of the three experiments. Changes also occurred in at least one of the experiments in each of the following parameters; blood globulin, total lipids, triglycerides, final body weight, and red blood cell count. (Marino, Ca., 3846-0017) It is therefore most reasonable to conclude that Mathewson, et al. generally confirmed Noval, et al.

All measurable human and animal biological variables exhibit daily periodicities, called biological rhythms, which are synchronized to one another and to the 24 hour period of the natural environment. Wever has conducted pioneering studies of biological rhythms and their relationship to electromagnetic fields. (Marino 7173) In his work, he employed underground bunkers, one of which was shielded against all electric and magnetic fields of terrestrial or atmospheric origin, the second of which was unshielded, i.e., the earth's natural fields were continuously present. The rooms were built in such a way that the human subjects could not distinguish between them. The subjects were isolated in the bunker for three to eight weeks, and their biological rhythms, such as activity and body temperature, were recorded. Wever found that 34 subjects who lived in the non-shielded room had a body temperature rhythm with a mean period of 24.87 ± 0.44 hours, while 50 subjects who lived in the shielded room had a body temperature rhythm of 25.26 ± 0.85 hours. The difference was statistically significant. (Marino 7174) Thus, the total of the natural electromagnetic fields had a significant effect on human biological rhythms, namely it shortened their period. Another significant effect was also observed. In 15 subjects who lived in the shielded room, internal desynchronization occurred. That is, while the body temperature rhythm continued to maintain a biological rhythm with a period near 25 hours, the period of the activity rhythm changed its value remarkably, sometimes lengthening and then sometimes shortening. Thus, the normal synchronization between the rhythms was destroyed. Internal desynchronization was not observed in the non-shielded room in which the natural fields of the earth were present. Thus Wever showed that the natural electromagnetic fields of the earth influence the interaction between the activity rhythm and the body temperature rhythm. (Marino 7175)

Having shown that the total of the earth's electromagnetic fields have a significant effect on human rhythms, Wever next studied the question of which component of these fields caused the effect. In 10 subjects, an artificial electric field (10 Hz, 0.025 volts/cm) was switched on and off in changing temporal sequence. No subject knew when he was being exposed to the field, and each subject acted as his own control. Wever found that the presence of the artificial electric field reversed the effects found previously. That is, with the field present, the 10 subjects showed lower values of the period of the body temperature rhythm, and in no case did internal desynchronization occur when the electric field was switched on. Moreover, when the field was switched on with the subject in a state of internal desynchronization, the desynchronization was stopped. Thus Wever showed that the artificial electric field on one hand, and the total of the natural electromagnetic fields on the other, influenced the human biological rhythms similarly in each respect investigated. (Marino 7176) His results therefore prove that the natural electromagnetic fields can affect human beings, and, that artificial electric fields of 10 Hz, 0.025 volts/cm can influence human biological rhythms.

Similar phenomena have been reported by other investigators. Altman and Soltau exposed guinea pigs to 2.4 volts/cm at 10 Hz, and maintained parallel groups under shielded conditions and under normal ambient conditions. They found that shielding produced changes in the hematocrit and the distribution of blood proteins, but that both parameters returned to normal in the presence of the artificially applied field. (Marino 7177) Lang exposed mice to 35 volts/cm at 10 Hz and maintained parallel groups under shielded conditions and under normal ambient conditions. Shielding produced changes in body water content, blood hemoglobin and blood sodium levels. The effects were eliminated following exposure to the artificial electric field. (Marino 7178)

Blanchi, et al. found that after 1000 hours of exposure to 1000 volts/cm at 50 Hz, the electrocardiograms (EKG's) of mice were significantly altered. (Marino 7158)

It has been found that after 192 hours of exposure at 400 and 800 volts/cm, chicks exhibited significantly altered electroencephalograms. The spectra of experimental and control animals were compared in 512 frequency bands between 0–62.5 Hz. Four significantly different bands were found in the animals exposed to 400 volts/cm, while seventeen significantly different bands were observed in the animals exposed at 800 volts/cm. (Marino, Ca., 3846-0018)

Magnetic Fields Effects

1. Acute Exposure

Utilizing 60 human subjects, Friedman, et al. demonstrated that 3 gauss at 0.2 Hz superimposed on a static field of 5 gauss significantly affected reaction time in both male and female human volunteers. (Marino 12313) The effect of full-body exposure on human cognitive and psychomotor functions was examined by Gibson and Morony. They discovered that after 24 hours exposure to 1 gauss at 45 Hz, both the ability to perform addition, and short term memory, were altered. (Marino 12315)

Eleven male volunteers were confined to a testing facility for seven days, during which the various tests were given. The magnetic field was turned on for a period of 24 hours during the subjects' seven-day stay in the experimental area. The subjects did not know when the magnetic field would be applied. The authors selected four sensitive tests to measure psychological functions: (1) RATER, which tested short-term memory; (2) SETA, which involved performance of a compensatory tracking task (subject required to maintain the pointer of a zero centered meter at the null position by manipulating a control device); (3) WAT, which tested the subject's ability to perform addition; (4) ROM, which measured coordination of the eyes with arm-hand manipulation (subject must manipulate blocks).

Neither the SETA nor ROM tests showed an effect due to field exposure, indicating that human psychomotor function was not affected under the conditions studied. Both the RATER and WAT tests, however, yielded statistically significant results. The WAT test showed that the experimental subjects' speed of performing addition decreased during their exposure to the ELF magnetic field. The RATER tests showed a significant increase in performance of the experimental subjects, as compared to the control subjects, due to exposure to the field. Milburn investigated the ability of human beings to perceive magnetic fields (1 gauss) and electric fields (2.3 volts/cm). He employed a forced-choice testing procedure and found that 2 of 43 subjects studied were able to perceive a magnetic field at 400 Hz. (Marino 12316, Ca., 3846-0020)

Smith and Justesen exposed mice to 17 gauss at 60 Hz and found that locomotor activity levels increased immediately upon application of the field. (Marino 12216, Ca., 3846-0020) Persinger, et al. found that rats exposed for 21–30 days to 3–30 gauss at 0.5 Hz displayed greater activity upon removal from the field as compared to the control rats. (Marino 12316, Ca., 3346-0020)

2. Chronic Exposure

Chronic exposure to low strength magnetic fields generally produces an effect on growth or physiology of the test organism.

Utdintsev, et al. found that exposure of rats to 200 gauss at 50 Hz for one day increased the lactate dehydrogenase activity in the cardiac and skeletal muscles. (Marino 12339) Rats exposed to 200 gauss at 50 Hz exhibited a significant increase in hydroxycorticosterone in adrenal tissue and blood plasma after one and seven days of exposure. Lantsman explored the effect of exposure to 200 gauss at 50 Hz on phagocytic function (ability to destroy harmful bacteria) of the reticuloendothelial system of mice. He found that eight hours of exposure per day for four days inhibited the efficiency of phagocytosis in several organs. (Marino 12338)

Bassett, et al. investigated the effect of magnetic field on the organization and strength of the repair process which occurs during the healing of a bone fracture. They applied an asymmetrically pulsed field repeating at 65 Hz, with a peak value of several gauss, to dogs which had undergone fibular osteotomies (surgical breaking of the fibular bone). They found that the field accelerated the time course of the repair process (Marino

7151). In a subsequent study, Bassett and coworkers examined the effect of ELF fields on people suffering from congenital and acquired pseudarthroses (bone non-unions). It was found that the ELF fields caused bone growth, indicating a promising approach to avoid amputation in the surgically resistant non-union. Patients were exposed for 12–16 hours per day for three to six months and a success rate of 73–76 percent in the induction of new bone growth was seen. (Marino 12308)

Erhman, et al. examined the effect of a magnetic field on the amount of medication used by several hundred patients. With regard to ten typical medical complaints, they found that a field of several gauss at 4-12 Hz brought about a reduction in the amount of medication consumed which greatly exceeded the reduction achieved with placebos. (Marino 12316, Ca., 3846-0022)

Beischer, et al. exposed human subjects to a magnetic field of one gauss and observed a significant increase in their serum triglycerides (Marino 7228) The volunteers in Beischer's controlled laboratory study were confined to a specially constructed platform for one week, during which they were exposed continuously to the magnetic field. A significant increase in serum triglycerides was observed one to two days after exposure in nine out of ten men exposed to the field. Similar trends were not seen in the control subjects. Beischer concluded (Marino 7228):

In summary, the results of this pilot study suggest that an alternating magnetic field of 45 hertz and 1 gauss strength may cause a time-delayed increase of serum triglycerides in man.

The importance of Beischer's observations were greatly accented by observations made at the Naval Research Unit No. 4 on personnel who had been working near the Sanguine Wisconsin Test Facility, where elevated triglycerides were found in six of eight subjects. (Marino 7229) The fact that identical observations were made by the Navy under different research protocols, at different times and places, with different subjects, lends much credence to their validity.

Giarola, et al. found that exposure of one day old chicks to 1.3 gauss at 45 and 60 Hz for 28 days depressed their growth rate by 9–11 percent as compared to unexposed birds. (Marino 7153)

Persinger, et al. exposed rats for 0–26 days to 1–30 gauss at 0.5 Hz and observed progressive changes in total body weight, thyroid weight, testicle weight, and water consumption. (Marino 12316 Ca., 3846-0022) Ossenkopp explored the influence of 3–12 gauss at 0.5 Hz on rats exposed *in utero* for 22 days. A number of physiological and behavioral effects were manifest by the pups after birth including retardation of time of eye opening and teeth eruption, and depression of motor activity. (Marino 12316, Ca., 3846*0022)

Combined Field Effects and Special Topics

1. Soviet Epidemiological Investigations

Soviet investigators have conducted medical and physiological surveys of personnel occupationally exposed to strong electric fields emanating from components of the Soviet electrical power system.

Physical examinations of high voltage switchyard workers revealed that 41 of 45 subjects studied presented some neurological or cardiovascular disorder during and shortly after field exposure. (Marino 7211) The examination showed instability of the pulse and blood pressure, tremors of the extremities, and hyperhidrosis. (Marino 7212) Accompanying these observations, the electrocardiograms showed bradycardia in 14 subjects and slowed atrioventricular conduction in 10 subjects. Laboratory studies of the peripheral blood showed marked spherocytosis in 60 percent of the subjects examined. (Marino 7212) A physiological study of 54 occupationally exposed workers showed that the electric field produced functional changes in the autonomic nervous system which were related to the duration of exposure. (Marino 7214) Medical surveys carried out at 16 high voltage substations involving a total of 286 people revealed adverse effects of exposure to the electric field on the central nervous system and the cardiovascular system. (Marino 12237) A physiological survey of 319 people who worked at high voltage substations and overhead transmission lines also revealed unfavorable changes in health. (Marino 12337) Twenty-three men were exposed to power frequency electric fields while various central nervous system and cardiovascular system indices were measured; the results showed that fields stronger than 50 volts/cm have an adverse effect on man. (Marino 12337) A clinical study of personnel of 330 kV substations revealed a variety of harmful effects of field exposure manifested by alterations in blood pressure and electrocardiogram. (Marino 7178)

In a recent experiment male rats were exposed for up to four months in an effort to assess the human health hazard posed by such high voltage transmission lines. Unusual motor activity and hyperemia of the nasal mucosa were observed in rats exposed to 50 volts/cm. In the groups exposed to 10–50 volts/cm, a variety of alterations in normal physiology were seen including a reduction of blood cholinesterase activity in an increase in urinary corticoids. Dystrophy was seen in a variety of tissues at the conclusion of the exposure period, the extent of which was proportional to the intensity of the applied field and the duration of exposure. (Marino, Ca., 3846-0025)

Within the Soviet Union, occupational exposure to power frequency electric fields is regulated by a set of Hygienic Rules which govern the permissible duration of exposure at various field intensities. (Marino 7209) Although as early as 1970 the modern Soviet literature contained more than 100 reports of the influence of ELF electric fields on biological systems, (Marino 12340) it appears that the Rules are based principally on the medical and physiological surveys discussed above. Standards governing the exposure of agriculture workers and the general public are being developed. (Marino 12348) A variety of other rules relating to the design and construction of high voltage transmission lines presently provide some protection to both groups. (Marino 12347, 12374)

2. Bird Orientation

It has been proven by a series of highly competent scientific investigators that very weak ELF fields, such as associated with the Project Sanguine/Seafarer antenna, can affect the orientational ability of migrating birds.

In pilot studies, it was shown that the headings of homing pigeons were altered in the vicinity of the Sanguine/Seafarer antenna. (Marino 7169) In more detailed studies, Southern constructed cages on the ground directly over the buried antenna to explore the effect of the field on the instinctive directional preference of three to nine day old ring-billed gull chicks. When the chicks were released in the center of the cage with the antenna turned off they showed a directional preference for the southeast. When the antenna was energized the birds dispersed randomly and exhibited no mean bearing. (Marino 7168) Larkin and Sutherland carried out radar tracking of individual migrating birds flying over the antenna at altitudes of 80–300 meters. They observed that when the antenna was activated or when its operating condition was being changed (off to on or on to off) departures from straight and level flight occurred significantly more often than when the antenna was turned off. (Exhibit W-5). In radar tracking studies Williams and Williams reported changes in the flight direction of migrating birds of 5–25 degrees when the antenna was activated. (Marino, Ca., 3846-0027)

3. Plants

The growth of beans exposed to 0.1 volts/cm was 40 percent greater than that of the control plants after 64 days of exposure. Rosenthal applied 0.01–0.10 volts/cm and 1 gauss at 75 Hz to sunflower seeds and observed differences in seedling mortality, stem and root length, between the exposed and unexposed populations. A survey of the plant life near high voltage transmission lines suggested that the fields caused a slight enhancement of growth. (Marino 12316, Ca., 3846-0028)

Additional Reports

Many additional reports describing biological effects of ELF electric and magnetic fields have appeared, and continue to appear, in the open peer-reviewed scientific literature since the time of the testimony of the staff sponsored witnesses.

Conclusion

Based on the report described in the foregoing review, it must be concluded that the electric field and the magnetic field of the proposed transmission lines will each probably cause biological effects in the subjects to them. (Marino 7197, 12319)

The ELF studies are summarized in Exhibit C-5. Listed therein are a very large number of scientific experiments which show that ELF electric and magnetic fields cause biological effects. The experiments were performed by reputable scientists at reputable scientific institutions (see Exhibit C-5). A heavy majority of the reports were subjected to the peer review process prior to publication. (Marino 12317) The strength of the field used in each cited experiment was such that it will occur somewhere on the right-of-way of the proposed transmission line. (Exhibit C-5, column D1) If a particular field strength causes a certain biological effect in a laboratory, then the same field strength will cause

the same biological effect near the right-of-way of the proposed transmission line if the same biological system is exposed under the same circumstances. (Marino 12317) This follows from the universal inability of biological systems to distinguish between two sources of an applied field when the parameters and circumstances of the field presented from each source are identical. Under these conditions of identity, specific effects due to exposure to the fields of the proposed transmission line could be predicted. (Marino 12317) The actual biological systems that will be exposed to the fields of the proposed transmission lines include people. The exposed group will consist of the old, the young, the sick, the healthy, men, women, children-a completely uncontrolled set of exposed subjects. Since the particular biological systems that will be exposed and the conditions of such exposure will both differ from the corresponding systems and conditions studied in the laboratory, no human agency can predict the specific biological consequences that will occur in specific subjects exposed along the right-of-way. (Marino 12318) Notwithstanding our ability to predict specific effects in specific subgroups of exposed subjects, the foreshadowing of the literature are ominous and avoidable. (Marino 12318) In each individual report described in Exhibit C-5, ELF fields interacted with and influenced the physiology or behavior of a biological system. In no case is the mechanism of interaction understood. (Marino 12318) With respect to each individual experiment listed in Exhibit C-5, a biological mechanism of interaction, was invoked in the laboratory which could be invoked along the right-of-way as a consequence of exposure to the field of the proposed transmission line. (Marino 12318) In view of the number and diversity of the experiments listed in Exhibit C-5, and bearing in mind the relatively short exposure times that are normally employed in laboratory experimentation (Exhibit C-5, column 7), as compared to the very long-term exposure that will occur in subjects living along the right-of-way, it is probable that biological effects will occur in some exposed subjects. (Marino 12319) It is not possible to foresee the precise biological effects that will likely occur in individual subjects because no free-world company, organization or government has conducted a systematic study of the question. (Marino 7197) With minor exceptions the research in the literature cited above was performed by investigators for reasons other than evaluating the safety of transmission lines. The problem of safety of transmission lines did not influence the design of such experiments. It is, therefore, not possible to determine which specific effects are scientifically certain to occur in particular individuals. (Marino 12318) There is no scientific base to permit definitive answers to the myriad of very specific questions that can be asked (i.e., will a farmer be adversely affected by the proposed transmission line if he passes under such a line once a day, three days a week, thirty-two weeks a year, except on holidays, in a tractor with tires four feet in diameter made of carbonized rubber, traveling at five miles per hour; if so, how so? (Marino 7199) Such specific information will come only from studies appropriately designed to furnish it. (Marino 7199) It is not realistic to expect that answers to very specific questions will be deductible from the general literature.

POINT 2: THE COMMISSION MUST EMPLOY A SAFETY FACTOR IN DETERMINING THE MAXIMUM PERMITTED CHRONIC HUMAN EXPOSURE LEVEL FOR ELECTRIC FIELDS OF HIGH VOLTAGE TRANSMISSION LINES.

CRUEL AND INHUMANE

The electric and magnetic fields of high voltage transmission lines, such as the proposed transmission lines, have the capability of altering biological function. In such instances the necessity of employing a safety factor is well recognized. (Michaelson 9927, Becker 9002, Marino 12319) Such necessity is based upon the unacceptability of permitting the public to be involuntarily exposed to levels of a substance or agent that has been shown to produce biological effects in experimental animals, or to levels which presumably would produce such effects (or related effects) if tests were performed. (Marino 12312) It is therefore self-evident that to permit chronic human exposure at or near electric field strengths which have produced biological effects in test animals would be cruel, barbaric, and inhumane. It is therefore necessary to employ a safety factor so that the maximum legal permissible chronic human exposure level will be set and defined at a specific numerical value below that level which produces biological effects in animals during controlled laboratory studies.

