SUCCESSFUL TREATMENT OF NEOPLASMS IN MICE WITH GASEOUS SUPEROXIDE ANION (O_2^-) AND OZONE (O_3): WITH A RATIONALE FOR THE EFFECT.

by

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I want to make it clear at the outset that I had no intention of doing cancer research when I started my career. Furthermore, I do not claim to be an expert in cancer research. In working toward my Ph.D. in Physiology under A.C. Ivy at Northwestern University Medical School, I did research on methods of electroanesthesia in animals. When I got my M.D. degree, I became an internist. In 1948 I became Dr. Sam Rosen's surgical assistant on his invention of the Stapes Mobilization operation for conductive deafness. From him I learned about hearing problems, and got interested in alleviating the problem of sensorineural hard-of-hearing, and deafness.

In conjunction with Warren S. McCulloch, one of the founders of Cybernetics, we found a patient at Bellevue Hospital in New York City, who had been committed for "hearing voices". We determined that, outside of hearing voices, his psychiatric profile was normal. We found out that his job was the key to the diagnosis. He ground metal castings against carborundum wheels. Dental examination showed that his metal fillings were coated with carborundum dust. We placed him in a Faraday Cage, which eliminates all common electrical and radio signals, and found that his voices ceased. We found that he was precisely tuned to radio station WOR in New York City. His teeth were cleaned, and he was cured of the "psychiatric" problem. I set out to find the scientific basis for this phenomenon of "hearing radio waves".

It was obvious that the carborundum behaved like the "crystal" rectifier in the old crystal radio sets of the 1920's. Joe Lawrence, a dentist, joined me in this research in the early 1950's, when we were stationed at the Army Chemical Center, Edgewood, Maryland. We began to do research on the phenomenon of hearing radio waves. [1,2] Referring to Fig. 46 we found that when a person, standing in the near

field of a low power radio transmitter, stroked a wire resting on his cheek, he could hear a voice signal, and increase the RF (radio frequency) field on his skin from +200 mv to +250 mv. When the wire was clamped between the teeth and stroked there was a 10 db gain in hearing. Fig. 44. When a plastic box was cemented around the wire, it was found that sound was being generated in the wire - an electroacoustic effect. [3,4] It is to be noted that hearing sensation occurred only when the wire was stroked by the skin. The mystery of skin-stroking a wire in the presence of amplitude modulated RF was solved (Fig. 47) when it was found that an ordinary diode held in the teeth without stroking, gave the sensation of hearing. A model of this effect is shown in Fig. 45. The actual wave-shaping by the non-linear element, i.e., either skin stroking, or the use of a rectifier element such as a crystal, or a diode, is shown in Fig. 3. In 1A we see a normal amplitude modulated radio wave. In 1B we see that stroking will clip the positive half of the wave form, and allow the negative pulses to pass across the tissues giving perfect hearing sensation to both normal, and sensorineural impaired humans. Fig. 42 showes the power spectrum, and the side bands. [5,6,7]

From this basic finding, Lawrence and I, and our engineering staff, developed the manually controlled laboratory instrument shown in Fig. 4., with which we learned how to get deaf subjects to hear words and speech. [8] We found that before a deaf person could hear, he had to undergo a one to two month course of transdermal (TD) electrotherapy daily. This consisted of repetitively sweeping the head, via electrodes, with pure tones over the frequency range from 20 Hz to 10,000 Hz modulating a 30 to 50 KHz carrier wave for one hour each day. This clinical work resulted in the development of a completely automatic treatment program in the instrument shown in Fig. 7. Lest we forget, we did solve the technology of hearing radio waves through the teeth, as shown in some of the patents issued, Figs. 8, 9, and 10. [9,10,11,12,13]

In carrying out large scale Transdermal Electrotherapy in cooperation with several medical schools on patients with sensorineural hearing loss, other beneficial effects were uncovered.[14] It was found that Meniere's disease could be cured in two weeks of treatment.[15] In elderly senile patients there was a restoration of short term memory. There was an acceleration of bone healing in refactory fractures. Significant improvement was found in cases of impaired vascular circulation.[16] In the course of safety and hazard studies on animals, it was found that blood coagulation was significantly delayed, *in vitro* and *in vivo*. A joint research program was carried with New York University Medical Center, Cardiovascular Research Laboratory. The team was made up of Dr. George Reed, Dr. William Brewster, Dr. Luis Cortes, and myself. Our goal was to prevent blood coagulation in an articial heart device by using the TD electrotherapy signal on the blood. We were successful.[17] In Fig. 3 we see a dilute suspension of red blood cells under a microscope without the TD signal energization. The cells clump and settle out in about four minutes. In Fig. 1 we see the TD energized red blood cells in the same cell as Fig. 3, but now they are energized by the TD signal; they develop a negative charge, and repel each other so that they do not clump, do not settle down, and *in vivo* do not coagulate in an artificial heart pump in animals. Fig. 5 shows the method of doubling the shelf life of stored whole blood by means of continuous TD signal charging, and Fig. 7 shows the method applied to a human.

One day, while I was studying the effects of the TD electrical fields on the dynamics of a dilute suspension in Ringers solution of red blood cells under a microscope, I observed bubbles coming from both of the electrodes. I ran a gas analysis on the Ringers solution, and found that

I had been observing the splitting of water molecules by electrolysis at incredibly low power levels, i.e., 0.16mw. It was this single observation that turned me in the direction of studying cancer. I shall now describe how this came about.

I had been heavily influenced by Dr. Warren S. McCulloch to believe that water structure was the basis of life structure and organization. So I began an intense study of water structure and the electrolysis of water by means of the TD signal generator.

The block diagram of the water electrolysis equipment is shown in Fig. 1. Component I is the same TD signal generator as was used in the hearing experiments. Component I is coupled to Component II (shown in top view as a coaxial electrode arrangement) by a series inductive-capacitance circuit. Fig. 2 is a side view of Component II, and the space between the copper center electrode and the concentric iron electrode is filled with a 0.9% saline solution termed Component III. The center copper electrode is surrounded by a high temperature-fired ceramic jacket which is porous to water molecules. Fig. 3 shows more clearly, the geometry of Component III. My initial goal was to measure the efficiency of this system for the production of hydrogen and oxygen as a fuel.[18] Fig. 14 shows in a simplified way the thermodynamics of water decomposition in (b), and the exergonic reaction when hydrogen and oxygen gases are brought together and burned to release energy. I measured all of the gas production by the Mass Spectrometer, and measured the electrical power consumed in the endergonic reaction with precision calibrated instrumentation, and with this data calculated the efficiency of the system.[19] I was able to attain a 90% efficiency in the first half-hour of electrolysis, and thereafter it steadily declined to about 11%. The mass spectrometer revealed that the oxygen was being consumed in some unknown chemical reaction.

All conditions of the experiment were sterile, run under a high vacuum, and contamination, or loss, from an outside source was impossible. Yet at the end of each experiment when the apparatus was taken apart it was found that Component III was filled with a flocculent albuminoid material which had a fish-like odor.

I shall very briefly review the course of chemical events. The first slide shows the chemical content of the solution before electrolytic action started. The second slide shows the chemical content of the solution after three minutes of electrolysis. The main addition is copper and iron electrolytically removed from the electrodes. The next slide shows a computer print-out of the mass spectrometer analysis of the products of electrolysis, and the next graph plots the significant data. The pH rises in the first 30 minutes of electrolysis from 4.27 to pH 13.0. This is due to the production of hydroxyl ions. The oxygen drops from 21% to a fraction of 1% in two hours. The hydrogen rises from zero to about 90% by volume in several hours. The nitrogen drops from 78% to about 5% in four hours. The CO_2 starts at a non-detectable level, and slowly rises to about the 2% level in seven and a half hours. And the Argon does not disappear with vacuum pumping, but tends to increase as a function of time. The next few slides show the chemicals that were synthesized in the electrically pulsed Component III solution.[19] What is very wrong with this experiment is that when all the nitrogen was removed and replaced with helium, there was carbon in the solution, and there was nitrogen in the solution. Now where did the nitrogen and the carbon come from? In order to test a hypothesis the Component III solution was changed from a sodium chloride solution, to a sodium hydroxide solution.

When this was done, no organic compounds were formed, as had been the case with the sodium chloride solution, and no carbon or nitrogen was formed in the solution. [21] This finding forced me to reluctantly accept the possibility that we were looking at the Kervran reaction in vitro. [22] The next slide shows the Kervran reaction.