CLEAR AND PRESENT DANGER OF SYNERGISTIC INTERACTIONS

The electrical power carried by high voltage transmission lines such as the proposed lines is manufactured at one location, transported and ultimately used or consumed at the terminus of the line. It travels from the point of generation to the point of consumption not through the conductors, but rather through the space surrounding them. (Marino 12332) The region which the power transmitted by the proposed lines would occupy extends a considerable distance outward from the transmission line. (Exhibit D-3) When an individual was within this region, a portion of the electrical power being transmitted would impact him. Transmission line energy is composed of an electric field and a magnetic field. Thus, when subjects were exposed to the energy of the proposed transmission lines, they would actually be exposed to simultaneous electric and magnetic fields. (Marino 12333) It has been shown that ELF electric fields and ELF magnetic fields separately cause biological effects. (Exhibit C-5) The "real life" situation, however, namely the simultaneous and phased application of both fields, has not been studied. The biological response to the simultaneous application of the fields may be equal to the summation of the effects produced by each field, or may be greater than the summation of independent effects of the two fields. (Marino 12333) The latter response is called potentiation and represents the condition whereby one agent is made more potent in the presence of another agent. Thus, the situation which will actually occur under the proposed transmission lines, namely, the phased simultaneous application of the electric and magnetic fields, has not been studied experimentally.

There is a real and present danger of a synergistic effect between them. Moreover, there is a real and present danger that synergistic interactions will occur between the energy flux of the proposed transmission lines (i.e., the electric and magnetic field taken together) and other agents present in the environment at various locations along the

right-of-way. (Marino 12333) Such agents may be electrical (radar, radio stations, etc.) or non-electrical in nature (air pollution, drugs, etc.).

Thus there is a complete dearth of information regarding the magnitude of the synergistic interactions that would be produced by the proposed transmission lines, because no experiments have been performed which truly reflect the exposure conditions that would be created by the proposed transmission lines. The Commission must take the aforesaid informational gap into account during its determination of the permissible chronic exposure level. This can only be accomplished by setting the maximum legal permissible chronic human exposure level at a fixed numerical value below the levels which produce biological effects in test animals, so as to make some allowance for synergistic interactions.

APPLICANTS' DIRTY HANDS WITH REGARD TO THE SOVIET SCIENTIFIC LITERATURE

It is recognized by the Soviet government that power frequency electric fields cause undesirable effects in exposed workers. (Marino 7209) The Soviets believe that power frequency electric fields affect people's health, and that the reaction can develop after two to five months exposure. They further believe that the effects are cumulative, dose-related, and depend strongly on individual physiological differences. (Marino 7210) The Soviet government has promulgated nationwide rules and regulations regulating the nature and extent of permissible occupational exposure, and has put into effect a variety of rules and procedures governing the construction, design, and operation of high voltage transmission lines which are intended to ameliorate the effects of the electric field thereof. (Marino 7209, 12347, 12374) The Soviet Union is in the process of developing exposure standards for agriculture workers, and the general public. (Marino 12348) There is underway within the Soviet Union a vast research program dealing with the biological effects of power frequency electric fields. (Marino 12248) As far back as 1970, the open scientific literature of the Soviet Union contained more than 100 reports of biological effects of ELF fields, and since that time the scope of the Soviet research effort has increased. (Marino 12348)

Notwithstanding the vast research effort that has been underway within the Soviet Union and the rules and regulations to which it has led, and notwithstanding the apparent eagerness of the Soviets' power engineers to cooperate with their American counterparts in the exchange of scientific information (Marino 12342-12346), almost no acceptable Soviet scientific information on the biological effects of ELF fields is openly available in the United States. (Marino 12348) It follows that;

- (1) the Soviets have never been requested to tender information, or
- (2) the Soviets have been requested, but have refused, or
- (3) the Soviets have tendered the information, but the utility companies including the applicants and their witnesses have not made it generally available.

Since applicants' witnesses have often touted their close relationship with their Soviet

counterparts, and have complained nowhere that their requests have been refused, it follows that the second possibility is not applicable. Thus, regardless of which of the remaining two possibilities is true, the applicants are before the Commission with dirty hands because they have either not tried to obtain information useful to the Commission, or they have obtained it but have chosen to withhold it. Withholding information or failing to obtain it where there was a clear duty to do so is wrongdoing. The applicants should not be permitted to profit from wrongdoing at the expense of the health and welfare of the people of New York. Since only the applicants have the resources to obtain the Soviet information, and since they have not produced it, and since, surely, if the information were produced it would be adverse to the interests of the applicants as they have framed them in this hearing, the Commission must therefore construe the available scientific literature (Exhibit C-5) more heavily against the applicants than would otherwise be the case. This could most easily be accomplished by the adoption of a safety factor which makes allowances for presently unavailable information within the Soviet Union which is adverse to the interests of the applicants.

INDIVIDUAL VARIATION

The record establishes that hereditary factors render chronic exposure to the fields of 765 kV lines of greater potential hazard to certain portions of the general population. (Marino 12432) For instance, black people exhibit higher than average rates of high blood pressure and related cardiovascular disorders. Robert O. Becker, MD., has testified that the changes produced within the bodies of laboratory animals and people, exposed to ELF fields, are similar to those observed clinically in people having high blood pressure and related cardiovascular disorders. (Marino 12432, Becker 3986 f) Consequently, chronic exposure to the fields of the proposed transmission lines may be particularly hazardous for those groups in the population having inherited or other systemic factors predisposing them to the development of high blood pressure and other cardiovascular diseases. There are other examples in the record tending to indicate that particular groups within the general population are more susceptible than the average to chronic exposure to the fields of 755 kV lines. For example, numerous studies have shown that the young are particularly susceptible to ELF fields. The safety factor is the only mechanism that permits the regulator to make allowance for individual physiological variation.

POINT 3: THE ONLY CREDIBLE SCIENTIFIC EVIDENCE SHOWS THAT THE MOST APPROPRIATE SAFETY FACTOR IS 100

In evaluating the safety-in-use of food additives, a safety factor of 100 has been explicitly chosen by the Federal government. (Marino 7243) The Federal rule seeks to balance the desire of a manufacturer to gain an economic advantage with the desire of the government to protect the public health. (Marino 7243) The numerical value of 100 was chosen as the appropriate balance point, and it is therefore significant as a precedent when a similar balance must be struck. (Marino 7244) That is, the policy considerations underlying the adoption of a safety factor of 100 for food additives are

also present in connection with involuntary exposure of the general public to power frequency fields, and therefore that the same numerical value should be adopted. No evidence has been adduced tending to justify any other numerical value of the safety factor.

Considerations of some other safety factors illustrates the pertinence of the safety factor of 100. The Occupational Safety and Health Administration (OSHA) has promulgated an occupational safety standard for permissible microwave exposure of $10\text{mW}/\text{cm}^2$. This standard is based on the known ability of microwaves to cause heating in biological tissue at levels ten times higher, and thus the safety factor is 10. (Marino 7245) While a safety factor of 10 may be appropriate for occupational exposure, it is inappropriate for the general population because the general population is uncontrolled. (Marino 7246) It contains the old, the young, the healthy, the sick and all variations thereof. Additionally, the whole range of exposure periods is possible from occasional to chronic. This is to be contrasted with the occupational setting in which it is presumed that the employees are healthy, and wherein their exposure can be controlled and monitored by the employer. (Marino 7246)

The federal safety factor for new microwave ovens is 100 ($1.0\text{ mW}/\text{cm}^2$). It is based on the rationale described above (i. e., more protection for an uncontrolled population), and on the possibility that the Soviet microwave standard and not the American microwave standard is the correct one. (Marino 7246) The Federal safety factor for carcinogenic substances is infinite. That is, if a substance causes cancer in animals, it cannot be used in food. (Marino 7247) Thus, putting aside the special cases (carcinogenic substances, for which the safety factor is infinite, occupational exposure, for which the safety factor is 10), the precedent is well established in the United States that a safety factor of 100 is the appropriate numerical value with relation to the public at large when a balance must be struck between economic advantage and the public health.

POINT 4: THE COMMISSION MUST ORDER THAT 0.1 VOLTS/CM SHALL BE THE MAXIMUM LEVEL OF THE ELECTRIC FIELD OF THE PROPOSED TRANSMISSION LINES TO WHICH HUMAN BEINGS MAY BE CHRONICALLY EXPOSED.

EXPERIMENTS PERFORMED AT OR BELOW 0.1 VOLTS/CM, OR WITHIN A SAFETY FACTOR OF 100

It would be cruel, inhumane and barbaric to permit or allow the citizens of New York to be exposed to levels of electric field intensity emanating from the proposed transmission lines above which, at which, or near which, biological effects have been observed in test animals. The proposition is self-evident. Due and deliberate consideration of the scientific literature in evidence shows that many experienced competent investigators have reported alterations in the biological function of test animals and humans following the application of an electric field of 0.1 volts/cm, or lower, or an electric field within a safety factor 100 (i.e., 10 volts/cm) To wit: Frient, at the Naval Research Institute, reported that 10 minutes exposure altered the physiology of amoebas. Moos, at the

University of Illinois, reported that 10–150 days exposure altered the behavior of mice. Marsh, at the University of Iowa, reported that five days exposure altered the growth of flatworms. Altman, at the University of Saarbrücken, reported that 12 days exposure altered the physiology of guinea pigs. Reisen, at IIT Research Institute, reported that 40 minutes exposure altered the physiology of cells. Mathewson, at the Armed Forces Radiobiology Research Institute, found that 28 days exposure altered the physiology of rats. Lott, at North Texas State University, reported that 90 minutes exposure altered the physiology of rats. Bawin, at UCLA, reported that 20 minutes exposure altered the physiology of brain tissue. Gardner, at the University of Wisconsin, reported that 64 days exposure altered the behavior of humans. Hamer, at UCLA, reported that five minutes exposure altered the behavior of humans. Gavalas, at UCLA, reported that five minutes exposure altered the behavior of monkeys. Persinger, at Laurentian University, reported that 40 minutes exposure altered the behavior of humans. Wever, at Max Planck Institute, reported that eight weeks exposure altered physiobiology of humans. Durfee, at the University of Rhode Island, reported that three days exposure altered the growth of cells. König, at the Technical University in Munich, reported that five minutes exposure altered the behavior of humans. Goodman, at the University of Wisconsin, reported that 600 days of exposure altered the growth of slime mold. Noval, at Temple University, reported that 30 days exposure altered the growth of rats. Southern, at Northern Illinois University, reported that two minutes exposure altered the behavior of birds. Graue, at Bowling Green State University, reported that two minutes exposure altered the behavior of birds. Larkin, at Rockefeller University, reported that two minutes exposure altered the behavior of birds. Williams, at Swarthmore College, reported that two minutes exposure altered the behavior of birds. McCleave, at the University of Maine, reported that two minutes exposure altered the behavior of fish. Moreover, applicants witnesses have testified that there exists an equivalence between electric fields and magnetic fields. (Exhibit NNN) Accepting this assertion, *arguendo*, it follows that all magnetic field exposure experiments performed at exposure levels up to one gauss are equivalent to electric field levels which fall within the aforementioned range. To wit: Bassett, at Columbia University, reported that 28 days exposure caused altered growth in dogs, and that three to six months exposure caused altered growth in humans. Persinger, at Laurentian University, reported that 10–26 days exposure altered the physiology of rats. Ehrman, at Tübingen, reported that three weeks exposure altered the physiology of humans. Beischer, at the Naval Aerospace Research Laboratory reported that exposure for one day altered the physiology of humans. Milburn, at UCLA, reported that two minutes exposure altered the behavior of humans. Gibson, at the Naval Aerospace Research Institute, reported that exposure for one day altered the behavior of humans. It follows that the Commission has a manifestly clear duty to prevent the chronic exposure of human beings to an electric field strength duty greater than 0.1 volts/cm. Whether the duty is carried out by an order to underground the proposed transmission lines, or an order to widen the right-of-way, by some other means, the touchstone of all contemplated designs must be that chronic human exposure in excess of 0.1 volts/cm shall be forbidden.

PROPOSED TRANSMISSION LINES CONSTITUTE INVOLUNTARY HUMAN EXPERIMENTATION

The civilized world abhors involuntary human experimentation (Nuremberg Code; Declaration of Helsinki, 1964, World Medical Association).

It would be illegal, unconscionable, and involuntary human experimentation to permit human beings in New York to be chronically exposed to an electromagnetic environment, created by the proposed transmission lines, at intensities which exceed the average daily exposure suffered in the absence of such lines. Therefore, chronic exposure to fields of the proposed transmission lines in excess of 0.1 volts/cm is impermissible.

There are a very large number of scientific reports showing that ELF fields cause biological effects. The experiments were performed at field intensities that would be produced by the proposed transmission lines as far away as 2000 feet from the center conductor, and beyond. (Exhibit C-5) In seeking to minimize the economic impact of any order necessary for the protection of the health and welfare of the people of New York, the Commission may deem it sufficient that the maximum permitted exposure level shall not be lower than the average ambient exposure presently experienced by the people of New York as a consequence of exposure to electrical devices other than high voltage transmission lines. The record indicates that a suitably weighted value for the average chronic exposure to power frequency fields presently experienced in New York is 0.1 volts/cm*. Thus, 0.1 volts/cm is an appropriate value as an exposure limit because it does not result in an increase in the average ambient exposure. Any value which did result in an increase in the ambient exposure would constitute human experimentation because there exists scientific evidence establishing that such fields are biologically active.

In New York, "human research" is defined as (N.Y. Pub. Health Law, Section 2441):

any...research,...which utilizes human subjects and which involves physical or psychological intervention by the researcher upon the body of the subject and which is not required for the purposes of obtaining information for the diagnosis, prevention, or treatment of disease or the assessment of medical condition for the direct benefit of the subject.

The physical intervention caused by the proposed transmission lines would consist of the minute currents, fields, and voltages that would be created within the bodies of the exposed subjects at levels where physiological and growth altering effects have occurred in laboratory animals. The psychological intervention would consist of the minute currents, fields, and voltages that would be created within the bodies of the exposed subjects at levels where behavioral alterations have occurred in laboratory tests.

It is further provided (Section 2442):

No human research may be conducted in this state in the absence of voluntary

informed consent subscribed to in writing by the human subject...
and (Section 2443);

No one except a researcher shall conduct human research in this state.

The law restricts those who may be “researchers,” and provides for the creation of human research review committees.

Unless the Commission and the applicants are prepared to fully comply with the letter and the spirit of the applicable portions of the Public Health Law, the Commission cannot authorize an exposure level in excess of 0.1 volts/cm.

Federal regulation of human research has come from the Department of Health, Education and Welfare (45 C.F.R., Part 46) pursuant to its authority to regulate research which it funds, and from the Food and Drug Administration (21 C.F.R. 312.1) pursuant to its authority to regulate research which provides evidence of drug safety. The pivotal consideration in determining whether a human being is protected under Federal law is whether there is a “subject at risk” which means (45 C.F.R., Section 46.103(B)):

any individual who may be exposed to the possibility of injury, including physical, psychological, or social injury, as a consequence of participation as a subject in any research, development, or related activity which departs from the application of those established and accepted methods necessary to meet his needs, or which increases the ordinary risks of daily life, including the recognized risks inherent in a chosen occupation or field of service.

There is a large and growing list of reports of ELF field induced biological effects. Included therein are many reports describing biological effects at and below the intensity levels that would be produced along and beyond the right-of-way of the proposed transmission lines. It is plainly, abundantly, and forcefully clear that the exposure of human beings along the right-of-way, and beyond the right-of-way would place said human beings “at risk,” because they would be exposed to the same intensity levels of the same physical agents shown in the laboratory to have the capacity to alter biological function. The most odious and reprehensible aspect of such exposure would be its involuntariness, inasmuch as such human beings would be generally unaware even of such risk; *a fortiori*, they would not have consented thereto. Thus, chronic exposure at intensity levels above that of the ambient would constitute involuntary human exposure within the meaning of Federal law if such exposure were being financed with Federal money.

There is no responsible scientific investigator in the United States who would expose human beings to ELF fields at any intensity level above that of ambient, for purposes of basic research, without securing informed consent. It is inconceivable that the Commission would authorize the applicants to perform such exposure for the purposes of profit.

TORTIOUS CONDUCT BY APPLICANTS

The tort of battery is committed when there is intentional contact with another's body and that contact is neither consented to nor privileged. (Restatement, Second, Torts § 18) It is not necessary that one be physically injured, or have suffered financial loss. The injury is to dignity associated with the unpermitted and intentional invasion of a person's inviolability. There is liability regardless of whether the contact results directly or indirectly from the other's conduct. (Restatement, Second, Torts § 18, Comment (a):

All that is necessary is that the actor intend to cause the other, directly or indirectly, to come in contact with a foreign substance in a manner which the other will reasonably regard as offensive.

(Restatement, Second, Torts § 18, Comment c) Knowledge of the contact is not required for liability (Comment d).

Inasmuch as exposure to the electrical environment of the proposed transmission lines would cause and create within the bodies of the human beings exposed thereto, currents, voltages, and electric fields which when caused and created within the bodies of test animals, have produced alterations in the physiology thereof such exposure would constitute multiple batteries by the applicants against the exposed human beings. Moreover, the applicants have no right to interfere in the lives of human beings and expose them to risks, thereby interfering with the right of people to use and enjoy their own property. Thus, acceptance of the right-of-way proposed by the applicants (and its associated chronic exposure limit) would colorably authorize the tort of nuisance.

It follows that if the Commission were to adopt the irresponsibly small right-of-way proposed by the applicants, such unjust action would effectively authorize a myriad of law suits by involuntarily exposed people. On the other hand, there would be no basis for legal action, either at law or in equity, if the chronic exposure level was not allowed to exceed the ambient. That is, if the permissible chronic human exposure level was set at 0.1 volts/cm.

UNCONSTITUTIONAL TAKING AND SOME CONSEQUENCES

The proposed transmission lines would carry only a portion of their deliverable electrical power within the right-of-way proposed by the applicants. (Marino 12333) A substantial portion of said power, on the order of 50 percent, would be channeled along the direction of the lines but would exist at lateral distances beyond the right-of-way. (Marino 12333, Exhibit D-5) Thus the applicants are petitioning the Commission to order and approve a constructive easement over much more land than applicants would condemn, and in which they would have absolutely no legal interest. Such an order by the Commission would result in an unconstitutional taking of private lands for addition, the applicants would have no legal interest in, or legal right to enter, those lands

adjacent to but beyond the proposed right-of-way whereat a substantial portion of the deliverable electrical power would be confined in transit. It is possible to build and market electrical transducing devices which convert the deliverable electrical power from an energy flow, which is the species under which it exists in transit, to the more familiar form of household current. Such devices might operate with impunity on private lands adjacent to the proposed right-of-way, thereby altering significantly the total amount of deliverable power.

POINT 5: THE COMMISSION MUST ORDER THAT 1.0 VOLTS/CM SHALL BE THE MAXIMUM LEVEL OF THE ELECTRIC FIELD OF EXISTING HIGH VOLTAGE TRANSMISSION LINES TO WHICH HUMAN BEINGS MAY BE CHRONICALLY EXPOSED.

The Commission must go further than establishing a chronic exposure limit for the proposed transmission lines. It must also provide protection against existing high voltage transmission lines because the scientific literature which shows that the proposed transmission lines would be a human health hazard, also shows that existing high voltage transmission lines are a human health hazard. (1) Neither the record in this hearing nor the scientific literature allow a precise determination of the most appropriate numerical value for the permissible chronic human exposure to existing high voltage transmission lines. (2) The laboratory research of witnesses Marino and Becker, and other colleagues, which is in evidence in this hearing in enormous detail, shows that exposure of rats to 150 volts/cm for 30 days produces a biological stress response, but that vastly more serious and debilitating results occurred in mice during long term multigeneration exposure to 150 volts/cm and 100 volts/cm. (3) Whereas the multigeneration study of mice resulted in extremely adverse consequences to the test animals, and whereas that research has undergone the most thorough, searching and rigorous cross-examination in the history of the application of scientific results to decision-making by regulatory agencies and been shown thereby to be free of all significant scientific and procedural flaws, that therefore the safety factor of 100 ought to be applied to the electric field level of 100 volts/cm, which was experimentally determined to be hazardous to mice, thereby resulting in an absolute upper limit on the permissible chronic human exposure to existing transmission lines of one volt/cm.

(1) The pages of the record of this hearing are pregnant with implications for existing high voltage transmission lines. It is generally accepted that the cost of retrofitting existing lines to new levels of safety based on new scientific evidence would be great. The Commission, which has the difficult task of balancing such cost against the increased level of protection afforded thereby, does not have before it in the record sufficient data to make a responsible judgment of a precise numerical value. There is lacking demographic data of the distribution of households in relationship to the lines of various voltages, and there is lacking specific research suitable for evaluating the degree of hazard and suitable for defining techniques and procedures for protection against ELF fields. In our society, however, which recognizes the dignity of human life, there is a limit beyond which regulatory authorities may not go in placing the health of the public at risk notwithstanding any financial considerations. The record clearly

indicates that such upper limit is one volt/cm.

(2) Mice were exposed for three generations to a 60 Hz electric field in the vertical direction. In the first generation the growth of both the females and males was stunted by 29 percent and 15 percent respectively. In the second generation the growth of both the females and the males was stunted by 42 percent and 44 percent respectively. In addition, the mortality rate was ten times higher among the exposed animals as compared to the control animals. In the third generation the growth of the males was stunted by 20 percent. In other experiments, mice were exposed to a 60 Hz electric field in the horizontal direction. In the first generation the growth of both the females and the males was stunted by 8 percent and 11 percent respectively. In the second generation the growth of both the females and the males was stunted by 19 percent and 17 percent respectively. (Exhibit G-4)

(3) No other specific set of experiments in history have received the attention which the applicants have devoted to the research of Marino and Becker. (Marino 12428–29) They supplied interim reports of the progress of their work from the beginning of their participation in the hearing in 1974. They answered two very detailed sets of written interrogatories concerning virtually every aspect of their research. They conducted five of applicants' experts on a tour of their research facilities, during which they answered many questions concerning the details of the exposure apparatus employed in their experiments. They provided the applicants with copies of all the raw data concerning all of their experiments, amounting to more than three hundred pages. There has never been such complete and total disclosure of raw research data. Pursuant to a demand from the applicants, Marino searched his correspondence file looking for letters sent to him by other scientists which contained comments on his research. Applicants also brought their own vast resources to bear in obtaining information concerning the background and private correspondence of Marino and Becker which had any relationship, however tenuous, to their research. The applicants actually commissioned experiments to independently test the validity of the results of Marino and Becker, and they hired a statistician to search through the raw data looking for arithmetic errors. Finally, Marino was cross-examined for 13 days, and Becker was cross-examined for four days. Most of the 17 days of cross-examination was devoted to the aforesaid research of Marino and Becker. In spite of the great interest shown by the applicants in the research of Marino and Becker, they have uncovered no flaws therein, nor have they generally alleged such flaws. Applicants'; witness Schwan testified during the direct and rebuttal phases of this hearing. Applicants' witness Carstensen testified during the direct, rebuttal and surrebuttal phases of this hearing. Applicants'; witness Miller testified during the direct and rebuttal phases of this hearing. Applicants'; witness Ness testified during the rebuttal phase of this hearing. None of the aforesaid witnesses even alleged the existence of flaws in the multigeneration study of mice conducted by Marino and Becker which would vitiate the results reported. Such allegations have come only from applicants witness Michaelson, and have been shown to be totally baseless. (Marino 12469–12472)

It follows from the above that the multigeneration experiments of Marino and Becker performed at 100 volts/cm are appropriate experiments to employ for the purpose of

setting an upper limit for the permissible chronic human exposure to the electric field of existing high voltage transmission lines. In conjunction with the safety factor of 100, it is thereby found that an absolute upper limit irrespective of financial considerations should be one volt/cm.

POINT 6: RADIATION FROM THE PROPOSED TRANSMISSION LINES MAY INCREASE THE INCIDENCE OF HUMAN CANCER AND ALTER GLOBAL CLIMATE. FURTHER HEARINGS ARE REQUIRED AND UNDERGROUNDING OF THE LINES MAY BE NECESSARY.

HISTORY

Marino pointed out that radiation from the proposed transmission lines might result in an increase in human cancer and an alteration in global weather patterns. (Marino 12350–12356) Applicants moved to strike the testimony on the basis that it was “not proper rebuttal” and was “not material”. The Examiners granted the motion on the basis that a full evaluation of the issues would take too long. Staff appealed, the Commission overruled the Examiners and authorized a surrebuttal phase of the instant hearings wherein the applicants might be afforded an opportunity to respond to the evidence. Direct testimony was then prefiled during the aforesaid surrebuttal phase on behalf of the applicants by Malcom Savedoff. Thereafter the Examiners, on their own motion and without the benefit of argument by counsel, ordered that Savedoff should be cross-examined for no more than one day, and that the examination should be held in Albany. This ruling effectively prevented all cross-examination of Savedoff (letter from Marino to Simpson, copy to Secretary Madison, July 5, 1977) Thus the record before the Commission on the subject of the radiation from the proposed transmission lines, contains the testimony of Marino (Marino 12250–12356), who was cross-examined, and the testimony of Savedoff who was not cross-examined.

THE PHYSICAL PHENOMENON

Robert Helliwell of the Radioscience Laboratory, Stanford University, investigated the propagation of Very Low Frequency (VLF) (300 Hz–30 kHz) electromagnetic waves between Roberval, Quebec, and Siple Station in the Antarctic. The two stations are conjugate, each being located at the end of a magnetic field duct. (Exhibit E-5) VLF energy which enters the duct is channeled along it and passes into the magnetosphere where it interacts with electrons to produce a variety of new frequencies and time variations which are detectable at the conjugate point.

Lightning discharges produce VLF electromagnetic waves which enter the ducts. It is also possible to deliberately inject such waves into a magnetic duct much as via the 21.2 km antenna located at Siple. Helliwell found that electromagnetic radiation from the Canadian power system is inadvertently being injected into and channeled along the particular magnetic duct which he employs in his measurements.

The VLF electromagnetic waves which enter the duct pass into the magnetosphere where they interact with trapped electrons. Helliwell has found that the magnetospheric amplification process occurs for an input power as small as ten watts, and can result in a gain of more than three orders of magnitude. Some electrons which have surrendered energy to the wave drop out of the magnetosphere and rain down on the ionosphere. This in turn causes collision processes which produce a spectrum of bremsstrahlung X-rays. There is a normal background of precipitated electrons due to galactic sources and natural electromagnetic noises, and there are intermittently higher counts when a nearby lightning discharge occurs. Thus, the electron precipitation caused by power lines is additive to that which occurs naturally.

No research has been performed to determine either the magnitude or the biological significance of the electron precipitation caused by high voltage transmission lines.

Among the many unanswered questions are: (1) the amount of power that will be radiated by the proposed transmission lines at the fundamental frequency and at the first 100 harmonics, (2) the magnitude of the natural versus artificially induced electron precipitation, (3) the spatial distribution of the precipitated electrons, and (4) the nature of the interaction process which occurs when the electrons precipitate onto the ionosphere, and the biological consequences thereof. Satellite observations have shown that VLF electrical activity has the highest probability of occurrence in regions threaded by geomagnetic field lines that intersect industrialized areas. This result confirms recent land-based observations of the influence of transmission line radiation on magnetospheric dynamics. Thus, there are strong indications that radiation from transmission lines plays a significant and hitherto unsuspected role in the dynamics of the magnetosphere.

THE POSSIBLE BIOLOGICAL CONSEQUENCES

The precipitated electrons will be scattered by particles in the upper ionosphere, and in that process will emit X-rays of about 2 keV. Such photons have a radiation length of less than 1/2 km, and are, therefore, absorbed far above the earth's surface. The absorption gives rise to secondary processes which involve the production of ultraviolet light which can pass through the atmosphere and strike the earth. One effect of the electron rain would therefore, be an increase in the total amount of ultraviolet light which strikes the earth. Qualitatively an increase in the ultraviolet light that strikes the earth is quite capable of causing biological effects. The number of instances of human skin cancer depends in part on the amount of ultraviolet light at ground level. Interest in this relationship has been stimulated by the possible link between freon and depletion of the ozone layer of the atmosphere, a process which also has the effect of increasing the UV which strikes the earth via a completely different mechanism. Thus, the radiation from the proposed transmission lines could increase the amount of ultraviolet light that strikes the earth in sufficient amounts so as to increase the incidence of human skin cancer.

There is another possible effect associated with the proposed transmission line, which

is related to the earth's climate. Solar emissions of ultraviolet light and charged particles varies with sunspot activity. A number of workers have shown a relationship between these variations and changes in the earth's climate. Thus, the physical factors which appear to be related to climatic change also occur as a consequence of the radiation from high voltage transmission lines, thereby raising the possibility that such lines may cause changes in global weather patterns.

TESTIMONY OF APPLICANTS' WITNESS SAVEDOFF

Savedoff testified that emissions of ultraviolet light due to power line radiation from the proposed transmission lines, above 1 kHz, could be as high as .02 percent of the ultraviolet light that comes from the sun (Savedoff 13857), and, that this increase did not seem to him to be great enough to cause cancer (Savedoff) or affect global climate. (Savedoff 13866) Savedoff's testimony however is of no significant value in assessing the hazards posed by the radiation from the proposed transmission lines.

Inexplicably, Savedoff confined his attention to power line radiation in the band of 1–20 kHz. (Savedoff 13853) Inasmuch as the fundamental frequency and the first four harmonic frequencies, whereat most of the power line radiation would be expected to be concentrated, are all below 1 kHz, it follows that Savedoff has not even addressed a significant portion of the biological problem raised during the rebuttal phase. Moreover, since Savedoff was not cross-examined, the Commission can only speculate on why he believes that an increase of .02 percent in the ultraviolet light striking the earth "is not significant". (Savedoff 13865) An increase of .02 percent in the ultraviolet light would cause between 10 and 100 cases of skin cancer a year in the white population of the United States (Biological Impacts of Increased Intensities of Solar Ultraviolet Radiation, a Report of Ad Hoc Panel on the Biological Impacts of Increased Intensities of Solar Ultraviolet Radiation to the National Academy of Sciences, 1973). It is therefore inconceivable that Savedoff could provide a rational basis for his view. Finally, Savedoff said that if a change in global climate were to result from emission of ultraviolet light due to power line radiation, one would expect to see a change in climate due to nuclear explosions in the magnetosphere (Savedoff 13864), but, since such explosions have not been proven to affect the climate, that therefore the emission of ultraviolet light due to power line radiation will not affect the earth's weather. (Savedoff 13865) Savedoff's premise however, is mere velleity. To establish that emissions of ultraviolet light due to power line radiation do or do not affect global climate, it is no more useful to associate nuclear explosions with global climate than it would be to associate eating peanut butter sandwiches with global climate. In addition, there have been no significant or definitive studies of possible links between nuclear explosions in the magnetosphere and subsequent changes in global climate. It is impermissible to equate the absence of a study with the absence of a link.

CONCLUSION

The extent of the global hazard posed by radiation from the proposed transmission lines is presently unclear and potentially enormous. Such hazards might be found, upon further inquiry, to be sufficiently great so as to necessitate under-grounding of the proposed transmission line. It would therefore be a mockery of the administrative hearing process to fail to explore the issue in a subsequent hearing.

In the subsequent hearing, evidence should be adduced from independent* scientists concerning:

- (1) the amount of power line radiation which will be created, and
- (2) the effect of such radiation on the magnetosphere, and
- (3) the biological significance of such effects with regard to causation of cancer and alteration of global climate.

POINT 7: THE COMMISSION HAS BEEN DECEIVED CONCERNING THE HEALTH HAZARDS OF INDUCED CURRENT.

The applicants have framed the issues with regard to induced current created by exposure to high voltage transmission lines in such a manner that the Commission was led to conclude (Opinion No. 76-12):

To the extent he is insulated, a charge may also be induced on a person in the electric field of the line. This induced charge can flow as a current, should the person touch a grounded conductor such as a metal fence post. Because of the low level of current that could result in this situation—barely above the threshold of perception for even the most sensitive people—the parties do not urge that this phenomenon is a hazard.

Notwithstanding that the parties did not urge that the phenomenon is a hazard, it is in fact a health hazard of dimensions far outstripping the two aspects of induced current which the applicants did elect to raise.

Consider the class of people who would routinely engage in domestic, commercial, agricultural, business, or recreational activity within 3000 feet of the proposed transmission lines. Exclude from the aforesaid class all those who would be in such close proximity to the lines that a spark discharge or a perceptible steady-state current would flow when any conductor in the vicinity was touched. Thus, the class of people to be considered, which numbers into the tens of thousands, are people who *routinely* experience *sub-threshold* electric currents due to the proposed transmission lines during the course of their normal activities. whenever they touch a conductor. Depending on the distance between the subject and the line, the aforesaid currents would be of the order of millionths of an ampere (microamperes), thousandths of a millionth of an ampere (nanoamperes), or millionths of a millionth of an ampere (picoamperes). *There are approximately 135 reports in the open peer-reviewed*

scientific literature which describe the growth altering affects of currents in the microampere, nano-ampere, and picoampere range. (see for example; Electrically Stipulated Bone Growth in Animals and Man: A review of the Literature, J.A. Spadaro, Clin. Orthop., 122, 325, 1977, and the 119 references cited therein. Also Electrical Osteogenesis: An Analysis, A.A. Marino and R.O. Becker, Clin. Orthop., 123 280, 1977, and, Clinical Experiences with Low Intensity Direct Current Stimulation of Bone Growth, R.O. Becker, J.A. Spadaro and A.A. Marino, Clin, Orthop., 124, 75, 1977). All such information has been denied to the Commission. In comparison to the information withheld from the Commission, the information made available is meaningless and insignificant. The applicants have lulled the Commission into the expectation that all problems of induced current could be dealt with merely by grounding fence posts and by taking other similar relatively trivial steps. In fact however, the problem of induced currents is much more vast and has not been addressed in these hearings.

POINT 8: THE COMMISSION MUST ORDER THE APPLICANTS TO GIVE NOTICE TO THE PEOPLE OF NEW YORK OF THE EXISTENCE OF A VALID SCIENTIFIC DISPUTE CONCERNING THE HEALTH HAZARDS OF EXPOSURE TO THE FIELDS OF HIGH VOLTAGE TRANSMISSION LINES.

The proposed transmission line is a regulatory-public health problem with the following aspects. A private corporation (applicants) is manufacturing a product (electrical power). As a consequence of the production of its product, the corporation emits or causes to be emitted a substance or entity (electric and magnetic field) into the environment. Construing the entire record most favorably to the applicants, it can be said:

that there exists a valid scientific dispute between competent scientific and medical authorities concerning whether chronic exposure to the electric and magnetic fields of the proposed high voltage transmission lines and existing high voltage transmission lines produce biological effects in the bodies of exposed people, and also, a dispute whether specific biological, effects so produced are a health hazard.

The aforesaid exposed people are generally unaware that an electric field and a magnetic field are in fact specific physical entities associated with high voltage transmission lines, that such fields are inherently capable of producing action at a distance, and that chronic exposure thereto places their health at risk in the opinion of at least some independent scientists.

The law imposes a strict duty of disclosure whenever an individual with a great deal to lose is exposed to a risk by someone with considerably greater knowledge (Prosser, Torts, 99) Thus, sellers are required to make full disclosure of all hazards involved in their products (*Witt v. Chrysler Corp.* 167 N.W. 2d 100; *Marcus v. Specific Pharmaceuticals* 82 N.Y.S. 2d 194). Policemen must warn suspects of their constitutional rights and offer legal assistance (*Miranda v. Arizona* 384 U.S. 436). The applicants similarly have a heavy duty to inform the people, of New York of the

aforesaid valid scientific dispute so that the people themselves may investigate and decide whereat the truth lies. The Commission must therefore order that a Notice of Dispute describing the aforesaid valid scientific dispute be sent to every person living or working adjacent to the proposed right-of-way, and that the general public be appropriately informed thereof. The Notice of Dispute should contain:

- (1) an explanation of the origin of the electric and magnetic fields and their relationship to high voltage transmission lines; and
- (2) a description of some of the biological effects that have been observed in laboratory animals, the intensity levels at which they occurred, and the opinion of those scientists which constitute the aforesaid valid scientific dispute; and
- (3) a description of the benefits to society of permitted continued existence of electric and magnetic fields of high voltage transmission lines in the living space of human beings; and
- (4) a description of the techniques or procedures that are effective in reducing the extent of exposure; and
- (5) an offer to answer any inquiries.