The Kervran reaction has been studied in vivo for many years, and confirmed by many workers. As far as I know, this is the first time that it has been observed in vitro. The nuclear control systems of these biochemical reactions are of the type developed by the theoretical physicist, Olivier Costa de Beauregard, Director of the Institute Henri Poincare in Paris. [23]

$$n \rightarrow p + e^- + \bar{\nu} \qquad (1)$$

$$p + \nu \rightleftharpoons p' + \nu' \qquad (2)$$

$$p \rightleftharpoons p' + \bar{\nu} + \nu' \qquad (3)$$

The equations imply the conversion of a neutron (n) to a proton (p) by virtual exchange processes, the neutral currents of Weinberg. These processes produce protons (p and p') of different energy levels; and two neutrinos (ν and ν') of different energy levels. ($\bar{\nu}$) represents the antineutrino, and (e-) the electron. In one state the proton will be bound to an atomic nucleus, and in the other state it will be relatively free in a chemical binding. Kervran reactions, or as they are sometimes called, biological weak transmutations, have been observed for the elements marked with an arrow in the Table of Elements. For example, the oxygen atom can enter into a virtual nuclear reaction with p or n to yield, ^{14}N, or ^{19}F. The normal flow of electrons in the terminal respiratory chain in the mitochondria will yield $2H + \frac{1}{2}O_2 \rightarrow H_2O$, an exergonic yield of energy. However, if this normal reaction is blocked by the chemical reaction, $^{1}_{1}H^{+}_{0} + {}^{16}_{8}O_8 \rightarrow OH^-$, there will be an increase of pH inside the mitochondrial as shown in the diagram. Such an increase in the pH inside the mitochondrial membrane can have profound effects on the electron flow and energy yield. We will take this topic up later.

We now describe our light microscopy studies of the organic matter that appeared in the sodium chloride solution energized by amplitude modulated carrier signals. As usual the solution and apparatus were sterilized, and vacuum pumped to remove the contaminating gases, nitrogen, carbon dioxide, and argon before the TD electrical field was applied. The microscope was a Wild research microscope with 100X planapochromat objective, and 32X bifocal eyepieces to give a maximum gain of 3200X at high resolution. I used the dark field method of illumination. Here is a microphotograph of what a sterile solution of 0.9% sodium chloride looks like before it is electrolysed with the TD signal. It is surprising that the individual crystals of sodium chloride can be located as tiny doughnuts, or toroids, against the dark field.

Now here is what the sodium chloride solution looks like after three minutes of electrical energization at 50 mw. This frame is a one second exposure. When one observes this scene with the eyeball one notes that the particles are flickering and oscillating. A critic would say that these eight-pointed light patterns are merely lense artefacts. When one uses a strobe light to stop the action it measures an oscillation of eight flashes per second. This effect occurs only in the early stages of electrolysis, and is not found later.

Eventually, I identified the molecule that was oscillating, but more of that later. In 1960 I was in Mexico with my friend Aldous Huxley and his wife Laura. In the course of a long discussion, I found that Laura practiced "laying on of hands" therapy. We arranged for a test of this alleged ability in Los Angeles, California on August 15, 1960 at the Sepulveda Veterans Hospital. Dr. Barbara Brown ran the electroencephalograph equipment. The design of the experiment was to see if Laura could exert any effect on a

— heme or Ferriheme

patient with ventricular extra-systoles, and occasional mild cardiac fibrillation. The subject and the operator were both connected to the EEG machine with additional readouts for respiration, EKG, and skin resistance. Laura was not allowed to touch the patient, but merely bring her hands within a few inches of the patient. The main finding was that when Laura brought her hands within four inches of the patient's thoracic spine - Laura's EEG suddenly showed high amplitude 8 Hz waves, and at the same time the patient's brain waves were entrained at 8 Hz with phase locking. I might add that a five year follow-up showed that the patient had been cured of her cardiac problem. This experiment has since been repeated by many workers. [24] Thereafter, Joe Kamiya developed a teaching method so that people could train themselves to autogenically evoke (8 Hz) Alpha waves. [25] When the Soviets went on the air in July 4, 1976 with their 100 megawatt transmissions of extremely low frequency waves (ELF) the intelligence community of the U.S. was caught, unaware, of this new technology. The Soviet ELF pulses covered the frequency range of the human brain. No one knew what the purpose of this new technology was. I had a hypothesis that this was a new mind control weapon that could entrain a human being's EEG. Bob Beck and I designed an experiment that conclusively proved that the Soviet transmissions could indeed entrain the human brain, and thereby induce behavioural modification. I reported this finding to the intelligence community in the U.S., and my paper was promptly classified. [26] A CIA commission of inquiry reported to President Carter that there was no substance to our findings. Today, five years later, all of our findings have been confirmed by various agencies of the U.S. Government. However, they went one step beyond

our findings, and proved that a certain ELF frequency (Classified) will cause cancer. [27] I have repeated these experiments, and found this to be true. The mechanism of this effect is that the ELF frequency modifies the function of the RNA transferases so that amino acid sequences are scrambled and produce unnatural proteins. The ELF exerts its' effect on the nuclear level, more specifically, the nuclear magnetic resonant property of the nucleus. The table shows the spin-spin coupling constants of various common chemical chains. Note the common chemical groupings with coupling constants around 8 Hz. [28] Note that a powerful carcinogen, ethylene dioxide, has coupling constants around 3 to 5 Hz. Note that another powerful carcinogen, formaldehyde, has a coupling constant around 41 Hz. Parrish, et al, [29] have found that the spin-spin coupling constants for water in malignant brain tumors (in humans and dogs) range from 4.8 to 13.4 Hz., whereas normal brain gray matter ranges from 8.6 Hz to 11.3 Hz. Thus malignancy shows a spread of frequencies from low to high ELF range i.e. with respect to normal brain EEG's, and carcinogens have a wide spread from 3 Hz to about 41 Hz around the center frequency for normalcy of 8 Hz. However, a single ELF frequency can produce cancer.

However, let us return to an examination of what we found in the electrically energized sodium chloride solution. Here again is the control - normal saline solution before electrical energization. Now the oscillating particles were entrained by the earth's natural oscillating magnetic field at 7.83 Hz (rounded off to 8 Hz). We determined eventually that the particle responsible for the oscillation was Ferrichrome, one of the strongest complex formers known for Fe (III). [30] The iron binding center is an octahedral arrangement of six oxygen donor atoms of trihydroxamate.

Ferrichromes are most important in the biosynthetic pathways of very complex compounds of iron, and Vitamin B12 (cyanocobalamin) is shown in the lower part of the figure. The next slide shows material that is an aggregate of several cocci-like masses of a bluish-green hue. This picture was taken at the 18th minute of electrical energization. The next slide shows forms that have a high mobility looking very much like bacteria. The next slide shows the form that evolved after one hour of electrolysis. There was no further evolution of "cell" form after this form had been reached. At this point in my research, I remembered that highly active mitochondria take a form very much as shown in the last slide. Here, in this slide we have pictures of what mitochondria look under different conditions. [31] In the next slide we see that mitochondria can take an arboreal form when they go from the resting state to the active state. [32] I then remembered from my medical school days, when we studied the blood of syphilitic patients under the dark field microscope, that we occasionally saw pleiomorphic bacteria. When I asked my instructor what these were, I was told that they were just debris, and to forget it. So I now went back to the microscope, and began to study these pleiomorphic bacteria afresh. In the forty years since medical school days a whole literature had been built up around these lowly bodies. [31] I became convinced that what I now saw in the blood of patients, particularly those with cancer, was very similar to what I was seeing in my <u>in vitro</u> preparations.

My next step was to take these arboreal forms out of the TD cell, and place them on a microscope stage heated to 37° C. and nurture them with D-glucose 6-phosphate in 5% solution. In a matter of minutes, the branch-like forms were covered with little beads of yellow, orange, green and blue

material.* The next slide shows the branched material beginning to clump and organize. At this point the morphology of the arboreal forms, and the metabolic events just cited, led me to entertain the hypothesis that I was dealing with a very primitive metabolic chemistry in which iron compounds like ferritin, ferrodoxin, and transferrins were serving as electron acceptors for electrons (H) arising from water. When I stopped the electrolysis of the saline solution, I found that the general reaction,

$$H_2O + A \xrightarrow[\text{energy}]{\text{electr.}} A\,H_2 + \tfrac{1}{2}O_2$$ ceased.

A represents the electron acceptor, and in this case is an iron compound, of the type just cited. An important feature of this Hill reaction is that electrons are induced to flow away from water molecules to acceptor A, thus yielding molecular oxygen from the water. In order to appreciate the meaning of this electrochemistry we see in the Table that in animal metabolism in the terminal respiratory chain electrons flow from the negative sign to the positive sign to produce water. [33] In the plant the electron flow is reversed and goes from the positive sign to the negative sign, a sort of uphill flow, electronically speaking. It occurred to me at this time that nature might have worked out a system to account for spontaneous cancer cures by reversing the flow of electrons in the mitochondrial terminal respiratory chain, and thereby producing more molecular oxygen to combat the cancer process. It also occurred to me that increased oxygen would tend to pull the proton/proton spin-spin coupling closer to the 8 Hz normative center frequency of biological systems. But I had no proof for these speculations. I did have some experience however

* These forms did not replicate after prolonged culture in various media. The reason is that I withheld sulfur from the solution in all my experiments.

in the clinical area from 1975 and on when I bought an ozone producing machine, the OZONOSAN PM 60, and did research on decubitus ulcers with Dr. Harry Becker at the Veterans Hospital in Montrose, N.Y. We found that hyperoxygenation and ozone gas treatment cleared up chronic decubitis ulcers in a matter of weeks. In a sense, this experience with ozone prepared me for the next step, which was a meeting with Migdalia Arnan, M.D., a Board Certified Pathologist, and her colleagues.

I will briefly summarize her main findings, because her paper will follow mine. Dr. Arnan found that a normal human cell, when immersed in formaldehyde gas, converts to a cancer cell in a few minutes. She then found that a human cancer cell if irradiated with intense white light under a microscope would undergo a (thermal) death in twelve minutes. She then discovered, under bright light microscope illumination, that unstained human cancer cells, as seen in the next slide, had pale green bodies in the cytoplasm about the size of mitochondria. It was at this point that we both gave a "Eureka" yell, and realized that her clinical discoveries, and my electrical and chemical investigations clarified each other. Furthermore, she and her colleagues had proven that if ozone gas is administered directly into a malignant tumor in mice, the tumor would dissolve in a matter of seconds to minutes and leave the normal surrounding tissue unaffected.

It is not yet generally recognized in the biological sciences that all life is immersed in an oscillating magnetic field that originates from protons in the sun. The slide shows the magnetic oscillations from the sun.[34] These ELF waves have a sharp resonance on earth due to cavity resonances, peaking at 7.81 to 7.83 Hz. This is the center frequency of the electromagnetic power spectrum of the human brain, the so-called Alpha frequency, of 8 Hz. We have already indicated that a "healthy" ELF center frequency exists for proton-proton spin-spin coupling in the chemistry of the body,

particularily in such control functions as genes and enyzymes for DNA and RNA. We have indicated that certain ELF frequencies at extremely low power, can induce cancer. I might add that the amount of power required to induce cancer at the correct ELF stimulus is measured in the range of microwatts. In short, ELF frequencies at super low power levels can control the well-being of organisms.

Now what happens when an organism is deeply insulted by chemicals, injury, or amputation? Let us take the most extreme case, i.e., amputation of a limb in a salamander. Robert Becker, M.D. has shown that the salamander limb can be regenerated if certain procedures are followed. [35] First, a skin flap of epidermis only (no dermal tissue allowed) is placed over the stump. Under this epidermal flap it has been found that regeneration occurs when red blood cells in the wound site undergo de-differentiation, i.e. revert to very primitive cells, the blastema. The figure shows red blood cells in their earliest stage when they still have a nucleus. [36] Such an early RBC form is what a de-differentiated cell looks like. Note the way in which such a cell takes up Iron transferrin and feeds it to the mitochondria.

My evidence indicates that the pleiomorphs found in the blood in association with cancer, as first reported by J.F. Glover, M.D. in Canada in 1923, [37] and verified by many workers subsequently, are in fact mitochondrial fragments from de-differentiated red blood cells that are released in response to the insult of cancer. These pleiomorphs carry a type of transferrin (not yet identified) that serve two functions. The first, as recently reported, by Goubin, et al, [38] in Nature, vol. 302, 10 March 1983, shows that the nucleotide sequence of a cloned transforming gene, that induces cancer in chickens, suggests that it encodes a

protein that is partially homologous to the amino acid terminus of transferrin and related proteins, although it is only about one-tenth the size of transferrin. The second function of this type of transferrin, I believe, is to reverse the electron flow in the mitochondria by changing one of the heme molecules into a chlorophyll type of molecule. The purpose of nature in this electron flow reversal is to electrolyze water in order to produce more oxygen to swing to local ELF frequency toward 8 Hz using both the Kervran nuclear transmutation mechanism, and the known effect of oxygen to lower the NMR spin-spin coupling of a solution.

The findings of Dr. Arnan also show that the mitochondrium is not only transformed in the reversal of electron flow, but actually produces Quantasomes, the chlorophyll bearing bodies of plants, as shown in one of her electron micrographs. This is a Quantasome found in a human cancer cell and accounts for the pale green bodies easily found in human cancer cells, if one just looks, and is not color blind. Now how does this theoretical mechanism account for the efficacy of ozone in the treatment of cancer tumors?

The analysis begins with an understanding of skin and membrane properties. One begins with square wave electrical spectroscopy according to the method shown in the slide. This yields various decay curves for voltage and current as shown in the next two figures. One also plots the impedance locus of the skin which shows loci for ELF, and for kilohertz frequencies. From this data one develops equivalent circuits for the various configurations of signal used on the skin, membranes, and water. A typical equivalent circuit for nerve is shown in Fig. 1A which also holds for the skin in the ELF range. Our studies, as well as that of others shows

that the water molecule has the tetrahedral form as shown. The equivalent circuit for the water molecule is shown in Fig. 22. Von Hippel and others have established that the water molecule has a dielectric resonance in the 8 Hz range.[39] The importance of water in biological structure and function is well known. Suppose that one were to substitute a molecule that mimicked the water molecule, for the true water molecule? We don't really know what would happen because there is nothing known quite like a water molecule. But I have a proposal to make. If one looks at the last figure, and conceives that ozone could actually have a tetrahedral form (and no one knows its true form) what would it behave like? The only change required is to substitute the Hydrogen atoms with O^+ atoms. The net effect of this ozone geometry would be to reverse the polarity of the EMF source at the left, and the polarity of the ferroelectric capacitor on the right, and reverse the diode so that the P semiconductor would face the capacitor. The circuit would now reverse the electron flow. In addition the ozone tetrahedron would have far more oxidizing power than water. Thus ozone would behave in the following manner as a therapeutic agent:

1) It would easily substitute for water in terms of geometrical fit into any biological structure. Wherever water would fit, ozone would fit.
2) Ozone would seek out the H_2 molecule by the following reaction: $H_2 + O_3 \longrightarrow H_2O + O_2^-$

This is a powerful exergonic reaction which would not only be a bond breaker, but release enough heat at the molecular level to melt the altered conformational states of proteins, oncogenes and various go/no go genetic switches.

I have tested this possibility, in the late sixties, while doing safety and hazard studies of the TD system on dogs. I used old and sick dogs in some of my studies, and some of them had surface malignant tumors. The procedure was as follows: In running high voltage hazard studies on animals I observed in a very dark room (a Faraday Cage) that a bluish plasma glowed between the electrode face and the skin. I could also smell ozone in the air. This effect occurred at 1100 volts (p-p) and 11 mA (rms) current. I found that I could tolerate this level of signal on myself without any discomfort, and the dogs could tolerate this signal after some training. I treated three dogs that had malignant tumors under the skin one hour a day for three weeks with this high voltage ozone-generating signal. There was no damage to the skin of the dog, and the tumors melted away under the skin during the three weeks. Others have repeated this type of radio frequency treatment of malignant tumors, subsequently.[40]

SUMMARY

We have presented a theory of a probable cause of cancer supported by some fragmentary experimental evidence. There are many further tests that can be made of the theory. I must emphasize that this is only a preliminary formulation. The theory, both empirically and experimentally led from separate sources to a rational therapy for malignant neoplasms in animals. The essence of the theory is that nuclear spin properties form an integrating topology for the development of chemical evolution centered on proton-proton spin-spin coupling in water. It is well to recall

here that the human body is made up of some two thirds, by mass, of water. It is also well to recall that the human body is made up, by count, 92%,of hydrogen atoms. The dynamics of hydrogen and oxygen are of great importance in the structure and function of the human body. For example, if the brain is deprived of oxygen for several minutes, the person will not only become unconscious, but permanent damage may result in the organization of the brain at a molecular level. There is another disintegrative pathology called "cardiac fibrillation" wherein the individual myocardial fibrils suddenly cease to beat in synchrony, and death can result within five minutes, if the condition is not normalized. A topological theory has been advanced by Winfree which shows that tiny electrical pulses intercalated at a precise phase angle in the normal heart natural period, called a topological singularity, or a "black hole", is sufficient to initiate fibrillation of the heart.[41] In NMR there is a spin echo technique called the "magic sandwich" in which certain magnetic and radio frequency phase cancellation operations are carried out in an orthonormal sequence, and a phase coherence in the spin system that appears to be lost, is restored.[42] This experiment, carried out with Calcium Fluoride (with the ^{19}F isotope) has the uncanny property of reversing the Hamiltonian$_D$ in the equations, which is equivalent to making the time flow backwards at half the normal speed. See Appendix I. This is a situation where the Kervran transmutation from $^{16}_{8}O_{8}$ to $^{19}_{9}F_{10}$ can place this form of fluorine at a critical point in the mitochondrial apparatus and cause time to flow backwards: or in other words, reverse the flow of electrons in time, as positrons.[43] These are some of the possibilities of the theory. We can now summarize the main points by reference to the graphic display.