If the Commission fails to order the applicants to issue the Notice of Dispute, then it condemns the public to learn of the issues raised in the present hearing through vastly more inferior and unreliable sources, and thereby casts the entire fact-finding procedure of the Public Service Commission into disrepute.

POINT 9: THE COMMISSION MUST CREATE AN ADMINISTRATIVE RESEARCH COUNCIL TO OVERSEE THE FUNDING OF BASIC AND APPLIED RESEARCH DEALING WITH THE SAFETY OF HIGH VOLTAGE TRANSMISSION LINES.

NEED FOR AN ADMINISTRATIVE RESEARCH COUNCIL

The Commission has the ultimate responsibility to ascertain that high voltage transmission lines are operated in a manner not hazardous to human health. It might be asked therefore, from where does the Commission expect that the facts and information necessary to carry out its mandate will be obtained? The only organization in the United States with the capacity to provide such information is the Electric Power Research Institute (EPRI). EPRI however, is so completely industry-oriented that all material emanating therefrom relating to health hazards of high voltage transmission lines is tainted, biased, and consequently worthless. The Commission must therefore create an Administrative Research Council (ARC) to oversee the performance on basic and applied research concerning the effects of electromagnetic energy on people and the environment in connection with the manufacture and transport of electrical power. The ARC should be authorized to fund research by competent independent* investigators to furnish the information necessary to properly and efficiently regulate high voltage

transmission lines and simultaneously protect the health of the people of New York. The ARC should contain a Review Section composed of independent* individuals possessing the expertise necessary to offer advice to the Commission based on the results of the research performed by ARC investigators and that performed by others.

UNRELIABILITY OF THE ELECTRIC POWER RESEARCH INSTITUTE

The initial research project sponsored by EPRI (RP-98) found biological effects due to ELF electric fields. After five years and a total cost of \$533,000.00 the project was abruptly canceled at the recommendation of EPRI's Scientific Advisory Committee precisely at the point where the investigators began to report serious biological effects due to ELF exposure. Applicants' witness Michaelson is a member of that Committee and concurred in the decision to terminate. EPRI has two major projects underway (RP-799 and RP-129). In both cases the experimental protocols have been designed in such a way that no possible result of the experiments will be adverse to the utility industry. (Marino 12434) It is not possible for the experiments to furnish results showing that exposure to the fields of high voltage transmission lines is hazardous. (Marino 12434) Both experiments are being performed at four to eight times the exposure level at which applicants' witness Carstensen (Carstensen 3395), Michaelson (Michaelson 3717), Schwan (Schwan 3163), and Miller (Miller 5820), have testified is relevant to evaluating the safety of high voltage transmission lines. Moreover it will be several years before the EPRI projects are completed. Thus, their research program provides a false sense of movement towards resolution of the issue of safety of high voltage transmission lines. EPRI has several other projects underway, but notwithstanding that they have provided information thereon to the witnesses for the applicants, and notwithstanding that EPRI has repeatedly held itself out as a public service organization, and notwithstanding that the ratepayers of New York provide financial support for EPRI, EPRI has refused repeated requests from the staff of the Commission for copies of such information on the basis that the information is privileged.

It follows that the research funded by EPRI will not be useful to the Commission in assessing the safety of 765 kV transmission lines. EPRI's Scientific Advisory Committee is heavily weighted in favor of the interests of the electric utility industry. Its currently funded research does not reflect concern for the actual problems created by high voltage transmission lines. Moreover, the propriety of EPRI's action of terminating RP 98 at precisely the point at which the investigators began to report adverse affects in animals, reflects questionable policies, and undermines any confidence in the objectivity of their program.

Finally, EPRI cannot be relied upon because it makes available only a carefully selected portion of its information concerning ELF field induced biological effects. The situation strongly parallels that described in a recent headline: "Chocolate the World's Most Perfect Food—Report of Independent Study Group in Hershey, Pennsylvania."

POINT 10: ALL ARGUMENTS PURPORTING TO SHOW THAT THERE WILL BE NO HARMFUL BIOLOGICAL EFFECTS IN SUBJECTS EXPOSED TO THE ELECTRIC AND MAGNETIC FIELDS OF THE PROPOSED TRANSMISSION LINES ARE WITHOUT MERIT.

INTRODUCTION

Four distinct arguments have been advanced by the applicants to show that the proposed transmission lines are safe.

A. Experimental Scientific Evidence

It is argued that there exists laboratory evidence upon which one may confidently base a judgment that high voltage transmission lines such as the proposed transmission lines will not cause biological effects in subjects exposed to the electric and magnetic fields thereof.

B. Biophysical Calculations

It is argued that it is possible to do mathematical calculations which are properly applicable to subjects exposed to high voltage transmission lines such as the proposed transmission lines which establish that, according to the laws of physics and engineering, such transmission lines will not cause biological effects in the exposed subjects.

C. Utility Operating Experience

It is argued that high voltage transmission lines such as the proposed transmission lines are safe because there are no recorded instances of death or injury or disease of any kind attributable to exposure to their electric or magnetic fields.

D. Difference Between “effect” and “hazard”

It is argued that not every biological effect that may be caused by the electric or magnetic field of high voltage transmission lines in subjects exposed thereto is necessarily hazardous, and therefore, if a determination of the existence of a biological effect is made, there must be a further determination that the effect is a. hazard before the utility company may be required to cease the production thereof. (Marino 12321–12324)

SPECIFIC ARGUMENTS

A. Experimental Scientific Evidence

There are two distinct issues which arise with regard to the biological effects of the electric and magnetic fields of high voltage transmission lines.

Can such fields cause biological effects; and *will* such fields cause such effects? When we turn to the relevant scientific literature in an attempt to examine these issues, we find two general categories of studies. There are experimental studies in which the investigator observed a cause and effect relationship between the applied field and the parameter being measured (“found an effect”), which shall be referred to as ELF-plus reports. Similarly, there are studies in which the investigator failed to observe such a relationship (ELF-minus). Thus, there arises the question of which group of studies logically constitute acceptable scientific evidence for each issue.

ELF-minus reports have evidentiary value on the issue whether high voltage transmission lines, such as the proposed transmission lines, *can* cause biological effects in exposed subjects in only two cases, (1) wherein ELF-plus reports do not exist, and (2) wherein both ELF-minus and ELF-plus exist and contradict one another. Neither case applies in the present hearing. (*supra* and Exhibit C-5) In all cases other than those enumerated above, the ELF-minus reports merely establish the existence of certain conditions for which a specific effect is not observed. The establishment or enlargement of this limited class does not make it more likely that the class of all conditions will be unproductive of a biological effect, because the ELF-plus already exists. Thus, the ELF-minus serve no evidentiary purpose with respect to the issue of the possibility of biological effects.

The ELF-minus reports have evidentiary significance with regard to the issue of whether the proposed transmission line *will* cause physiological, growth, or behavioral effects in the exposed subjects. The weight accorded to each report will depend on how closely it relates to the actual conditions that would prevail if the proposed transmission line were to be constructed. Thus, the ELF-minus experiments performed in connection with Project Sanguine (Sanguine-ELF-minus), will clearly have significance and some weight on the issue whether the Sanguine antenna *will* cause biological effects. The Sanguine experiments, however, were performed at Sanguine field strengths, which are about one million times less intense than the field strength, of the proposed transmission line. Therefore, the Sanguine-ELF-minus reports, although of significance in this proceeding on the issue stated, can be accorded little weight. Indeed, all ELF-minus reports thus far cited in the present proceeding can be afforded little weight with respect to the issue whether the electric and magnetic fields of high voltage transmission lines will cause biological effects in subjects exposed thereto because, in each instance, the studies were performed under laboratory conditions of exposure that were vastly less intense than those that prevail near typical high voltage transmission lines with respect to applied field strength and duration of exposure.

The ELF-plus reports are the only proper scientific evidence on the first issue stated above. They establish beyond reasonable doubt that ELF fields *can* cause biological effects. They are obviously evidence on the issue whether high voltage transmission lines such as the proposed lines *will* produce such effects in the exposed subjects, and are open to the same test for weight as described above.

It must therefore be concluded that the ELF experimental literature affords the proponents of high voltage transmission lines, such as the proposed transmission lines,

no substantial support that exposure of the general population to the electric and magnetic fields of such lines will not cause biological effects.

B. Biophysical Calculations

By biophysical calculations are meant mathematical computations involving biological systems on the basis of which it is argued that some effect can, or will, or cannot, or must, occur as a consequence of ELF field exposure. Arguments based on theoretical calculations of necessity depend on numerous unverified and unverifiable assumptions concerning the nature of the physical system under investigation. Theoretical calculations of the possibility of ELF electric or magnetic field biological effects are properly employed to guide scientists in the choice of experiments. They are, however, not evidence because they are incapable of conveying information bearing on the likelihood of any biological effect due to ELF field exposure. Before any theoretical calculation, one knows that any given biological effect is either impossible, possible, probable, or definite. The calculation leaves the situation unchanged. This chronic infirmity of theoretical calculations is recognized in other forums. A review of the major environmental health issues raised in the United States has not revealed a single example wherein a state or federal regulatory agency or court has given decisional impact to theoretical calculations showing the absence of the possibility of a biological effect when competent investigators have reported such effects. (Marino 12322) Theoretical calculations are therefore, not evidence on either issue discussed above.

C. Utility Operating Experience

While it is true that no documented instances of harm to members of the public have resulted from exposure to the electric or magnetic field of existing high voltage transmission lines, such as the proposed lines, it is likewise true that no significant epidemiological studies have been performed upon which a claim that no such harm has occurred might be based. At best therefore, the claim rests upon brief and uncontrolled observations to the general effect that existing lines do not appear to be causing harm in the exposed subjects. The absence of gross, immediate, acute, and obvious effects on health when one passes near a high voltage transmission line is indeed a kind of low-level indication, that such lines are not obviously hazardous. Even though most people probably do not know what electric or magnetic fields are, if very gross sorts of things happened to people or animals in the vicinity of a transmission line, then surely a connection between them and the line would be made. When one entertains the idea of mere subtle effects occurring, the brief and uncontrolled observations are utterly inadequate for the purposes of assessing hazard. By way of example, if the absence of proper epidemiological studies together with brief and uncontrolled observations were sufficient to indicate the absence of subtle hazard, then the absence of parallel together with parallel observations in the controversy surrounding the depletion of atmospheric ozone or surrounding the contamination of the

watershed by chlorinated hydrocarbons could be viewed as evidence that these phenomena are not hazardous to human health. Since such an argument is unreasonable, it must be concluded that the operating experience of the utility companies affords no substantial evidence that high voltage transmission lines such as the proposed lines are safe. The only rational legal basis for standards setting for high voltage transmission lines is an evaluation of the *probability of risk*, and not a demand for a *proof of effect*.

D. Difference Between “effect” and “hazard”

Let us assume that the proposed lines caused a biological effect in some part of the general population exposed thereto. The assumed biological effect may be any physiological, growth, or behavioral effect.

In such a situation, there is a strong presumption that the biological effect is potentially hazardous. There are no instances in which a state or federal, court, or administrative agency indulged in the contrary presumption. (Marino 12329) There is no precedent for an argument by the private corporation that they should not be regulated because the effect that they caused in the exposed subjects had not been proved hazardous.

The presumption of hazard arises directly from the proscription against involuntary human experimentation. To urge that a biological effect induced in a subject exposed to the fields of high voltage transmission lines should not be prevented until it has been shown to be hazardous is tantamount to urging the performance of human experimentation to evaluate the degree of biological insult caused by the transmission lines. Moreover, such human experimentation would be involuntary since, in the setting described above, informed consent is not obtained. Since involuntary human experimentation is a completely unacceptable alternative, it follows that any biological effect caused by high voltage transmission in exposed subjects is strongly presumed to be hazardous.

It must therefore be concluded that there is no basis for a distinction between an “effect” and a “hazard” in the context of high voltage transmission lines such as the proposed lines, and that such a distinction is medically unethical (Becker 9004) and legally unprecedented.

POINT 11: THE TESTIMONY OF APPLICANTS WITNESS HERMAN SCHWAN REGARDING THE HEALTH HAZARDS OF HIGH VOLTAGE TRANSMISSION LINES IS WITHOUT MERIT.

SUMMARY OF TESTIMONY

Herman Schwan has testified that exposure to the fields of the proposed transmission line will not be harmful or unsafe. (Schwan 3162-9ff) His conclusion is based on the

argument that for nominal electric and magnetic fields of the proposed transmission line of 10 kV/m and 1 gauss respectively, the electric field and the current density that would be induced in an exposed subject are much smaller than the corresponding safe values. (Schwan 33162-11ff) Specifically, the fields of the proposed transmission line will induce a current density in an exposed subject of 0.0000001 A/cm^2 (J-induced), whereas 0.0001 A/cm^2 (J-safe) may be safely experienced. Also, the fields of the proposed transmission line will induce an electric field in an exposed subject of 0.00005 volts/cm (E-induced), whereas 0.1 volts/cm (E-safe) may be safely experienced. (Schwan 3162-14ff) J-safe and E-safe are conservative and conclusive. (Schwan 3166-18) They are approximate values for completely safe exposure. It probably takes substantially greater values to produce harmful effects. (Schwan 3166-21ff)

Thus, Schwan believes he knows the specific levels of induced current density and induced electric field that may be safely experienced. He believes also that he knows the specific levels of these parameters that will actually occur in the subjects that will be exposed to the fields of the proposed transmission line. He concludes that since the former will exceed the latter, the proposed transmission lines are safe. Most of the analysis in his testimony is devoted to explaining the basis of his assertion J-safe= 0.0001 A/cm^2 (Schwan 3167-3 to 3168-1), and that the safe electric field is 0.1 volts/cm (Schwan 3168-18 to 3173-12).

Schwan devotes some effort to an analysis of the Soviet position on high voltage transmission lines, and concludes that the Soviet experience supports the applicants' position (Schwan 3173-13 to 3176-16).

The testimony of Herman Schwan has no merit because (Marino 12357-12392):

1. Schwan has not identified a safe internal current density, and
2. Schwan has not identified a safe internal electric field, and
3. Schwan's analysis of the Soviet experience with high voltage transmission lines is superficial and incorrect, and
4. During his cross-examination, Schwan contradicted his own direct testimony, and the testimony of applicants' other witness by substantially accepting as valid many ELF reports which recite an electric field induced biological effect, and
5. Schwan followed an improper dual standard in determining which scientific reports he accepts.

SCHWAN HAS NOT IDENTIFIED A SAFE INTERNAL CURRENT DENSITY

Schwan has argued that since an internal current density of 0.0001 A/cm^2 will not cause tissue heating or tissue excitation, it is safe. (Schwan 3167-3 to 3168-7) Conceding, *arguendo*, his premise*, the conclusion that 0.0001 A/cm^2 is safe is not a logical

consequence thereof.

On the one hand, Schwan believes he knows how nerves work, that is, he understands the mechanism underlying information transfer in neural tissue.

With such knowledge, he is able to conclude that the presence in neural tissue of a current density of 0.0001 A/cm^2 will not alter or impair neural function and is therefore, safe with respect to neural function. (Schwan 3168-3 to 3168-8) On the other hand, there are a great many other systems within the body for which knowledge of the mechanisms of action and control is lacking. Schwan of course shares in the aforesaid ignorance. For example, the mechanism by which the body controls the healing bone fractures is unknown. It therefore, cannot be predicted whether the presence of a current density of 0.0001 A/cm^2 inside such healing tissue will be safe. A similar comment applies to all healing tissue. The mechanisms regulating the production of insulin by the pancreas and the production of adrenaline by the adrenal glands are unknown. It therefore, cannot be predicted whether the presence of 0.0001 A/cm^2 inside the pancreas or adrenals will affect their function. A similar comment applies to the function of every gland and organ in the body. The etiology of many human diseases is unknown. It therefore, cannot presently be predicted whether the likelihood of developing such diseases is altered by the presence within the body of a current density of 0.0001 A/cm^2 . We do not understand the mechanisms underlying the processes of learning or memory; we therefore, cannot predict whether these processes will be altered by the presence within the body of a current density of 0.0001 A/cm^2 .

Since the mechanisms underlying the great multitude of biological processes are unknown, Schwan cannot appraise his asserted safe current density with respect to such processes as was possible, in the single case in which he claimed knowledge of the mechanism. Thus, even if one concedes that 0.0001 A/cm^2 is a safe current density with respect to neural function, there are a great number of bodily functions and processes which remain unconsidered, and for which a safe current cannot be identified.

In his direct testimony, Schwan advances a number of positions, all of which are unfettered by specific references to the work of other. In particular, his position that tissue heating and tissue stimulation are the only biologically significant mechanisms is unsupported by citations, references or analysis. Schwan was therefore specifically asked to provide citations to all reports or studies which provide the basis for the opinion that there are no other "biological mechanisms of significance in evaluating exposure to electric currents." (Interrogatories served on Niagara Mohawk January 28, 1976.) His reply merely restated his position, and contained no specific documentation. Throughout his cross-examination, he also failed to document or justify his position. (Schwan 6754-6834) It must therefore, be concluded that no support exists, and that his position is a naked assertion, unsupported by authority, evidence or analysis. As a consequence of Schwan's failure to document or even render plausible his position, it is not logically possible to claim that 0.0001 A/cm^2 is a safe current density because its safety has only been considered with respect to one mechanism.

Thus far it has been conceded, *arguendo*, that 0.0001 A/cm^2 is a safe current density with respect to neural tissue.

The fact is however, the safety of 0.0001 A/cm^2 with respect to neural function is only a contested scientific theory.

In testifying that 0.0001 A/cm^2 is safe with respect to nerves (Schwan 3168-3 to 3168-8), Schwan offers to the Commission, as evidence, one scientific theory, while withholding the major competing scientific theory.

Nerves transmit information between various parts of the body. One school of neurophysiologists hold that information transfer occurs only when excitation occurs with the resultant propagation along the nerve of a wave of depolarization known as the action potential. Schwan adopts this view. Another school of neurophysiologists holds that information can be transferred even if there is no tissue excitation and hence no action potential.

Even it were true that 0.0001 A/cm^2 would not cause tissue excitation, it does not follow that this current density is safe with regard to neural function because the question whether it is safe with regard to alternate mechanisms of information transfer has not been resolved. Irrespective of the merits of the position of either group of neurophysiologists, a bona fide scientific dispute exists regarding the mechanism of information transfer in neural tissue. One could conclude that a current density of 0.0001 A/cm^2 is safe with respect to neural function only if it was concluded that one school of neurophysiologists was correct, and the other incorrect. It is improper for Schwan, who is not a neurophysiologist to intimate to the Commission that there is only one view regarding the mechanism of information transfer in neural tissue with respect to which a specific current density must be evaluated for safety. It is misleading for Schwan, in the complete absence of supportive evidence, to adopt and offer the view that one particular school is correct, when the issue has not even been resolved among professional neurophysiologists.

SCHWAN HAS NOT IDENTIFIED A SAFE INTERNAL ELECTRIC FIELD

Schwan argues that 0.1 volts/cm is a safe internal electric field because it will not produce dielectric saturation (Schwan 3169-14 to 3169-21), or harmful effects on biopolymers (Schwan 3169-21 to 3170-7), or fields which are significant compared to those naturally present (Schwan 3170-2 to 3170-12), or produce fields which penetrate cells (Schwan 3170-13 to 3170-21), or exert electrical forces on cells (Schwan 3171-1 to 3171-17).

In urging the existence of a safe internal electric field, Schwan deceives the Commission to the extent that he implies that it is a basis distinct from the current density of 0.0001 A/cm^2 upon which to assess safety. In reality, safe levels of internal current density and internal electric fields are redundant not distinct concepts. The current density and electric field at a point within a material are related by a constant

factor associated with the material called its resistivity (or conductivity). Schwan believes that he knows that the resistivity of body tissue is about 1000 ohm-cm. Since resistivity multiplied by current density equals electric field, it follows that if 0.0001 A/cm² were a safe current density for body tissue, then 0.1 volts/cm would be a safe electric field for tissue. Since however, it has been shown that there is no basis for the assertion of a safe internal current density it follows inexorably that Schwan cannot identify a safe internal electric field.

Since Schwan's testimony is tautological in substance but not form, it may be worthwhile to deal with his position in the language of electric field.

(a) 0.1 volts/cm and safety; dielectric saturation. (Schwan 3169-14 to 3169-21)

Schwan argues that dielectric saturation is a prerequisite for harmful field effects, and since it cannot occur at 0.1 volts/cm, such an electric field is safe. He provides however, no citations or references to explain or support or illuminate his rather enigmatic premise. He was therefore, asked specifically to do so via interrogatories.

In his reply he discussed elementary dielectric theory, and defined the term dielectric saturation. He failed however, to supply citations or references to support his premise. His premise that dielectric saturation is a prerequisite for harmful effects must therefore, be considered to be a mere naked assertion unsupported by any authority or evidence and therefore, impossible of sustaining the conclusion that 0.1 volts/cm is a safe internal electric field.

(b) 0.1 volts/cm and safety; biopolymers. (Schwan 3169-21 to 3170-7)

Schwan. argues that harmful effects on biopolymers have never been observed at 0.1 volts/cm, and if they could occur, "life as we know it probably could not have developed." He provided no citations or references to support or explain this view, and he was therefore specifically asked to do so via interrogatories. His reply listed four references. The citations however, have nothing whatsoever, to do with safe internal electric fields, or harmful effects of electric fields on biopolymers. They do not deal with the effects of electric fields on animals. They are texts concerned with the physics of the interaction between electricity, and macromolecules and membranes. They do not speak to the biological concepts of harm, safety, life, or evolution. Since therefore, the authority that Schwan cites does not support his position with respect to biopolymers, that position cannot be considered evidence that 0.1 volts/cm is a safe internal electric field.

(c) 0.1 volts/cm and safety; natural internal fields. (Schwan 3170-7 to 3170-12)

Schwan argues that inside tissue there are naturally electric fields of 1000 volts/cm, and more, and the proposed transmission line will cause fields within the tissue of exposed subjects that are "infinitely small," implying by such a comparison that 0.1. volts/cm is safe, or should be so considered.

High electric fields are present inside every corporeal body. They arise because all

matter contains positively and negatively charged particles. There is however, very little region of high electric field within any material. The fields induced in the tissue of subjects exposed to the fields of the proposed transmission line vastly exceed in magnitude, and greatly differ in frequency from that which is naturally present at virtually every location within the body of the exposed subject. Except in the realm of subatomic phenomena, one generally ignores the presence of high electric fields inside matter.

An electric field of 1000 volts/cm has no significance over dimensions which would make it of interest in this hearing. The sophistry of Schwan's argument is evident if one considers the consequences thereof. Schwan has stated that the resistivity of biological tissue is 1000 ohm-cm. Employing the electric field of 1000 volts/cm, there would exist a normal current density within the body of 1 A/cm^2 , which is ten thousand times greater than Schwan's safe current density. (Schwan 3166-4)

(d) 0.1 volts/cm and safety; shielding. (Schwan 3170-13 to 3170-21)

Schwan appears to say that 0.1 volts/cm is safe because cells are shielded by their membranes. His position however, is unreferenced and unexplained. Consequently, it is screened from analysis.

(e) 0.1 volts/cm and safety; electrical forces. (Schwan 3171-1 to 3131-17)

Schwan argues that electrical forces on cells are insignificant at 0.3. volts/cm. When asked to supply all citations upon which he based his position, he cited one report in his reply. The report however, furnished no support for his position. It only offers a theory employing dipole forces on cells exhibiting no net charge, to explain the observations of others that electric fields of 100 volts/cm are necessary to cause orientational effects in cells. Cells however, contain areas of fixed charge, and some cells exhibit a net electric charge. Consequently, monopole forces acting on an entire cell or on a part thereof may be vastly more important than the dipole forces which Schwan has studied. Assuming that Schwan's theory is correct, it explains what exists, and is not evidence or support to prove the nonexistence of effects which proceed via some mechanism other than that used in the theory.

It should be noted explicitly that even if it were true that 0.1 volts/cm was a safe internal electric field with respect to considerations of dielectric saturation, biopolymers, internal fields, shielding, and electrical forces, the assertion that such a field is therefore, safe for people to experience within their bodies is a generalization of truly impressive proportions. There is in fact, not one shard of evidence to indicate that the list of mechanisms which Schwan chooses to discuss with respect to safety, is sufficient for such purposes.

In his direct testimony (Schwan 3171-18 to 3173-8), Schwan refers to claimed weak field effects observed at the system level. Unfortunately, the studies which he had in mind are not. identified in his testimony. When specifically asked to do so, he stated only that they were to be found in the testimony of applicants' witnesses Miller and Michaelson. With regard to the results contained in the unidentified literature, Schwan

concludes that no biophysical principles have been suggested in support thereof, and that further research is required. (Schwan 3173-9 to 3173-11) To Schwan, a biophysical principle is a principle of physics applied to biology. (Schwan 6566) The conclusion of his analysis on transcript pages 3171–3173 would therefore, appear to be that principles of physics cannot explain some of the results discussed by Miller and Michaelson. It must be pointed out that this establishes the inadequacy of physics, and does not impeach the observations of biologists. There are very few, if any, biological functions explainable by the laws of physics.

SCHWAN'S ANALYSES OF THE SOVIET EXPERIENCE WITH HIGH VOLTAGE TRANSMISSION LINES IS INCORRECT

Schwan argues that the Soviet position with respect to the biological effects from the electric and magnetic fields of high voltage transmission lines verifies the applicants' position that adverse health effects will not result from the 765 kV transmission lines' electric field of 10 kV/m at 60 Hz. (Schwan 3173-3176) As a basis for this view, he cites the report by Lyskov and a discussion of the report which was coordinated by Tikhodeyev and Balderston for the USSR and the US delegation, respectively. Schwan's analysis consists essentially of three direct quotes from Lyskov, and one from Tikhodeyev.

Contrary to Schwan's testimony, the Soviet position with respect to the biological effects of *electric* fields from high voltage transmission lines is irreconcilable with that of the applicants' in this hearing. Schwan correctly testifies that the Soviet position with respect to the biological effects of the *magnetic* field of high voltage transmission lines, and the Soviet position with respect to the consequences on *nonsystematic* exposure to the *electric and magnetic* fields of high voltage transmission lines are consistent with that of the applicant. In doing so however, he contradicts the testimony of the applicants' witness Michaelson.

Electric field. Quoting from Lyskov, Schwan lists Soviet electric field intensity standards (design criteria) for high voltage transmission lines (Schwan 3174-14 to 3174-21), and he quotes language indicating that the Soviet high voltage transmission line operating experience has been favorable. (Schwan 3174-1 to 3175-4) Schwan's testimony implies that since the Soviet design criteria permit ground level electric field strengths higher than that of the proposed transmission line, and since the Soviet operating experience has been favorable, the Soviet position supports the applicants' position that the proposed transmission line will be safe. (Schwan 3176-13 to 3176-16) Schwan chooses to ignore however, the applicable Soviet rules and regulations which are part of the Soviet regulatory response to high voltage transmission lines. The Soviets have work rules governing the extent of exposure to high voltage transmission line electric fields. They are developing comparable rules for other groups. Soviet high voltage transmission lines are built 984-1640 feet from planned population sites. They are not built within 328 feet of inhabited dwellings.

For a transmission Line similar to that proposed here, the Soviet Zone of Influence would be 362 feet. Within the Zone of Influence, unauthorized people are not permitted, and agriculture is limited and must be carried out in shielded machinery. Beaches, shops, etc., must be located a sufficient distance from the edge of the Zone of Influence.

Buildings are not permitted within the Zone of Influence. It is within the set of applicable rules and regulations, including those described, that the favorable operating experience described by Lyskov and Tikhodeyev has been achieved. The Soviet rules and regulations are a result of a broad Soviet research effort into the area ELF field biological effects. (Marino 7206-13 to 7219-8) To the extent that Schwan's testimony states or implies that the Soviet position on the biological effects of the electric field of high voltage transmission lines supports the position of the applicants, his testimony is in error.

Magnetic field. The Soviet view of the biological effects of the magnetic field of high voltage transmission lines appears to be that there are none. The Soviet view of the hazard of the non-systematic exposure of the public to the electric and magnetic fields of high voltage transmission lines is that there is none. (Marino 7210-18) In a sense therefore, the Soviet positions are consistent with those of the applicants. Schwan's testimony is structured to exploit this consistency. His first two quotes are of the language indicating the Soviet view on magnetic fields (Schwan 3174-1 to 3174-8), and the language indicating the Soviet view on non-systematic exposure. (Schwan 3174-14 to 3174-17) The point is that only in these two areas, and only in the limited sense described can it be argued that the Soviet view supports the position of the applicants.

Contradiction of Michaelson. The area of magnetic field induced effects in biological systems is the focus of a considerable research effort in the Soviet Union.

One consequence of the Soviet research effort is the apparently official Soviet view that the magnetic field of high voltage transmission lines does not constitute a health hazard. Schwan quotes the Soviet view approvingly. (Schwan 3174-1 to 3174-8) It follows therefore, that he believes that the Soviet scientific literature dealing with the biological effects of ELF magnetic fields is of sufficient quality and reliability upon which to base an opinion.

Such a direct reliance on Soviet studies is inconsistent with the testimony of applicants' witness Michaelson who has testified that the Soviet scientific literature is unreliable and largely unavailable.

SCHWAN'S CROSS-EXAMINATION TESTIMONY DIRECTLY CONTRADICTED BOTH HIS DIRECT TESTIMONY AND THE TESTIMONY OF APPLICANTS' OTHER WITNESSES

In his direct testimony, Schwan adopted the view that he could identify for the

Commission safe values of the internal current density and electric field. He chose to describe his safety levels in terms of internal values of field and current. (Schwan 3162-11 to 3162-21). It must be understood how one arrives at internal values of these quantities. Given a biological system exposed to a specific external electric field (which is measurable) one employs a number of assumptions and thereby derives mathematically a value for the internal electric field and current density which is a consequence of the applied external electric field under the assumptions employed. (Carstensen Exhibits NNN and D-4) For example, according to Schwan, a man exposed to the ground level fields of the proposed transmission line will experience an internal current density of 0.0000001 A/cm^2 , and an internal electric field of 0.00005 v/cm . (Schwan 3162-1 to 3162-21) It is the custom among investigators in the ELF area when reporting experimental results to specify the biological system studied, the external electric field applied, and the result obtained thereby, and to refrain from asserting values for internal fields and currents because invariably such values are based on unverified and unverifiable assumptions employed in the calculation. In his only publication in the ELF area involving biological experimentation, in which he studied amoebas, Schwan also followed this custom.

If one inverts Schwan's mathematical calculations, the strength of the applied external electric field which corresponds to Schwan's safe internal electric field can be found. The external electric field so determined is $20,000 \text{ kV/m}$. That is, according to Schwan, an individual would have to be exposed to an electric field greater than $20,000 \text{ kV/m}$ before the internal electric field would be unsafe. Since such an electric field strength in air is impossible because air breaks down at about $2,000 \text{ kV/m}$, Schwan's testimony is equivalent to an assertion that ELF electric field biological effects are physically impossible. Schwan has consistently advocated such a view. In 1972, he stated "It is virtually impossible to evoke dangerous current densities in the human body by external low frequency fields." In 1973, Schwan described the results of a calculation in which he purported to show that a man, assumed to be shaped like a sphere, could be subjected to the entire power output of a typical electric generating plant, and still the induced currents would not be dangerous.

Schwan's viewpoint is quite extremist. There is no one who has spoken more forcefully in support of the utilities' views that there can be no ELF electric field induced biological effects. On the other hand, about 65 groups of scientific investigators in the free world, and an indeterminate number within the Soviet Union have reported the kind of biological effects which Schwan says are impossible. When confronted by specific reports showing ELF-field induced biological effects, Schwan substantially accepted as scientifically valid every report discussed. In those cases where reservations were expressed, they resulted from Schwan's misunderstanding of the individual report, and not from a defect within the report. Throughout his cross-examination, the only experimental reports which Schwan found to be invalid were reports cited by applicants' witness Miller to support his conclusions. Schwan went on to identify himself as possessing two standards for reading the experimental literature, depending on whether or not the results reported therein comported with his viewpoint. Schwan further testified that he has not read many of the reports relied upon, by the other witnesses for the applicants.

1. Bassett (Marino 7151-7 to 7152-12)

Bassett reported that ELF fields increase the rate of fracture healing in dogs. When asked if he accepted Bassett's results, Schwan replied that he "could not detect any faults from my reading of the article." (Schwan 6716) Carstensen on the other hand finds many faults with Bassett's report. (Carstensen 7005-10 to 7009-11)

2. Watson (Marino 7157-1 to 7158-10)

Watson found that ELF electric fields modify the growth rate of bones. When asked if he accepted Watson's results, Schwan that he had "no qualms with the general conclusions." (Schwan 6714)

3. Solov'ev (Marino 7163-21 to 7164-7)

Solov'ev described certain lethal effects on mice and insects of high intensity ELF electric fields. When asked if he accepted Solov'ev's results, Schwan replied "by and large yes," and "at such very high field strengths many effects can take place which are very detrimental." (Schwan 6712)

4. Goodman (Marino 7166-4 to 7168-12)

Goodman reported delays in the rate of cell division brought about by ELF fields. When asked if he accepted Goodman's results, Schwan replied "almost but not quite." (Schwan 6704) On the other hand, applicants' witness Miller believes that Goodman's work is "outstanding," and that its a "beautiful example of a well constructed well analyzed experiment." (Miller 5921)

Schwan's single objection to Goodman's work is that there is a possibility of an electrode poisoning effect. Such a possibility has been considered by the authors and others, and judged to be highly unlikely in view of the elaborate precautions taken during the experiment.

5. Southern (Marino 7168-13 to 7169-9)

Southern reported that ELF fields disrupted the orientational ability of birds. When asked if he accepted Southern's results, Schwan replied "yes and no." (Schwan 6694) Schwan's reservations are that the report is lacking in statistics (Schwan 6694-21) and contains certain inconsistencies. (Schwan 6696)

A careful reading of Southern's report shows that all the data pertinent to the experiment is in the report, as are all the results of statistical tests thereon. Southern employs the word "inconsistency" in describing some specific results, but the inconsistency does not, as Schwan implies, vitiate Southern's conclusion that ELF fields can disorientate birds. It should be noted that the editors and peer reviewers of *Science*, one of the most prestigious American science journals, apparently feel that Southern has not impeached his own research inasmuch as it chose to publish Southern's work.

Schwan's analysis of Southern's work is inconsistent with that of applicants' witness Miller who believes that it "lends support to the hypothesis that birds instinctive migratory directional behaviour can be influenced somewhat by the Sanguine field." (Miller Exhibit ZZZ, p.49) [The Sanguine magnetic field is comparable to the magnetic field of proposed transmission lines; however, the Sanguine electric field is about one million times weaker than the electric field of the 765 kV lines.]

6. Gavalas-Medici (Marino 7171-15 to 7172-8)

Gavalas-Medici reported behavioral effects in monkeys due to exposure to ELF electric fields. When asked if he accepted Gavalas-Medici's results, Schwan replied "not necessarily." (Schwan 6677-8) The basis of his reservation is that electrodes were used, and that they are "potentially suspect." (Schwan 6678-13)

Schwan however, gave no factual basis for the implication that the use of electrodes somehow impugns or weakens Gavalas-Medici's conclusion.

7. McCleave (Marino 7170-3 to 7174-15)

McCleave reported that fish could perceive extremely weak ELF electric fields. When asked if he accepted McCleave's results, Schwan replied "not necessarily." (Schwan 6666-17) Schwan's reservations are that "electrodes were used" (Schwan 6666-17), and that McCleave "could not confirm" (Schwan 6668-8) his results in later research. The electrodes used by McCleave to monitor activity were made of glass and plastic. The electrically conducting portion was outside the fish tank. The cardiac recording electrodes were twisted pairs of teflon coated wire which were implanted fore and aft of the heart, thereby maximizing the signal to the electrodes when the fish was *parallel* to the applied field. McCleave's results showed a maximum response when the fish was *perpendicular* to the field. Therefore, the electrode artifact hypothesized by Schwan (Schwan 6670-1 to 6670-8) could not have produced the observed results.