An electrical signal generator was developed which proved to have rehabilitative effects on humans. The same signal pattern proved to be efficient in the electrolysis of sodium chloride solutions. A by-product of such electrolysis was a new insight into the dynamics of chemical evolution leading to organism. These insights were applied to the problems of cancer cause and control. These insights were sharpened by the experimental work of Dr. Arnan and her colleagues, in controlling and dissolving mammary neoplasms in female mice by injecting O_2^- and O_3 gas into the tumors. This theoretical and experimental work pointed to the disruption of ELF NMR proton spin-spin coupling mechanisms as a probable cause of some types of cancer. This probable mechanism is summarized in the flow chart, and the top line shows the ELF range of such coupling constants. Many considerations indicate that 8 Hz is the center frequency that "pulls" all other frequencies toward it, to maintain biological organizational integrity. Such biological integrity can be quantized by reference to an arbitrary rate of cell division scale, pointing from left to right on line two. On the left is shown the well-known fact that deuterated water, 27% concentration, or higher, will stop all cell division in many species.[44] When the deuterated water is removed from the cell suspension - the cells resume normal cell division. This type of control is exerted, in general, by elements as shown, with spin 1, and a positive magnetic moment.

In the center column we list those stabilizing elements with Spin $\frac{1}{2}$, and magnetic moment, μ, having a positive multiple of 0.4 Bohr magnetons, and these are elements with odd number mass; or of even number mass, Spin 0, and $\mu = 0$. We have indicated that RNA transferases can be disorganized by microwatt levels of magnetic ELF radiation. It is theorized that such ELF waves affect the RNA transferases at a precise phase angle that triggers a topological singularity.

The column above this line shows some of the many possible pre-conditions which essentially disperse the gaussian distribution around the power spectrum center frequency of 8 Hz., and this effect in turn, stimulates the rate of cell division locally, and may then later manifest as cancer. The dispersive mechanism originally acts to trigger the release of iron compounds from the red blood cell membrane due to altered amino acid sequences in both the cell wall, and the iron compounds. This in turn triggers red blood cell de-differentiation (backward in time) to a primitive stage of evolution. In this primitive stage, which we associate with the mitochondrial fragment "pleiomorphs" found in the blood of some cancer patients, the normal mammalian electron flow in the mitochondrial terminal respiratory chain is reversed, so that it flows in the direction found in plant cells. This effect is triggered and fed by a Hill reaction in which the electron acceptor molecules are iron compounds. Chlorophyll and quantasomes then appear in the cytoplasm of cancer cells. The correct dose of ozone gas easily substitutes for water molecules in the "plant-like" terminal respiratory chain, and releases both oxidative the thermal effects which dissolve the neoplastic-forming molecules, and restores the normal respiratory electon flow in the normal tissue surrounding the neoplasms. This process re-integrates the atoms and molecules around the 8 Hz center frequency ELF NMR. In its essence this is a theory of nuclear control of cell division processes operating through spin properties, and nuclear magnetic resonant fields in the extremely low frequency range.

← In some cancer patients

ELF NMR Spin-Spin COUPLING FREQUENCY SCALE

Hz	-32 Hz	-16 Hz	0 Hz	8.00 Hz	16 Hz	32 Hz	64 Hz

Direction of increasing rate of Cell Division ⟶

actors that Decrease Cell Div.

When cells are placed in H_2O uspensions that contain 27% ^{2}or ore, of deuterated water, cell ivision stops, reversibly.

$^2_1H_1$ = Spin I = 1, μ = 0.85

$^4_7N_7$ = Spin I = 1, μ = 0.40

$^6_3Li_3$ = Spin I = 1, μ = 0.82

Nitrogen acts as an anesthetic, and Lithium is a cell depressant.

normal

STABILIZING ELEMENTS

$^1_1H_0$ = I ½, μ = 2.79, and all elements with spin ½, or integral ½ spins with odd number mass and μ = 0; or with spin 0 and even number mass.

All proton-proton, spin-spin coupling energies pull toward 8 Hz.

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Factors that increase Cell Div. and may lead to cancer.

Genetic susceptibly
Chemical Pollution
- Industrial
- Automobile emissions
- Cigarette smoking
- Food Additives
- Water pollution

Ionizing radiation
ELF radiation
Geographic soil factors
Nutrition
Trace elements deficiency
Viruses
Cosmic ray flux
Neutrino flux
Telluric ELF
Weak transmutations

ABNORMAL: All proton-proton spin-spin couplings pull away from 8 Hz + or -

RNA transferases + Tetrahedral forms of H_2O ⟶ Topological Singularity initiating local desynchronization.

ABNORMAL Polypeptide and protein transcription errors leading to - RBC de-differentiation, and increasing Iron losses of:
- Ferritin
- Ferredoxin
- Transferrins

OZONE TREATMENT: ⟶ Changing electron flow (reversal), and producing:
- Chlorophyll
- Quantasomes

Initiating photosynthesis by the Hill reaction,

$H_2O \longrightarrow H_2 = \frac{1}{2}O_2$

$CO_2 + 2H_2 \longrightarrow H_2CO + \frac{1}{2}O_2$

$(H_2CO)_n \longrightarrow$ Hexoses

Normal Terminal Respiratory Chain electron flow restored, as well as normmal rate of cell division.

FLOW CHART RELATING NUCLEAR SPIN PROPERTIES, MAGNETIC MOMENT PROPERTIES TO THE RATE OF CELL DIVISION AND TO ELF NMR COUPLING ENERGIES

P	Atom	N	I	μ	μ	P	Atom	N	I
1	* H	0	½	2.79	* -1.91	0	n	1	½
1	H	1	1	0.85	0	2	He	2	0
3	* Li	3	1	0.82	-1.17	4	Be	5	3/2
5	* B	5	3	1.80	0	6	*C	6	0
7	* N	7	1	0.40	0	8	*O	8	0
9	* F	10	½	2.628	0	10	Ne	10	0
11	* Na	12	3/2	2.21	0	12	*Mg	12	0
13	* Al	14	5/2	3.64	0	14	*Si	14	0
15	* P	16	½	1.13	0	16	*S	16	0
17	* Cl	18	3/2	0.82	0	18	Ar	22	0
19	* K	20	3/2	0.39	0	20	*Ca	20	0
21	Sc	22	7/2	4.52	-0.788	22	Ti	25	5/2
23	* V	28	7/2	5.14	-0.474	24	*Cr	28	3/2
25	* Mn	30	5/2	3.46	+0.090	26	*Fe	31	½
27	* Co	32	7/2	4.65	±0.75	28	*Ni	33	3/2
29	* Cu	34	3/2	2.22	+0.875	30	*Zn	37	5/2
53	* I	74	5/2	2.80	-0.776	54	Xe	75	½
83	Bi	126	9/2	4.08	0	84	Po	125	½

TABLE 1. COMPLEMENTARY PHYSIOLOGICAL PAIRS OF ELEMENTS RANKED BY PROTON NUMBERS.
(SOURCE OF DATA, REF. 11) Handbook of Physics, Condon.

P = PROTON NUMBER

ATOM = SYMBOL OF ELEMENT

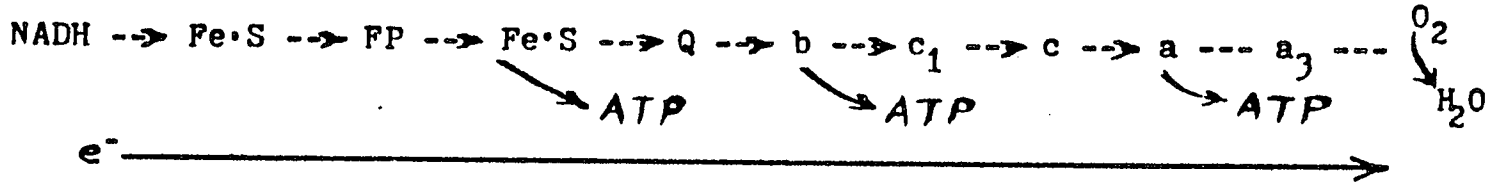
N = NEUTRON NUMBER

μ = BOHR NUCLEAR MAGNETON NUMBER ; I = SPIN

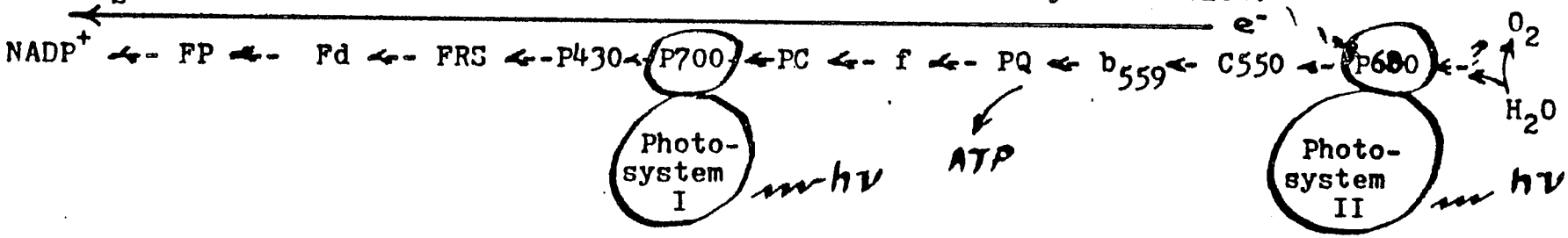
I = SPIN , $h/2\pi$

* = ESSENTIAL TO LIFE

The Respiratory chain of mitochondria in which the electron flow proceeds in the direction of NADH to oxygen. See below.