Schwan's implication that one series of McCleave's experiments detracts from another series (Schwan 6668) is not accurate. The experiments, referred to by Schwan, were not ELF experiments.

The view of McCleave's work by applicants' witness Miller differs from that of Schwan. Miller believes that McCleave's work supports the premise that fish can detect ELF fields. (Miller, Exhibit ZZZ, p. 44)

8. Wever (Marino 7173-16 to 7176-21)

Wever reported that ELF electric fields can alter human biorhythms. Schwan testified that Wever's work "appears to be well done" (Schwan 6619-10), but that "there lingers some doubt in my mind." (Schwan 6619-14) Schwan lists three objections:

1. "Wever did not make any allowances for naps." (Schwan 6619-19) In most of the experiments reported by Wever, the subjects were not allowed to take naps, so no problem with respect to naps arose. In those experiments with naps,

published analyses show that they have no effect on the observed results.

2. “Dr. Wever has conducted more than 100 experiments. Only a fraction of these experiments, something like 20 or 40 have been published. Why not all?” (Schwan 6620-9) Schwan’s statement is erroneous and unfair to Wever. Wever has in fact published the results of all his experiments which deal with ELF fields in anyway. Schwan was educated in Germany, and was an Associate (1937–1945) and Assistant Director (1945–1947) at one of the Max Planck Institutes where Wever performed his research. (Schwan 3154) It seems eminently reasonable therefore to assume that Schwan reads German, and consequently that he could have read the German report which contains complete information about all of Wever’s experiments.
3. Since the experimental subjects were exposed both the applied electric field and the electric field from light bulbs in the bunkers where they lived, the observed changes in the human biorhythms could have been due to the electric field from the light bulbs, and not the applied electric field. (Schwan 6621) The applied electric field in Wever’s experiment was 0.025 volts/cm (26). The electric field from a light bulb, at a typical distance away from it, is about 0.0020 volts/cm. Thus, if Schwan’s objection to Wever’s work had any merit whatsoever, it would indicate that electric fields ten times less intense than Wever’s applied field were capable of causing biological effects. In point of fact however, the electric fields from the lights in both the control and experimental bunkers were identical, and consequently the observed differences in the biorhythms in the subjects studied cannot be concluded in anyway to be due to the fields from the light bulbs.

9. Marino (Marino 7191-13 to 7197-7)

Marino reported that ELF electric fields altered the growth rate in three successive generations of mice. When asked if he accepted the results, Schwan replied “not necessarily.” (Schwan 6582-14) Schwan’s reservation is based on the belief that “discharges while drinking might influence his data.” (Schwan 6584-11)

Such a possibility has been discussed. (Marino 7195-21 to 7196-8) Whereat it was shown that any possible effect of the discharges affects only the severity of the observed effects, and has no bearing on their existence. Schwan has failed to take cognizance of the distinction.

10. Marino (Marino 7181-4 to 7191-12) Marino reported that ELF electric fields caused stress in rats. When Schwan was asked if he accepted the results, he replied “not necessarily” (Schwan 6600-5), and again expressed a reservation regarding discharges. The possibility that such discharges were a significant factor in the observed results was considered and rejected. (Marino 7187-3 to 7187-11) Schwan has similarly failed to take cognizance of the analysis.

SCHWAN'S TESTIMONY WAS PREPARED PURSUANT TO AN IMPROPER DUAL STANDARD FOR DETERMINING WHICH SCIENTIFIC REPORTS ARE VALID

Schwan's criteria for accepting experimental results are (1) the circumstances surrounding the report must not be faulty, (2) the work must not be subject to criticism based on defects or statistics, and (3) it must be confirmed by others. (Schwan 6571-13 to 6571-20) Unfortunately, these criteria apply only to reports which show a biological effect as a consequence of the exposure of the system to an ELF electric field. If a scientist reports a result which comports with his viewpoint, Schwan's criteria are different. When the conclusions of the experiment were that there was no effect, "I was not further interested in digging into the material." (Schwan 6732-2) Schwan stated repeatedly that he reads more carefully those studies which show an effect, as compared to those studies which show no effect. (Schwan 6732-21, 6734-11) Schwan testified that he read the Hazelton Studies (relied upon heavily by applicants' witness Miller (Miller, Exhibit ZZZ, pp. 1-26) much less carefully than he read the literature which reported a positive effect due to ELF field exposure, because the studies were negative, and because he is under time pressure. (Schwan 6735-4) Schwan stated that if the summary of the report didn't express conclusions which were antagonistic to his viewpoint, then he didn't read the report. (Schwan 6738-12) Referring to almost the entire set of documents upon which applicants' witness Miller relied to support his conclusion, Schwan testified that he read some of the reports, but many he did not read because they were negative reports. (Schwan 6744-2, 6744-17, 6746-23 to 6748-5)

Notwithstanding that he doesn't read the negative literature, Schwan accepts it as valid. (Schwan 3173-1 to 3173-5, 3170-19)

The validity of scientific experiments is not properly a function of the degree to which such results support a particular view. Whether a report describes a positive result ("When I varied X, Y changed") or a negative result ("When I varied X, Y did not change"), the applicable scientific standards by which one judges whether the results accurately describe nature are identical. It is no mean failure in scientific objectivity to do otherwise.

DEFENSE INTELLIGENCE AGENCY REPORT

Schwan's position in this proceeding originated in connection with microwaves. Since about 1950, Schwan has argued that microwaves can affect a biological system only by causing heating, or by stimulating excitable tissue. In this proceeding, Schwan has reasserted his view at the lower frequency of 60 Hz, joined his assertion with a statement that neither phenomenon will occur at 60 Hz, and concluded that 765 kV transmission lines are therefore safe.

On November 22, 1976, the Associated Press released a story concerning a newly declassified US Defense Intelligence Agency report. The report described research by Soviet scientists on the biological effects of exposure to low-level (i.e., non-thermal, non-stimulatory) microwave radiation. According to the report, the Soviet research suggests "the potential for the development of a number of anti-personnel applications."

Based on analysis of experiments conducted in the Soviet Union and Eastern Europe, the report says "Soviet scientists are fully aware of the biological effects of low-level microwave radiation which might have offensive weapon application." The report concluded that Soviet research in this area "has great potential for development into a system for disorienting or disrupting the behavior patterns of military or diplomatic personnel; it could be used equally as well as an interrogation tool."

The Defense Intelligence Agency report is to Schwan what Columbus was to the flat earth theorists; the report describes phenomena which Schwan has spent a professional lifetime denying were possible. Since Schwan's premises are not valid in the frequency range for which they were created, it follows that they may not be validly extended to the ELF region, as he has done in his testimony.

The Soviet studies described in the Defense Intelligence Agency report are empirical in nature. Therefore the possibility, perhaps the probability, exists that similar or related effects can occur in people exposed to the fields of 765 kV transmission lines via the same presently unknown mechanisms of interaction.

POINT 12: THE TESTIMONY OF APPLICANTS' WITNESS SOL MICHAELSON REGARDING THE HEALTH HAZARDS OF HIGH VOLTAGE TRANSMISSION LINES IS WITHOUT MERIT.

SUMMARY OF TESTIMONY

Sol Michaelson has testified that there will be no significant biological effects due to exposure to the fields of the proposed transmission line (Michaelson 3718-1) based upon his analysis of the reports in his testimony. (Response to interrogatories March 6, 1976.)

The literature cited by Michaelson however does not support his conclusion. (Marino 12420-12427)

Michaelson's testimony contains several additional misstatements of fact which will be addressed specifically.

REPORTS IN MICHAELSON'S TESTIMONY

1. Hauf. Michaelson discusses the work of Hauf's group (Michaelson 3726-2 to 3726-14, 3734-23 to 3735-5) involving short-term exposure to ELF fields. Hauf's work is relevant to the issue of whether the 765 kV line will cause biological effects in people exposed thereto. His specific work cited can be accorded little weight with respect to this issue because it involves total exposures of not more than three hours. Moreover, in later work Hauf has reported biological effect due to ELF exposure under identical conditions of exposure.

2. Johansson Michaelson discusses Johansson's work (Michaelson 3726-13 to 3727-2) involving short-term exposure to ELF fields. Johansson's work is relevant to the issue just described, but again is of minor significance because it involves a total exposure of only 75 minutes.

Inasmuch as the reports described above are a complete listing of those cited only by Michaelson, it must be concluded that Michaelson has not furnished any significant support for his conclusions.

ADDITIONAL MISSTATEMENTS

A. Michaelson's philosophical view of the concept of hazard does not properly apply to the proposed transmission lines.

Michaelson urges that there is a distinction between an effect and a hazard. (Michaelson 3720-16 to 3720-23)

His view is grossly improper however, in the context of this proceeding. A biological hazard in the context of the proposed transmission lines is a biological effect induced in the bodies of exposed subjects, or likely to be so induced based upon an evaluation of laboratory experimentation, which has not been shown clearly and convincingly to be harmless. (Carstensen 6428-16 to 6428-22) Michaelson who has had no training in the law, and who has conducted no human research would reverse the evidentiary burden. (Michaelson 3721-4, 10407-2). His view however, is alien to our legal system because its implementation would constitute involuntary human experimentation. It is totally unfair to impose the burden on the exposed subjects to prove hazard.

It should be noted that there has been a complete failure on the part of applicants to show that any biological effect likely to be induced in the bodies of subjects exposed to the fields of the proposed transmission lines is harmless. Further, the only medically competent witness who has participated in this proceeding has testified that all such likely effects are potentially hazardous. (Becker 9012)

B. Michaelson's testimony is in error to the extent that it implies that a condition for the validity of scientific experiments is that the observed results be established variation of the experimentally dependent parameter.

Applicants' witnesses at times, take a bizarre view of the experimental literature dealing with ELF field induced effects. They argue that since it is possible the observed results could be due to something other than the applied ELF field, the research is, ipso facto, dubious. Michaelson takes this view with respect to the Soviet studies. (Michaelson 3729-3 to 3730-5) The criterion implicitly adopted by applicants' witnesses would establish as equally dubious every scientific study ever performed and every such study yet to be performed. For example, referring to a study by Sazonova. (Michaelson 3729-17)

Michaelson says "It is possible to postulate a large number and variety of factors. other than exposure to the electric field as the cause of the observed differences." (Michaelson 3730-8). It is possible however, to say the same of every experiment performed or that will, be performed. Such a statement neither reflects adversely on the performing scientist nor advances the state of analysis in this hearing. The point is that Michaelson has no factual information on the basis of which he can contradict the authors of the Soviet studies.

C. To the extent that Michaelson's testimony implies that American engineers have attempted to obtain information from Soviet engineers, and have been refused such information, his testimony is in error. (Michaelson 3731-9 to 3732-3)

The record shows that it is the American engineers who have been reluctant to seek such information from their Soviet counterparts. The Soviets appear to have furnished all requested information, but the Americans appear to have been quite circumspect in the nature and scope of their requests (supra).

D. Michaelson's evaluation of the research of Dr. Dietrich Beischer is erroneous.

While he was Director of the Naval Aerospace Medical Research Laboratory, Beischer conducted an experiment involving human volunteers and found that ELF magnetic fields comparable in strength to that of the proposed transmission lines caused elevated serum triglycerides. (Marino 7227-8 to 7230-14) Beischer is one of the world's preeminent authorities in the field of biomagnetics. The facilities which were available to him during the course of his research at the Naval Aerospace Medical Research Laboratory are among the finest in the world. Beischer's research was performed completely within the administrative control and supervision of the U. S. Navy, which published his results, notwithstanding that they were adverse to the Navy's intent to construct the Sanguine antenna. Beischer's results were independently confirmed by a second group, also within the Navy, under an entirely different research protocol. Beischer's work was reviewed by a committee of seven experts, appointed by the U. S. Navy, and was unanimously found to be competent and to warrant further immediate study. Notwithstanding the facts stated above, Beischer's work has been impugned by Michaelson (Michaelson 3733-1 to 3734-22) and Miller (Miller 6171-22 to 6191-3). Neither Michaelson, who was a paid advisor on ELF to the Navy at the time of Beischer's work, nor Miller have any facts or contradictory data to support an attack on Beischer. They appear to be motivated by the certain realization that if Beischer's work stood unchallenged then their position that no further research is required prior to construction of the proposed transmission line would be vanquished.

E. Michaelson's testimony during redirect examination regarding the existence of biological effects due to ELF exposure contradicts his direct testimony that no such effects can occur.

During redirect examination, Michaelson contradicted his direct testimony by citing the Soviet studies by Chebotareva (Michaelson 10474-6), Portnov (Michaelson 10474-6), Portnov (Michaelson. 10474-15), Novikov (Michaelson 10474-231) Khvoles (Michaelson

10475-18), and Rakhmanov (Michaelson 10476-17) to support a contention that the literature shows that stationary and low frequency electric fields (Michaelson 10476-11) can cause a wide range of physiologic effects, including changes in blood indices, heart beat, respiration, and widespread morphologic changes (Michaelson 9842-11 to 9845-9, 9865-9 to 9878-20, 10473-14 to 19477-13).

Counsel for Rochester Gas and Electric failed to furnish copies of the complete studies when requested by Staff.

F. Michaelson's contention that the Soviet Union is not enforcing its standards with respect to ELF fields (10477-20) is utterly without foundation.

When asked by his own counsel. to supply documentation for this position, Michaelson cited articles by Glass (Michaelson 10478-2), Magnusson (Michaelson 10478-23), Rjazavov (Michaelson 10479-10), Dinman (Michaelson 10479-20), Goldman (Michaelson 10486-6) and Sandnutski (Michaelson 10481-16). With respect to the first five references, neither the reports themselves nor Michaelson's analysis of them (Michaelson 10477-14 to 10492-23) provide any support for his contention. The articles are completely unrelated to the contention in support of which they are cited. With regard to the last cited article, Michaelson says he read it (Michaelson 10481-15 to 10482-1), and he quotes language which he says is contained therein.

Actually, the quoted language (Michaelson. 10481-17 to 10482-1) appeared in the article by Glass, not that by Sandnutski. Michaelson does not have the original Sandnutski reference.

PROFESSIONAL BACKGROUND

Michaelson is a veterinarian, and he has published 26 articles in the field of veterinary medicine.

Early in his professional career, Michaelson acquired an interest in the biological effects of ionizing radiation. He subsequently published 35 papers dealing with the clinical symptoms manifest by laboratory animals, principally dogs, when they have been subjected to very large doses of X-rays. In almost all of his experiments, the procedure followed was identical. The animals were irradiated for several minutes, following which the dead animals were removed for autopsy and the remaining animals were observed closely to determine how long they could survive and, when death occurred, the precise cause thereof. In one of his first studies involving X-rays (p-3), Michaelson irradiated 100 dogs and found that only about 20 survived for 1 month following the exposure. In another experiment (p-4), he obtained comparable results. In experiments involving 95 dogs (p-16), Michaelson reported that 250 r of X-rays killed 50 percent of the dogs tested when the X-rays were directed against the dog's entire body, whereas 1775 r was required to kill the same percentage when only the head was irradiated. Comparable results were obtained when a different source of X-rays were employed. (p-17). Michaelson developed a technique for irradiating the dog's heart with 20,000 r so

as to produce cardiac necrosis (p-24). He described the neurological and clinical changes observed in dogs exposed to 5,000–50,000 r X-rays to the head (p-27) . During exposure there was an increase in respiratory rate with continuous salivation. Immediately after exposure there was evidence of disturbance in equilibrium and vomiting occurred. The dogs survived for 12–16 days. Comparable results were obtained in a related experiment. (p-36). Michaelson has reported that dogs irradiated with 1,800 r were not able to perform exercises as efficiently as dogs that were not irradiated (p-40). In studies involving 52 dogs, Michaelson concluded that X-rays can damage the thyroid gland and thereby induce hypothyroidism (p-45). About ten years after the beginning of his professional career, Michaelson became interested in the biological effects of microwave radiation. Since then he has published 51 papers which deal with the effects of microwaves. In 13 of the papers, Michaelson reported the results of laboratory experiments in which he participated. In the remaining 38 publications, which are all essentially identical, Michaelson expressed opinions concerning microwave effects and microwave safety. His 13 laboratory studies of microwave effects closely parallel his ionizing radiation studies. That is, in almost all instances the animals under study were given short duration, high intensity doses of microwaves. The frequency and intensity of the microwaves used by Michaelson were both comparable to those employed in normal household microwave ovens, and the effects on the test animals were comparably obvious. When Michaelson exposed dogs to .2–1200 mW/cm² for 2–3 hours, he observed that the dogs began to pant as soon as the irradiation was begun (p-19). As the exposure was continued the rate of panting increased, and the dog's body temperature rose. Salivation occurred and the dogs became restless. Weakness developed, and the animals became prostrate; thirst increased. In another study (p-37), Michaelson reported that 100 mW/cm² at 2800 Mhz caused extreme agitation, excessive salivation, labored panting, frequent rasping, impairment of locomotion, acute distress, and exhaustion. In the dogs exposed at 1285 Mhz however, the effects were less severe. Michaelson has shown that animals exposed to microwaves experience thermal stress, and that deep burns sometimes develop (p-43). Utilizing 165 mW/cm² at 2800 Mhz, Michaelson found that about 85 minutes is required to kill dogs, whereas rabbits survive for 10 minutes and rats survive for 20 minutes (p-61). Comparable results were obtained in later studies (p-73, p-84). Michaelson has done no original research in the ELF area.

There is nothing in Michaelson's professional experience as a veterinarian or researcher which indicates that he possesses knowledge or expertise in the area of the biological effects of the electric and magnetic fields associated with ELF radiation. Additionally, there is no indication from Michaelson's publications or his academic background as he has described it in his various testimonies which gives evidence that he possesses the mathematical or biophysical tools necessary to appropriately analyze the research of others in the ELF area for the benefit of the Commission. In proceedings involving the health hazards of various electrical devices and systems, Michaelson has testified on behalf of the Association of Home Appliance Manufacturers, Rockland Utilities Company, Raytheon Company and the San Diego Gas and Electric Company. In none of these testimonies is there an indication that Michaelson possesses the requisite educational background in physics or electrical engineering to attempt to integrate and synthesize the work of other researchers.