The photosynthetic electron transport chain, showing the flow of electrons from H_2O to $NADP^+$ via a sequence of electron carriers. See Key. See below.



Key:

c_{550} = cytochrome c_{550}

b_{559} = cytochrome b_{559}

PQ = plastoquinone

f = cytochrome f

PC = plastocyanin

P430 = Pigment 430

FRS = Ferredoxin-reducing substance

NADH = nicotinamide adenine dinucleotide, reduced form.

Fd = ferredoxin

FP = Ferredoxin-$NADP^+$

F·S = Ferrosulfate

Q = Quinone

c_x = cytochromes

ATP = Adenosine Tri-Phosphate

$NADP^+$ = nicotinamide adenine dinucleotide phosphate, oxidized form

$h\nu$ = photon

Figure 4.

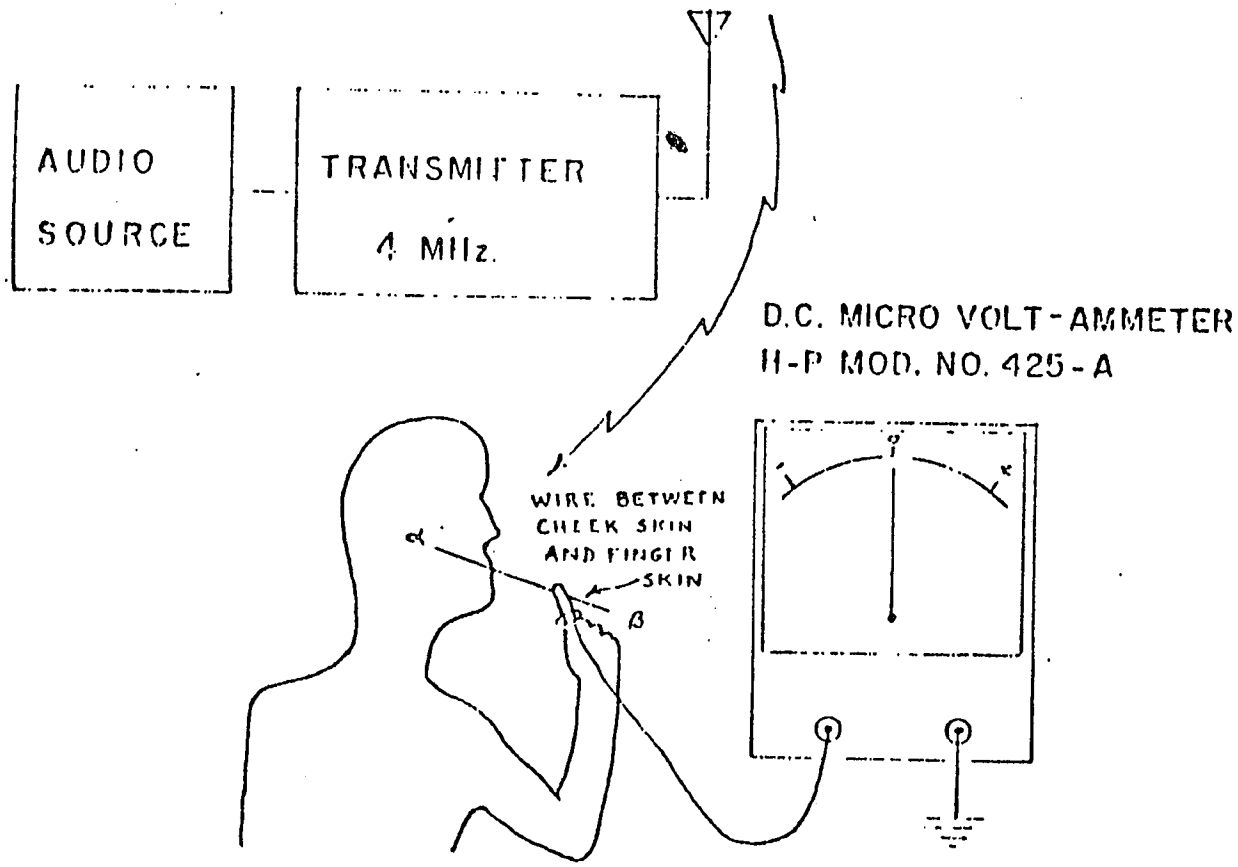


FIG. 46. MEASUREMENT OF DC SKIN POTENTIAL IN SHIELDED ROOM. RANGE OF DC OBSERVED IN 25 SUBJECTS.

1. WITHOUT RF FIELD: -60.5 mv TO +59.5 mv. (STATIONARY FINGER)
2. WITH RF FIELD: +200 mv FOR ALL SUBJECTS (STATIONARY FINGER)
3. WITH RF FIELD: +200 → +250 mv WITH EACH STROKE OF FINGER ON WIRE WHEN HEARING OCCURS WITH EACH STROKE OF FINGER ON WIRE.

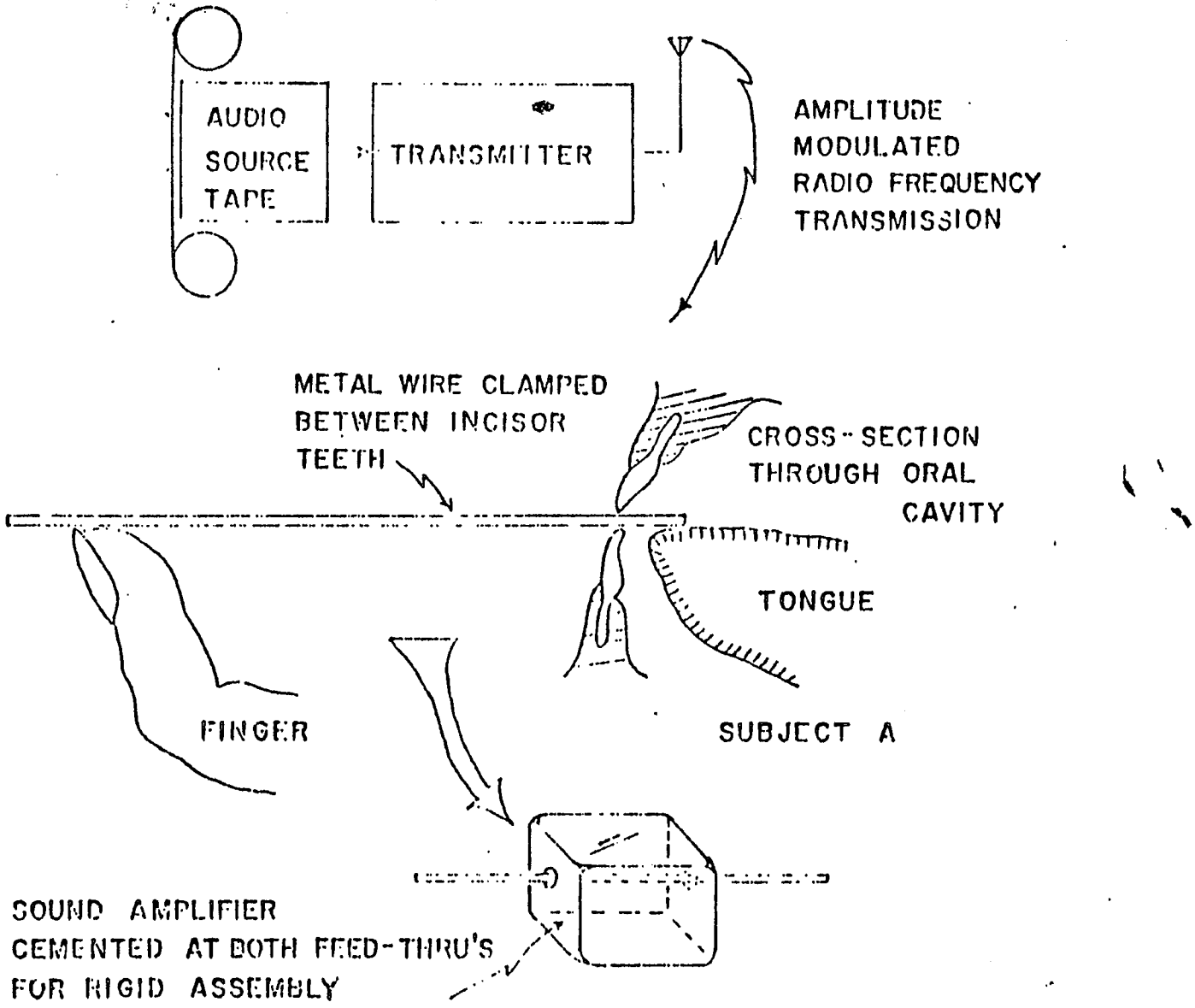
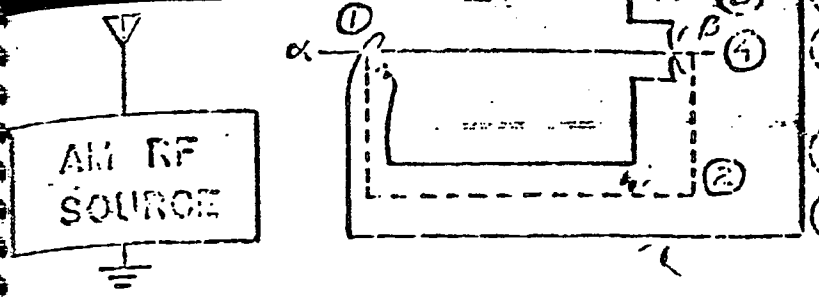
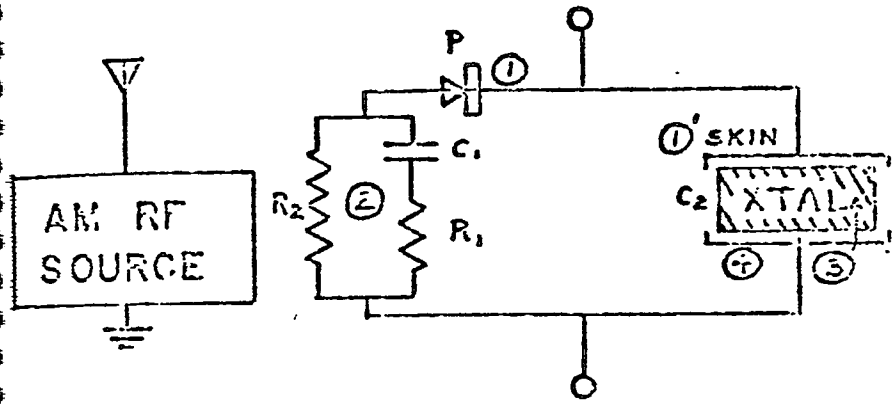