The research which Michaelson performed utilizing X-rays and microwaves deal with phenomena not observed in dealing with ELF experimental data. His work invariably involved the production of immediate and obvious effects following very acute exposure. In such research, both the existence of an effect and its cause, are absolutely certain. There is no dispute concerning the seriousness and life-threatening nature of the effect. The study of such biological phenomena may make it difficult to appreciate the original research of others in which the biological effects do not occur immediately upon application of the radiation, and in which the effect may be consistent with the survival of the test animal for the duration of the experiment. (Marino, Ca., 3846-0059 to 3846-0062)

PRIOR INCONSISTENT STATEMENTS

Michaelson has evolved two chronologically distinct but substantively identical careers as an advocate for the corporate viewpoint concerning the health hazards on nonionizing radiation at both ends of the electromagnetic spectrum. Sometime around 1968 he became a spokesman for the corporate interests in the microwave frequency portion of the spectrum. Thereafter, all his public testimony and articles espoused the corporate view that only thermally induced effects were possible in biological systems. This public posture was a reversal of his pre-1966 public posture to the effect that non-thermal (low-level effects) were possible. Michaelson's post-1968 position in regard to microwaves is distinguished by three characteristics; (1) he consistently espouses the corporate view but never provides analysis, arguments, or data to support his views; (2) he has performed no research at the exposure levels at which he says no effects exist; and (3) he has categorized all investigators in the field into two classes, those who agree with his view, and those who perform poor research or are otherwise incompetent.

Sometime around 1974 Michaelson became a spokesman for the corporate interests in the power frequency portion of the electromagnetic spectrum. Thereafter, all his public testimony and articles espoused the corporate view that no biological effects are possible as a consequence of exposure to the electric or magnetic fields of high voltage transmission lines. This public posture was a reversal of his pre-1974 public posture that such biological effects were likely. Michaelson's post-1974 position in regard to the power frequency of 60 Hz is distinguished by the same three characteristics enumerated above.

Difference Between Michaelson's pre-and post-1968 Posture on Microwaves

In 1967 Michaelson wrote:

Sufficient factual data are not available to establish a comprehensive safe level for microwave exposure because of factors related to microwave frequency which influence the biological response to this energy... Certain findings such as a possible effect on bone marrow and the thyroid must be carefully evaluated

because of their subtle nature and questionable relationship to thermal effects... Further knowledge of microwave hazards especially those of a subacute nature are required to establish safety regulations... The present "safe" level of 10 mw/cm² for whole body exposure, which is based on the average power density for all frequencies, has remained unchanged since its adoption...

In 1973 however, on behalf of the Association of Home Appliance Manufacturers he testified before the Committee of Commerce of the United States Senate that:

It is important to realize that the standard of 10 mw/cm² is a factor of ten below threshold of damage, assuming a long duration of exposure. This is an exceedingly safe level of exposure. It should be pointed out that the scientific and medical communities, after intensive investigations, have not been able to produce any substantiated evidence of injury below the level of 100 mw/cm²... As for the question of sensitivity of the nervous system, based on biophysical principles, there just is not enough energy from microwaves to result in any conceivable effect.

Following this testimony, a colloquy occurred between Michaelson and Senator Tunney of California.

SENATOR TUNNEY: Dr. Michaelson, on page 88 of a study authorized by you entitled "Biological Effects of Microwave Exposure," you state in regard to the studies undertaken by Soviets, and I quote:

The occasional reports of headache pains, sleeplessness, and other highly subjective symptoms among workers in the vicinity of microwave generating equipment have not been thoroughly investigated. These findings should not be ignored, as similar vague, mild and undefined symptoms which have been experienced in the course of microwave symptoms in the laboratory. Such symptoms do indicate a basic microwave effect.

Now, I would say that reading that statement and listening to your testimony would make it appear to me that you have changed your opinion since you wrote these words. Have you changed your opinion?

DR. MICHAELSON: Yes; remember, that was written in 1966 and it came out—you are talking about that blue-covered report?

SENATOR TUNNEY: Yes; it was written—

DR. MICHAELSON: It came out in 1967.

SENATOR TUNNEY: Well, it is "Biological Effects of Microwave Exposure" by Dr. Sol M. Michaelson, Roderick A. E. Thompson, Joe W. Howland, University of Rochester, Department of Radiation, Biology and Biophysics.

DR. MICHAELSON: Yes, that's all right. I know which one it is. I have written extensively since then and I have been very fortunate in having had the opportunity to read and survey the literature extensively and intensively in the last several years. I have also been very fortunate to be affiliated with many organizations in which these problems are being discussed, and I have been able to critically analyze many, many of the problems and I feel more confident now than what I appear to have been in 1967. I tend to be conservative in thinking biologically and scientifically. We were asked to review the literature at that time and we did the best job that we could. However, we do have six more years of experience now and we feel much more secure.

A few moments before the colloquy with Senator Tunney, Michaelson stated:

There is no reason to believe that current standards are inadequate for protection of the public... Now new data from the literature and now new valid arguments have been presented to change the situation from what it was last year, four years ago, or 15 years ago.

Differences Between Michaelson's pre- and post-1973 Posture on ELF

Additional material concerning a planned Navy study of the effects of ELF fields on human volunteers, which was submitted by Dr. Michaelson to the Commerce Committee stated:

It may be argued that man has been exposed for nearly three generations to electrical utility effects without apparent ill effects. However, at no time have subtle effects of ELF radiation been investigated carefully. It appears entirely possible that these fields are involved in the etiology of certain human illnesses which have increased spectacularly during the last century. Assanove in the USSR found cardiovascular effects and the asthenic syndrome in 50 persons (exposed) off and on for two to four years to the fields of electric power stations (50 Hz, a few gauss and 2 to 40 kV/m).

Besides serving the needs of an environmental statement by the navy, the study may shed light on previously unrecognized effects of utility power.

Human participants will be exposed exclusively to conditions under which millions of people live all over the world. However, the laboratory environment allows to control (sic) the environmental conditions and to make tests which were expected to reveal subtle changes in the clinical, physiological and psychological make-up of exposed persons. Thus, the services of a. few may benefit the public in general and the specific purposes of the Navy.

At no time before have the biological effects of magnetic and electrical fields in the utility power frequency range been investigated in the thoroughness planned in this project. If certain effects should be found, and our preliminary investigation indicates the possibility, many people will benefit from the suggestion of precautionary measures.

In 1975 however, on behalf of the Rochester Gas and Electric Corporation and the Niagara Mohawk Power Corporation, Michaelson said that exposure to the electric and magnetic fields of high voltage transmission lines would not produce biological effects in the exposed subjects. (Michaelson 3718)

In testimony in California on behalf of San Diego Gas and Electric, referring to the Sundesert 500 kV transmission lines, Michaelson said (Michaelson, Ca., 5268):

As far as these power lines are concerned, I still think we have had a lot of experience. We have had 50 years of power lines, from very low voltage power lines to high voltage power lines.

This is worldwide, goes for populated areas, goes over farmland; and we really haven't seen anything. If there were any overt responses, I am sure it would have been recognized by now.

He also testified that (Michaelson, Ca., 5212):

...we also have to understand that people have lived in the vicinity of power lines for many, many years; if anything were to develop, it would be noticed by now.

Michaelson's position as regards the Assanova study has similarly undergone a transformation; he now believes that the study is virtually worthless. (Michaelson 3729)

The Navy study to which Michaelson referred when he testified before the Committee on Commerce led ultimately to two reports. One report, that of Beischer discussed herein above, showed that ELF fields caused elevated levels of serum triglycerides in human subjects.

The other report (Gibson and Moroney supra) showed that ELF fields caused alterations in the ability of human subjects to perform standard psychological tests.

Michaelson did not mention the latter report in his testimony, but said that the former report was deficient in both its design and conduct. (Michaelson 3733) At the time the Navy study was designed and conducted, Michaelson was hired as a consultant by the Navy to assist in its design and conduct.

POINT 13: THE TESTIMONY OF APPLICANTS' WITNESS MORTON MILLER REGARDING THE HEALTH HAZARDS OF HIGH VOLTAGE TRANSMISSION LINES IS WITHOUT MERIT.

SUMMARY OF TESTIMONY

Miller has testified that the proposed lines' electric and magnetic fields do not pose an unreasonable risk to public health or safety or of harm to the environment. (Miller 5820-23) His conclusion is based on his analysis of the available scientific literature (Miller

5820-19, 5821-14) and his professional experience. (Miller 5820-20, 5821-18, 5821-21)

Neither however, basis furnishes substantial support for his conclusion. (Marino 12393-12409)

MILLER'S ANALYSIS IS OF THE BIOLOGICAL LITERATURE DOES NOT FURNISH SUBSTANTIAL SUPPORT FOR HIS CONCLUSION THAT THE FIELDS OF THE PROPOSED TRANSMISSION LINK ARE NOT HAZARDOUS

Miller has focused the major part of his analysis on the biological research conducted in connection with Project Sanguine. (Miller 5819-18, Exhibit ZZZ) The Project Sanguine antenna is designed to operate at a frequency comparable to that of the proposed transmission line. The magnetic field associated with the proposed antenna is comparable to that of the proposed transmission lines. The electric field of the Sanguine antenna however, will be about one million times weaker than the electric field of the proposed transmission lines. A variety of research projects have been funded by the U.S. Navy to generate information to permit evaluation of the environmental impact of the proposed Sanguine antenna. The research projects have been designed and performed employing a frequency, magnetic field, and electric field that are comparable to those associated with the proposed antenna. That is, the Navy program is designed to determine if the fields that its hardware will inject into the environment are hazardous. Consequently, every Sanguine research project involves the study of the biological effects of electric fields of a strength vastly smaller than that associated with the proposed transmission line. There is a marked asymmetry in the weight or significance that the various Sanguine related experiments have with respect to evaluating the safety of the proposed transmission lines. This asymmetry is reflective of the vast difference in the strength of the electric fields between the antenna and the proposed transmission lines. If a Sanguine related experiment shows a biological effect, then it has extraordinary significance and ominous implications as regards the safety of the proposed transmission lines. On the other hand, if a Sanguine related experiment shows no biological effect, then since the electric field strength employed in the experiment is so diminutive as compared to that associated with the proposed transmission lines, the weight assignable to such negative reports must be correspondingly minuscule. Thus, Miller's testimony, which essentially is a discussion of those reports from the Sanguine Project which showed no biological effect, is not evidence on the issue whether ELF fields can cause biological effects, and has vanishingly small weight with regard to the issue whether the 765 kV lines will cause such effects. During cross-examination (Miller 5959-5982), Miller agreed with this analysis (Miller 5965-10 to 5965-16, 5966-10 to 5966-12, 5969-9 to 5969-14, 5970-13 to 5970-22, 5973-2 to 5978-20, particularly 5978-16 to 5978-20) (170). Thus, Miller's testimony on cross-examination flatly contradicted his direct testimony.

Miller's Exhibit ZZZ

In his Exhibit ZZZ, Miller cites the research of Coate (pp. 1-26), Greenberg (pp. 26-28),

Goodman (pp. 31–34), Grissett and deLorge (pp. 39–41), Mantell and Marr (p. 41), McCleave (pp. 42–44), Reisen (pp. 44–45), Graue and Southern (pp. 45–50), and Krumpe (pp. 51–52). The reports of Goodman, McCleave, Reisen, Graue, and Southern, all describe biological effects due to ELF field exposure. The reports therefore, tend to establish an affirmative answer to the issue whether ELF fields can cause the biological effects enumerated above. That is, that ELF fields can affect biological systems. Much of Miller's Exhibit ZZZ is devoted to an attempt to explain away these reports, apparently with regard to the issue whether the 765 kV lines will cause biological effects in people exposed thereto.

The remaining literature cited by Miller in Exhibit ZZZ is some evidence that certain conditions of exposure to the fields of the proposed transmission lines will not produce biological effects. Since the work described in this literature was performed under conditions of exposure vastly different from those associated with the 765 kV lines, and the weight assignable to it in this hearing is correspondingly reduced.

1. Coate (pp. 1–26)

Miller devotes about half of Exhibit ZZZ to an analysis of nine studies by Coate. They were pilot studies. (Miller 5983-11) This means that they were initial or preliminary inquiries in the areas studied. (Miller 5983-23) None of Coate's studies have ever been peer reviewed. (Miller 6226-3) A lot of the studies were faulty in design. (Miller 6006-18) The studies were not done at a professional level. (Miller. 5994-17) Applicants' witness Schwan does not accept as valid two of the Coate studies and has not read the remaining studies (supra). The Coate studies were performed at the Hazelton Laboratories between 1968 and 1970. (Miller 5982-11) A government task force has found serious improprieties in the manner in which research is conducted at the Hazelton Laboratories. The Navy has not funded any Sanguine research at Hazelton after 1970. The Navy has concluded that some of the studies involved erroneous experimental procedures. Some of the Coate studies showed biological effects. (Miller 5995-6006) Thus, the evidence is overwhelming that neither Miller nor the Commission may rely on Coate's reports.

2. Goodman (pp. 31–34)

Miller describes Goodman's work regarding the exposure of slime mold to Sanguine strength electric and magnetic fields, and appears to conclude that Goodman has found an ELF biological effect. Miller applies Goodman's work to people, and concludes that it shows that the proposed transmission lines are safe. This conclusion is based on Miller's concept of current density. Miller however, admittedly lacks the professional expertise to employ this biophysical concept (Miller 5876-22, 5886-16 to 5886-22, 6085-20, 6088-10 to 6088-20, 6112-14 to 6112-17, 6158-19 to 6158-20, 6236-10 to 6236-18, 6248-1, 6236-13 to 6236-18, 6265-17). The results of his analysis are consequently unreliable.

Miller's view of Goodman's research is subject to further criticism on the grounds of inconsistency. With regard to Goodman's work, Miller has testified: "I think that this is an

outstanding study” (Miller 5921-17); also that it is a beautiful example of a well constructed, well analyzed beautiful experiment (Miller 5921-22); and that Goodman’s work was “an outstanding experiment.” (Miller 5971-11) After undergoing some rather difficult cross-examination (Miller 6082-6114) however, Miller began to perceive Goodman’s work as antagonistic to his position. (Miller 6114-1, 6115-2) Thereafter, Miller’s attitude towards Goodman’s research was quite different. (Miller 6146-16 to 61561-22) Miller referred to Goodman’s work as having “a lack of appropriate controls.” (Miller 6149-4) Miller suggested that Goodman’s results “may have been an artifact.” (Miller 6149-6) Also, referring to Goodman’s work Miller stated “I am criticizing the experiment saying it was not a properly controlled type of experiment.” (Miller 6156-2, see 6156A-6)

3. McCleave (pp. 42–44)

Miller describes McCleave’s experiments on fish and concludes that they support the premise that the fish studied can detect ELF fields. During cross-examination (Miller 6228- 6235), Miller attempted to explain away McCleave on the basis of an assertion that “fish have special organs for detecting electric fields.” (Miller 6233-13) His knowledge of such organs is based on what Schwan has told him. (Miller 6234-4) Miller does not know if the existence of such organs is a theory or a fact. (Miller 1231-23) Similarly, he doesn’t know if all fish have such an organ (Miller 6233-22) or if the fish in McCleave’s study have such an organ. (Miller 6234-1) Miller has no expertise and cites no authority to support his assertion that McCleave’s work on fish can be explained away on the basis that the fish have a specialized sensing organ. In point of fact, the fish studied by McCleave do not have such an organ.

4. Riesen (pp. 44–45)

Miller concedes that Riesen has observed “a biological effect due to exposure to ELF fields.” (Miller Ex. ZZZ, p. 44; 6236-3) He attempts to explain away Reisen’s work on the basis of a comparison of various current densities. His approach to Riesen depends on current density calculations in cells and in human beings which are unverified and unverifiable. Consequently, Miller’s opinion does not reduce the significance of Riesen’s work.

5. Graue and Southern (pp. 43–50)

Miller testified that Graue and Southern showed that the Sanguine test facility can affect the orientation of birds. Miller attempted to explain away their observations by urging that the effects will not be fatal to avian migratory instincts. Miller has however, no expertise and cites no authority to support his assertion that the work of Graue and Southern can be explained away as harmless with respect to avian physiology and migratory behavior. During cross-examination, Miller testified (6246-6289, 6303-6323) that the ability of birds to perceive ELF fields indicates that such fields can interact with cellular processes.(6247-7). His testimony flatly contradicts the testimony of Carstensen (Carstensen 6451-13, 64S2-3, 6453-7, 6454-13, 6460-23, 6491-1, statements by counsel 6463-20, 6462-17).

The only report cited by Miller in his direct testimony, which is not discussed in Exhibit ZZZ, is that of Hodges. Miller reported that Hodges and co-workers conducted a study for the Indiana and Michigan Electric Company on the growth rate and yield of farm crops grown under a 765 kV transmission line. (Miller 3833-8 to 5833-19) Miller testified that these scientists observed that the lines “did not have any observed effect (on growth rate or yield).” (Miller 5833-14, 6369-16 to 6369-20)

Miller’s testimony is pregnant with the implications that the Hodges study showed that fields of 765 kV transmission lines do not affect farm crops with respect to growth rate or yield. Such an implication is false, and Miller is fully aware of it.

Hodges studied the growth rate and yield of farm crops at three locations near a 765 kV transmission line; directly under the center conductor, 50 feet from the center conductor, and 100 feet from the center conductor. The electric field strength at each respective location was 2.7 kV/m, 4.1/ kV/m and 1.4 kV/m. (Miller 6388-6397) No other locations were studied. That is, there were no control locations at which farm crop growth rate and yield were measured so as to permit comparison with the observation made at the exposed locations. The proper conclusion of the Hodges study is therefore, that growth rate and yield of farm crops are similarly affected by electric fields in the range 1.4–4.1 kV/m.

Miller testified during cross-examination that he was quite concerned over the absence of control data. (Miller 6392-10) He wrote Hodges a letter asking why there was no control data, and telling him that such data was needed. (Miller 6392-12 to 6392-17). The point is however, that there is no control data, and Miller was fully aware of its absence. Consequently, his testimony with regard to the Hodges study is seriously misleading.