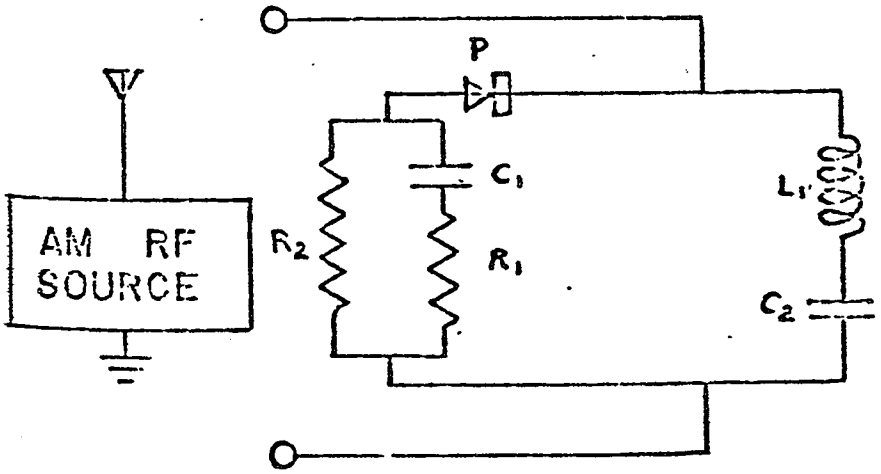
FIG. 44. RADIO FREQUENCY STIMULATION OF HEARING WITH WIRE MODEL.



A. PHYSICAL RELATIONSHIPS IN SKIN-STROKING OF WIRE



B. MODEL OF SKIN-STROKING



C. EQUIVALENT CIRCUIT OF SKIN-STROKING MODEL.

IG. 47. MODEL FOR HEARING RADIO WAVES BY SKIN-STROKING, AND ITS EQUIVALENT CIRCUIT IN THE BODY TISSUES. NUMBERS RELATE PHYSICAL ELEMENT TO CIRCUIT ELEMENT.

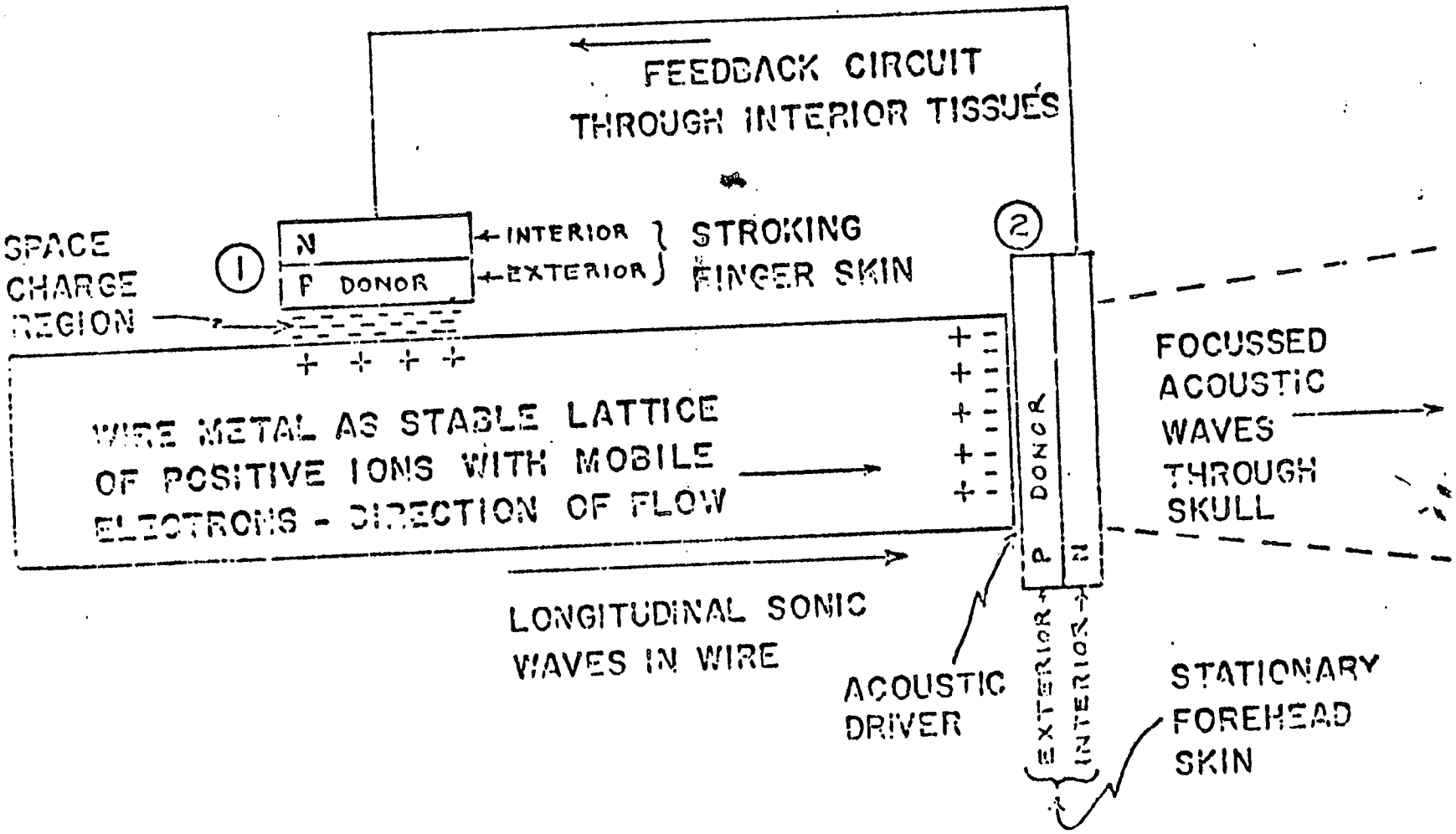


FIG. 45. WORKING HYPOTHESIS TO EXPLAIN HEARING BY "FINGER STROKING OF A WIRE" PRODUCING A FOCUSSED NARROW ACOUSTIC BEAM.

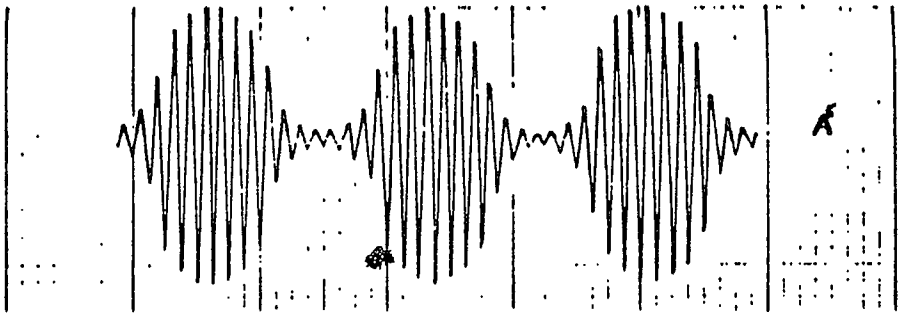


Figure 1A - Case IA.

One 1Hz AM carrier signal input across head. Bare metal electrode stationary on skin. The same input and output signal is observed for Case II.

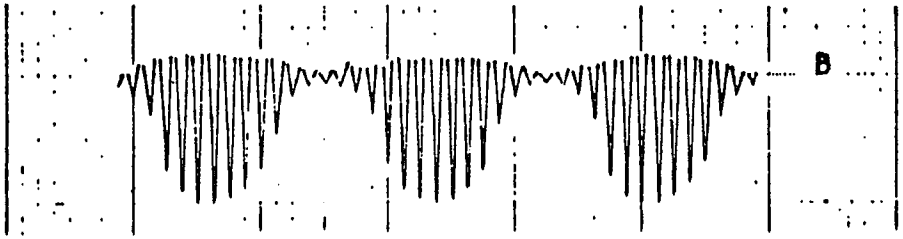
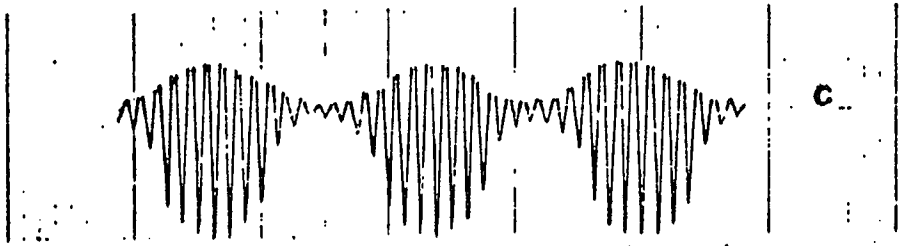


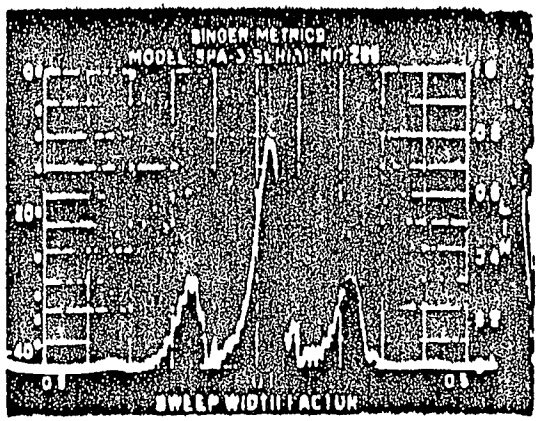
Figure 1B - Case IB.

TD input signal as shown in Figure 1A. Bare metal electrode stroked on skin across head. Output is full half-wave rectification of 1 Hz AM carrier signal.



TD input signal as shown in Figure 1A. One bare metal electrode and one mylar covered electrode stationary on skin across head. Output is partial half-wave rectification of 1 Hz AM carrier signal.

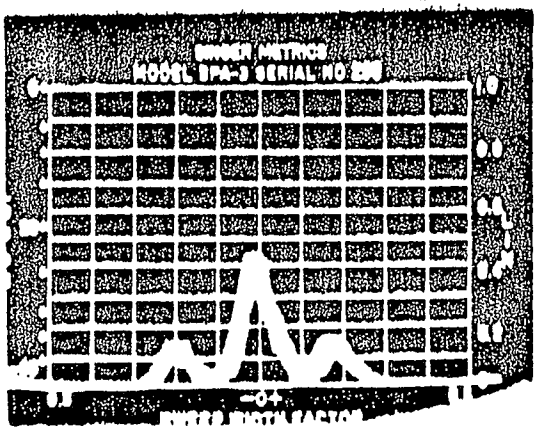
FIG.3. EFFECTS OF HEAD TISSUES ON TD SIGNAL WAVE FORMS WITH VARIOUS ELECTRODE CONFIGURATIONS