MILLER’S PROFESSIONAL EXPERIENCE DOES NOT FURNISH SUBSTANTIAL SUPPORT FOR THE CONCLUSION THAT THE FIELDS OF THE PROPOSED TRANSMISSION LINES ARE NOT HAZARDOUS

Miller’s professional experience is composed of his generalized educational background and his studies of bean plant roots. Also, after he was hired by the applicants he visited an operating 765 kV transmission line and a bird refuge, and he produced and directed color movies of rats receiving electrical shocks.

1. Generalized experience. Miller is a botanist. He holds a BS, an MS, and a Ph.D. in botany. He holds no other academic degrees. Every one of his published articles deals with plants. His entire professional background has been amply developed on the record. The record shows that he has no training or experience as a medical doctor. Miller therefore has no medical expertise on the basis of which he is qualified to offer medical opinions. The record shows that Miller has had no training or experience, as a biophysicist. On the contrary, the record is replete with instances in which Miller has disavowed knowledge of biophysics. (Miller 5876-22, 5886-16 to 5886-22, 6085-20,

6068-20, 6112-14 to 6112-17, 6158-19 to 6158-20, 6236-10 to 6236-18, 6248-1, 6265-17) Notwithstanding his clear confessions of non-expertise as a biophysicist, his testimony contains numerous instances in which he testified as if he possessed such knowledge. Similarly, the record shows that Miller has had no training as an ichthyologist, ornithologist, hematologist, or epidemiologist. Nevertheless, he has testified about mechanisms and theories within each of these areas. There is an obvious distinction between being qualified to read a scientific report and present the results and implications thereof to the Commission, and, being qualified to testify to the mechanisms and theories which possibly account for the results contained therein. In the latter instance, the record shows that Miller is unqualified as a witness, except as regards botanical considerations.

2. Bean plant roots. Based on a three year research project, Miller has shown that bean plant roots are unaffected by up to six days exposure to very weak Sanguine level fields. Obviously, no conclusions with regard to human safety are possible.

3. 765 kV line site visit. Miller visited an operating 765 kV site and subject to a large number of qualifications found that the vegetation was apparently unaffected by the transmission line. Obviously, no conclusions with regard to human safety are possible.

4. Bird migration. Miller has obtained data concerning bird migration, and has visited a bird refuge. (Miller 5828-24 to 5829-16, Exhibit ZZZ, pp. 50–51; 6278-6279, 6303-6318) He has concluded that two 345 kV transmission lines that are located ten miles north of the refuge do not appear to be affecting the birds' use of the refuge. (Miller 5829-2, Exhibit ZZZ, p. 51) The implication of Miller's testimony is that notwithstanding the controlled studies of Graue and Southern, his limited field observations show that transmission lines do not affect bird migration.

Miller's conclusion is based in part on his observation that "an extremely large flock of blackbirds (was) grazing (underneath the transmission line)" (Miller 6279-13), and on his observation of geese grazing directly under the transmission lines," (Miller 6279-10) and on his failure to notice "any drastic disorientation." (Miller 6314-21) Miller's uncontrolled, limited observations are clearly inadequate to sustain the import of his testimony. (Miller 6316-4, 6315-3)

Miller's conclusion is also based on some statistical data from page 50 of Exhibit ZZZ. There is no construction of this data which supports his conclusion that transmission lines cannot affect bird migration. (Miller 6331-6347)

5. Rat Movies. During cross-examination Miller was asked whether the applicants had duplicated any of the experiments which Marino had cited in his direct testimony. (Miller 6953-1 to 6958-4) Miller replied that he asked RG&E to construct test enclosures similar to those used by Marino (Miller 6958-16), and that he made movies of the behavior of rats in the enclosures. (Miller 6961-1) Miller testified that he observed that the rats received shocks when they attempted to eat or drink. (Miller 6959-6 to 6959-11) He further testified that pursuant to an invitation to visit and inspect Marino's research facility, he received a shock when he touched one of the cages. (Miller 6960-4) Miller

also said that he received a shock when he touched one of his own cages which he claimed was a replica of Marino's apparatus. (Miller 6961-2) Miller testified that Marino was unaware of the problems which his observations uncovered because cage labels obscured Marino's view. (Miller 6962-3). Finally, Miller suggested that when he put a nine volt battery in his mouth, the sensation which he received was appropriate to evaluate the sensation which the rats experienced when they ate or drank. (Miller 6962-15)

Upon the demand of Staff, RG&E furnished a copy of the movies described by Miller. The movies showed only normal rat drinking behavior by both the control rat and the rat exposed to an electric field of 150 volts/cm. By observing each rat's behavior it is not possible to determine which of the two rats is the experimental and which is the control. Thus, the movies produced by the applicants show that the rats are not experiencing electrical shocks when drinking. Miller's movies do not substantiate his allegation that the animals in Marino's experiments received shocks. Miller's assertions are untrue.

During his visit to Marino's laboratory Miller could not possibly have received a shock from the equipment because the only exposed metal parts were electrically grounded. Basic considerations of electrical engineering show that Miller's treatment of his replica of Marino's apparatus (Miller 6961-2) precludes the possibility of obtaining reliable information. It is amateurish to evaluate the electrical environment of the experimental rat as Miller did because the body potential of the rat and Miller differ vastly.

Miller's testimony regarding the position of our cage labels and food troughs is not accurate. During his visit to Marino's laboratory these matters were explained to him, but he has nevertheless chosen to ignore the explanation.

It is foolish for Miller to relate the sensation he experienced when he placed nine volt batteries in his mouth to that supposedly experienced by the experimental rats because it in no way simulates the actual experiment.

A few moments after he delivered his criticisms of Marino's research, Miller asked to go off the record (Miller 6965-11), whereupon with reference to performing experiments he stated "I follow the golden rule-he who has the gold makes the rules." It seems obvious that Miller followed a similar rule when he testified before the Commission.

POINT 14: THE TESTIMONY OF APPLICANTS' WITNESS EDWIN CARSTENSEN REGARDING THE HEALTH HAZARDS OF HIGH VOLTAGE TRANSMISSION LINES IS WITHOUT MERIT.

SUMMARY OF TESTIMONY

Carstensen has concluded that the fields of the proposed transmission lines will not produce biological effects in the exposed subjects. His conclusion is based on a series of biophysical calculations contained in the exhibits attached to his testimony. The calculations contained in the exhibits, however, are only arbitrary, unverified, and

unverifiable hypotheses, and have virtually no predictive value with respect to the safety of the proposed transmission lines. Additionally, Carstensen has given substantially prejudiced testimony with respect to the ELF biological literature.

BIOPHYSICAL CALCULATIONS OF NO VALUE

In his testimony Carstensen described some theories of physics, and then applied them to uniform oblate and prolate spheroids. In setting forth his various theories however, Carstensen dealt from a stacked deck. From among the infinity of scientific laws, rules, mathematical models, numerical data, assumptions, and hypotheses, he arbitrarily chose a specific subset of information which predicted that the proposed transmission lines would induce very small electric fields inside spheroids. No significant consequences however, flow therefrom because Carstensen's informational subset is not unique, original, or prototypal, and because people are vastly more complex than uniform prolate spheroids. There exists an indeterminately large number of informational subsets, every one of which is equally correct, which lead to an indeterminately large number of values of internal electric field strength. It is possible to utilize equally valid informational subsets and thereby demonstrate in inexorable fashion that the electric field that would be induced by the proposed transmission line in various mathematical models exhibits a variation of one billion per cent (Exhibit G-5, "Refutation of the Testimony of Applicants' Witnesses Carstensen and Schwan that Based on Mathematical Calculations the Proposed Lines are Safe"). Carstensen has therefore literally assumed that which he purported to prove, namely, that the electric field induced inside his model by the proposed transmission line would be small. Carstensen has conceded that there has been no verification by measurement of any value of the electric field strength that he predicted would be induced inside animals or people exposed to the fields of high voltage transmission lines. (Carstensen 7069)

A further and distinct error in Carstensen's analysis is his assumption, sub silentio, that if he could calculate the electric field strength induced inside subjects exposed to the fields of the proposed Sundesert lines, then he could determine whether that particular intensity would be hazardous to health. For virtually all systems within the body, knowledge of the mechanism of action and control is lacking. Carstensen of course shares such ignorance. For example, the mechanism by which the body controls the healing of bone fractures is unknown. It therefore cannot be predicted whether the presence of any specific intensity of electric field inside such healing tissue would be safe. A similar comment applies to all healing tissue. The mechanisms regulating the production of insulin by the pancreas and the production of adrenaline by the adrenal glands are unknown. It therefore could not be predicted whether the presence of a specific intensity of electric field inside the pancreas or adrenals would affect their function, particularly when the field was applied for long periods of time. Similar comments apply to all the glands and organs of the body. The etiology of many human diseases is unknown. It could not therefore, be predicted whether the occurrence of such diseases would be altered by the presence of a specific intensity of electric field within the subject's body. The mechanisms underlying the processes of learning and

memory are presently not understood. It could not therefore, be predicted whether these processes would be affected by the presence within the body of a specific intensity of electric field. Since the mechanisms underlying the great multitude of biological processes are unknown, Carstensen has no rational basis upon which to evaluate the impact of any specific intensity of internal electric field on physiological function.

PREJUDICE AGAINST BIOLOGICAL LITERATURE

Carstensen has evinced an ambivalence towards the ELF literature, to which he is a stranger. Sometimes he testified that ELF fields could not possibly cause a biological effect because his biophysical calculations precluded the possibility. (Carstensen 6451, 6452, 6453, 6454, 6460, 6491, 6463, 6462) This view led him to conclude that the approximately 65 research groups around the world who have reported such biological effects were all wrong. (Carstensen 6450-6465) Indeed, Carstensen reached his conclusion prior to having read the great majority of the ELF literature. (Carstensen 6476) At other times Carstensen adopted a variant of this testimony. He fastened onto the maximum ground-level electric field that would be created by his client's high voltage transmission line, and asserted that the experimental ELF studies performed at electric field strengths below that level were all examples of poor research, and those performed at electric field strengths above that level did not apply to the high voltage transmission line for that reason. Thus, when Carstensen testified on behalf of Quebec Hydro-Electric Corporation and when he testified in the present proceedings he fastened onto 10 kV/m. This choice resulted, in Carstensen's view, in a breakdown of the ELF reports into about 65 percent wrong and 35 percent irrelevant. (Carstensen 7005, 7017)

When he testified on behalf of San Diego Gas and Electric, Carstensen fastened on 8 kV/m, and was led therefore to essentially the same numerical breakdown. Carstensen exhibited still a third face during which he testified that there were valid reports of a biological effects occurring at field strengths below his client's ground-level maximum, but that all such effects were innocuous and not medically significant. (Marino 12410-12419)

Carstensen has baselessly condemned many experienced and competent scientists as people who commit glaring and obvious errors during the conduct of their research. It is clear that the fault lies with Carstensen who harbors a heavy bias against those who report biological effects which his calculations forbid. Common wisdom dictates that it is Carstensen's claims that his calculations are relevant to high voltage transmission lines, and not the experimental literature, which ought to be rejected.

Carstensen's comments regarding confirmation of experimental results represent a view through the wrong end of the telescope. If there is a necessity to duplicate any research, the responsibility rests with the applicant and not with the individual scientist who first observed the biological effect. If the applicants claim that some research report may be invalid, they incur the responsibility to duplicate the work to attempt to sustain

their position. A scientific report cannot be vitiated by a mere assertion of invalidity unsupported by contradictory data. Furthermore, it is only the applicants, the utility industry, and the governmental agencies with an interest therein who possess the resources to support duplication of ELF research. Many investigators who have published reports describing biological effects no longer have research support. Carstensen is well aware that there are only three groups in the United States today with significant research funds available in the ELF areas namely, the Energy Development Research Agency, the Electric Power Research Institute, and the Office of Naval Research, and that all three generally do not fund projects in the laboratories of investigators who have previously reported a biological effect due to ELF exposure.

POINT 15: PROCEDURAL PROCESSES HAVE BEEN SYSTEMATICALLY ABUSED. CORRECTIVE CHANGES IN THE HEARING PROCESS ARE REQUIRED.

Health and safety hearings have lasted for more than three years, and have attracted wide attention. As well as skill, selfless dedication, and honesty, the history of the hearing will also reveal abuses, excesses, and the unprincipled pursuit of self-interest. Preservation of the integrity of the Commission's hearing process demands that the excesses of the applicants be exposed and corrected.

RG&E's position among the applicants is that of first among equals. They have filed more testimony, submitted and responded to more interrogatories, conducted more cross-examination, taken more appeals, made more motions, and voiced more objections than all the other applicants put together. It is therefore to the conduct of RG&E that we look for an analysis of the abuses that have beset the hearing.

In its original application, RG&E required less than a page to assure the Commission that its proposed line's electric field would be harmless. In 1974, Marino and Becker submitted testimony tending to show that the line was hazardous. RG&E responded by hiring scientists who reached the same conclusion regarding safety reached earlier, but on colorably more credible grounds. The same pattern persisted during the next three years. Whenever new evidence was put before the Commission, RG&E hired someone from the scientific community to put the matter in issue. Thus, RG&E's extremist position, started in 1973, has never changed.

RG&E's framing of the issues and presentation of witnesses have been abusively self-serving and antagonistic to the search for truth. After Marino and Becker submitted pre-filed testimony in October 1974, RG&E sought the University of Rochester triad not because they possessed any special knowledge or expertise relevant to the hearing, but because they were willing, pliable, and convenient. RG&E never was the moon reflecting their witnesses' sun. The quality and logic of their scientific arguments was so completely inferior that only lawyers could have been responsible for the positions taken by their witnesses. It was RG&E which placed the 'Utility Operating Experience'

argument in evidence through Miller's mouth, and the 'Effect is not a Hazard' argument in evidence through Michaelson's mouth. It was RG&E, and not Miller and Carstensen who accused of incompetence all 65 groups of scientific investigators around the world who reported biological effects due to ELF field exposure. Thus, RG&E's case was designed ab initio only to implement business decisions by corporate officers, and not in any manner as an aid to the Commission in the pursuit of truth and the protection of the public welfare.

Throughout the presentation of its case, RG&E never perceived that it had a responsibility to the public at large, as well as to its stockholders. As a consequence, its case never went beyond the four corners of the testimony of staff's witnesses, nor did it cooperate in the exchange of information. In testimony distributed in October 1974, Marino cited eight references to indicate that ELF fields caused biological effects. In December 1975, all witnesses filed simultaneously. RG&E's witnesses regarded the eight references previously cited as the totality of the relevant literature, and their direct testimony was drafted accordingly. Marino however, cited 24 additional references which RG&E witnesses had not read prior to their testimony. RG&E demanded copies of all the reports which its experts had missed, and was so provided. In October 1976, all witnesses filed simultaneously in the rebuttal phase. RG&E's witnesses regarded the 32 references previously cited as the totality of the relevant literature, and their rebuttal testimony was drafted accordingly. Not surprisingly, each of its witnesses reached the same conclusion as they had reached on the basis of only eight reports. Marino however, cited 20 additional reports which RG&E's witnesses had not read prior to giving their rebuttal testimony. RG&E demanded copies of all the reports which its experts had missed, and was so provided. Prior to and subsequent to the aforesaid demands for information and reports, RG&E made still additional demands for reports, information and data, and was always provided with the material requested. When information was requested of RG&E however, it frequently refused on the grounds that it was not "readily available," or that their experts were too busy to search their files. RG&E has refused to supply National Academy of Science reports, Electric Power Research Institute reports, and Soviet reports, all of which are in its witnesses' possession. Thus, throughout the hearing there has been only a unilateral exchange of information, and RG&E has suppressed all adverse material within its possession or control.

RG&E has employed a steady drumfire of procedural tricks, tactics, and maneuvers, and has thereby frequently obscured the basic purpose of the hearing in a morass of legal formalisms. RG&E has maintained moot and frivolous appeals to the Commission, and has taken appeals in flagrant violation of the law of the case. Cross-examination by RG&E was characteristically churlish and puerile. RG&E routinely abused the motion to strike testimony, both by vast overuse and by predicating it on grounds that do not exist at law. RG&E engaged in incessant legal posturing, even in the face of irrefutable documentary evidence. For instance, in Exhibit P-6, RG&E's witness Michaelson expressed opinions to the Committee on Commerce of the United States Senate concerning the safety of high voltage transmission lines which were completely at variance with the opinions he expressed in the present hearing. In a letter to the Examiners, RG&E brazenly and falsely denied that Michaelson had given the aforesaid

adverse testimony to the Committee on Commerce even though it is a matter of public record, and even though Michaelson admitted that he submitted the material in testimony he gave in a California proceeding.

From the bully pulpit of its position of procedural superiority, RG&E made Marino and Becker the target of numerous abusive legal maneuvers. RG&E insisted that it had an unlimited right to cross-examine Marino. In furtherance of this position it cross-examined Marino for 13 days and Becker for 4 days. Throughout, RG&E incessantly demanded that Marino provide various reports and other information which necessitated large amounts of time and effort to accommodate, even though such material was openly available from other sources. RG&E investigated Marino's private life. RG&E falsely claimed on the basis of then secret movies that Marino and Becker's research had been discredited. It is clear that RG&E's tactic with regard to Marino and Becker's testimony was not to conduct a bona fide inquiry, but to turn the thumbscrews until the time requirements of participation, and other pressures, became so painful, that Marino and Becker would be forced to withdraw.

RG&E has treated the hearing as an adversary process, and has employed to an excess the procedural devices and strategies customarily employed by private litigants in a courtroom. They have treated the health and safety hearings as an ordinary money law suit, and have recognized no responsibilities towards non-stockholders. In private litigation there are two adversaries who stand on a relatively equal footing. In the present hearing, RG&E had no true adversary. The intervenors are vastly overmatched with regard to resources and scientific expertise, and the staff routinely takes no position until after the evidence is adduced. Thus the intervenors had a position but no resources, and the staff had resources but no position. The necessary prerequisites therefore for a true adversary relationship did not exist. Thus there was an absence of any significant checks and balances to prevent the litany of abuses of procedural processes which occurred. RG&E acted only in its own narrow corporate self-interest, to the exclusion of its societal responsibilities. Their conduct was deplorable, reprehensible, and inimical to the pursuit of truth and the orderly processes of justice. In the future hearings should be structured so that the role of the lawyer, through whom the great majority of the abuses described herein were committed, is greatly reduced and strictly regulated, with more reliance placed on a strong scientifically knowledgeable hearing officer.