A. FIGURE SHOWING SINGLE SWEEP

TRANSDERMAL HEARING SYSTEM
AMPLITUDE MODULATION, CASE II.
50 KHz CARRIER - 150 V (p-p) 10 mA.
1 KHz SINE MODULATION

SPECTRUM ANALYSER
50 KHz CENTER FREQUENCY
5 KHz BANDWIDTH SWEEP
100 DB ATTENUATION



B FIGURE SHOWING REPETITIVE SWEEPS

FIG 42 POWER SPECTRUM OF TD SYSTEM OUTPUT

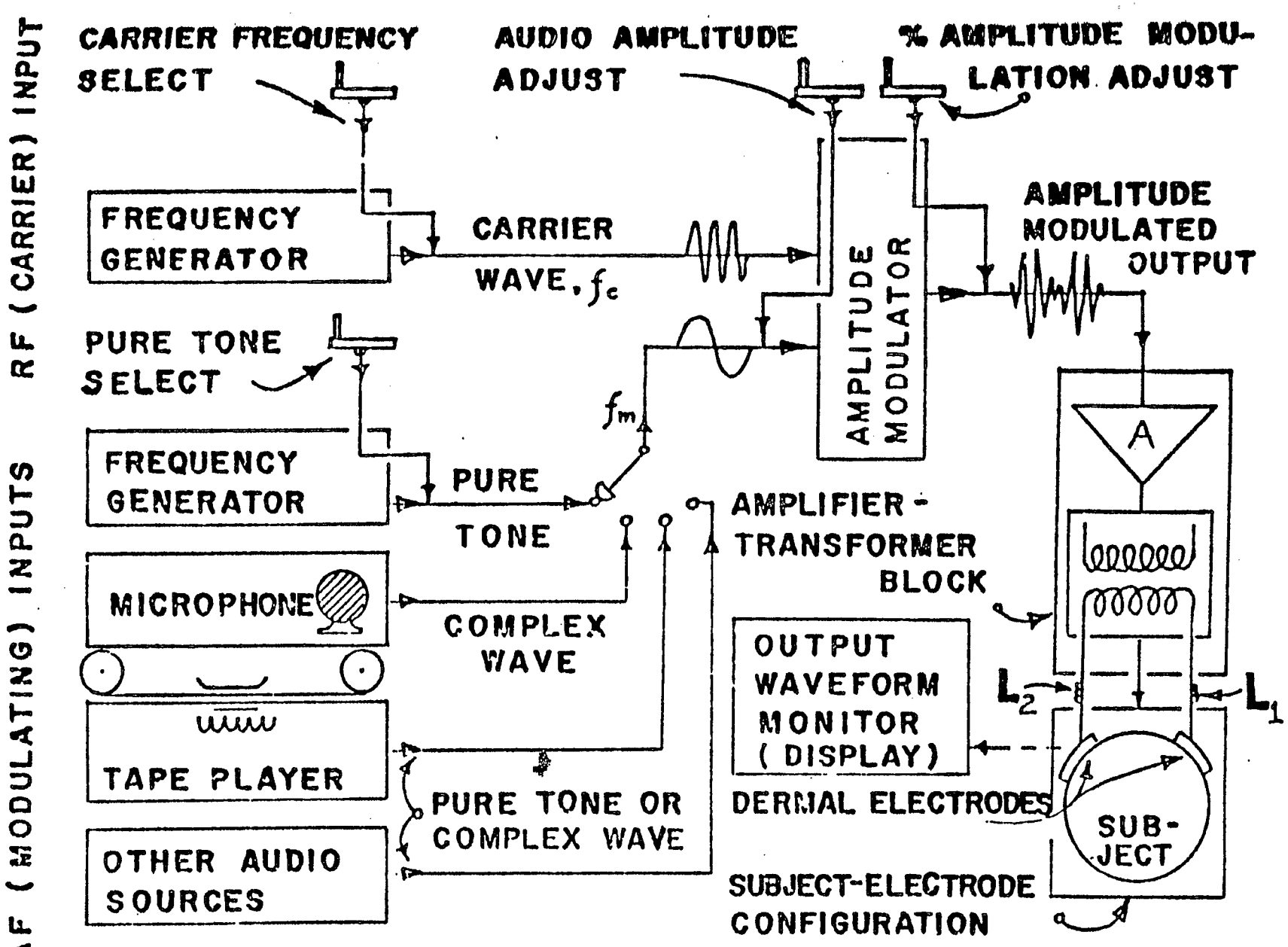


FIG. 4. MANUAL TRANSDERMAL AMRF SYSTEM BLOCK DIAGRAM

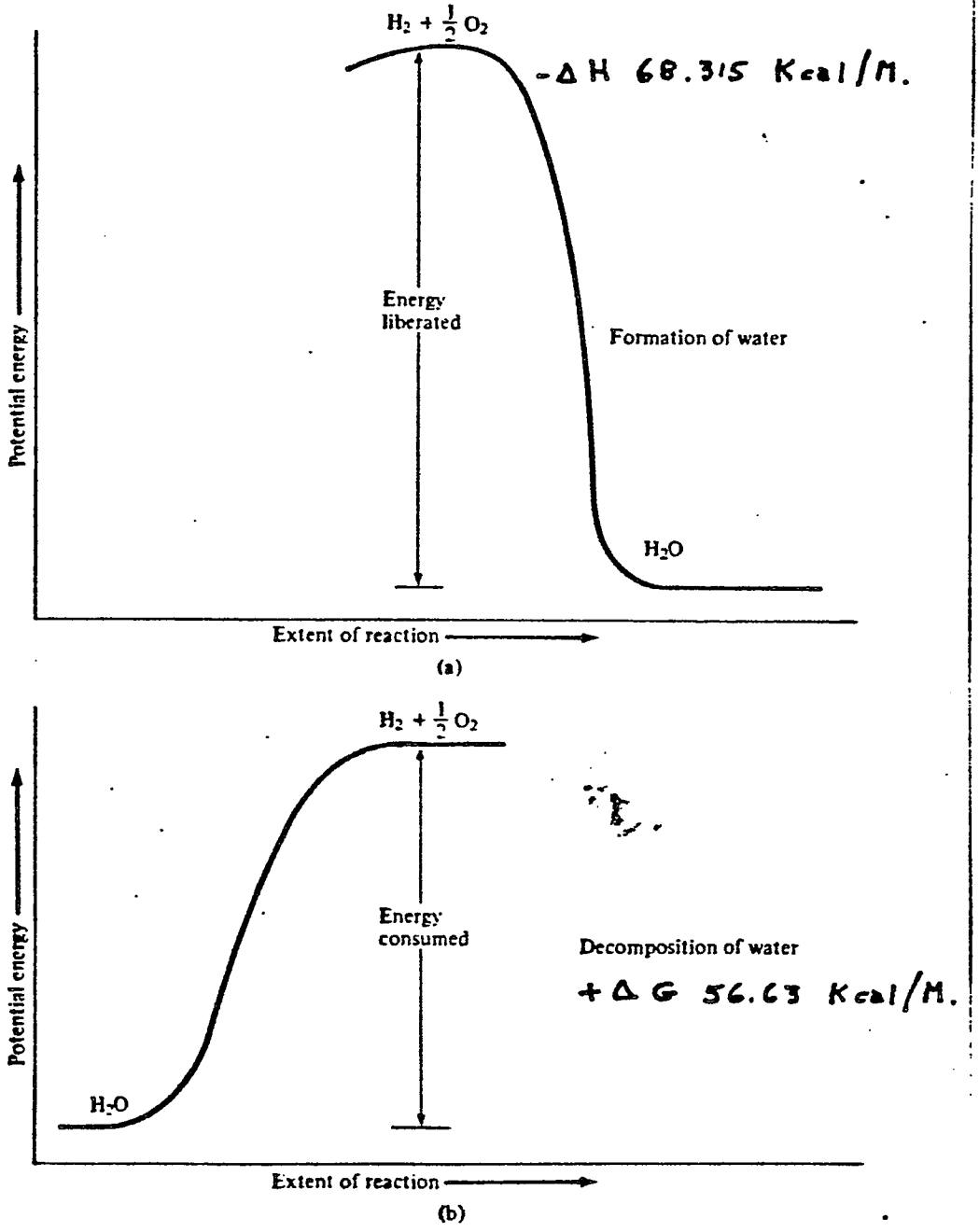


FIGURE 4.1. (a) An exorgonic reaction. Products have a lower potential energy than reactants, therefore, energy is released. (b) An endergonic reaction. Products have a higher potential energy than reactants, causing energy to be consumed.

Chemical Content of Solution:

A. BEFORE ELECTROLYSIS

$NaCl$, HOH

Air Contaminants

N_2, O_2, Ar

pH 4.27

CO_2 - not detectable

B. AFTER SEVERAL HOURS VACUUM @ 60 μ

$NaCl$, HOH

N_2, O_2, Ar, CO_2 - not detectable

Sample Identity:	#1-10:12 AM	#2-10:34	#3-11:01	#4-11:35	#5-12:00	#6-12:34 PM	#7-1:10
Constituents	Concentration, % by Volume						
Nitrogen	59+	37.6	18.2	11.0	11.5	9.6	5.0
Oxygen	18.7	9.6	0.98	0.88	0.86	0.87	0.44
Argon	0.87	0.77	0.40	0.37	0.50	0.30	0.174
Carbon Dioxide	ND	0.056	0.060	0.054	0.096	0.0137	0.0127
Hydrogen	21.0	51+	80+	87+	87+	89+	94+
Hydrogen, cc	3.6	NA	NA	NA	2.6	NA	NA
Oxygen, cc	3.2	NA	NA	NA	0.022	NA	NA
Amount of Gas Sampled,cc	0.12	0.44	0.44	0.50	0.46	0.35	0.49

Definitive Test

Sample Identity:	2:15P.M. 0 min	2:30 P.M. 15 min	2:45 P.M. 30 min	4:00 P.M. 0 min	4:30 P.M. 30 min
Constituents	Concentration, % by Volume				
Nitrogen	6.6	5.3	8.7	7.9	12.1
Oxygen	0.86	0.53	1.53	1.36	2.8
Argon	0.161	0.138	0.199	0.21	0.23
Carbon Dioxide	ND	0.0154	0.062	0.0058	0.082
Hydrogen	92+	94+	89+	90+	84+
Total Amount of Gas,cc	0.20	0.29	0.18	1.9	2.1
Hydrogen, cc	0.184	0.27	0.16	1.72	1.78
Oxygen, cc	0.0017	0.0015	0.00275	0.026	0.059

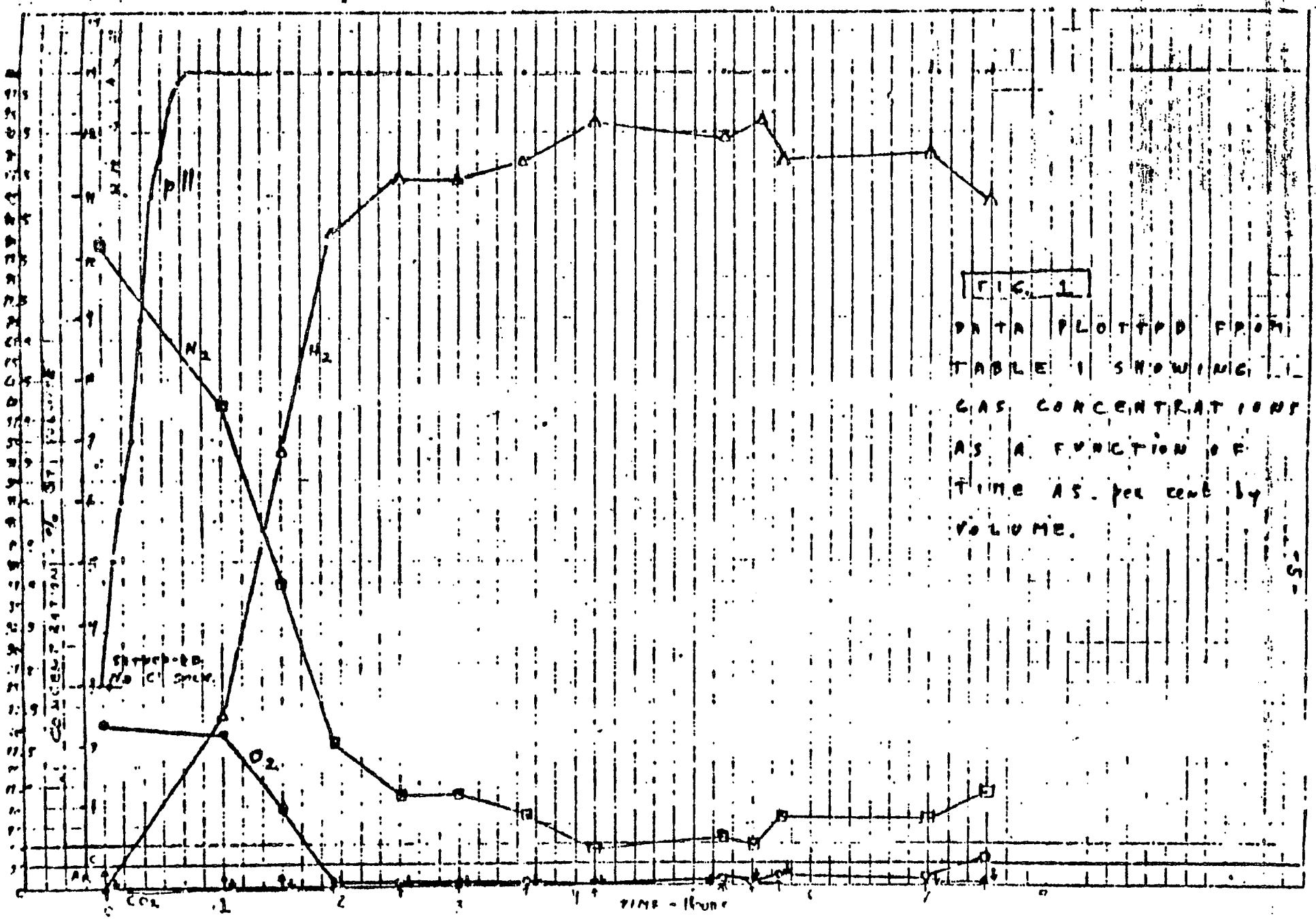


FIG. 1

DATA PLOTTED FROM TABLE I SHOWING GAS CONCENTRATIONS AS A FUNCTION OF TIME AS per cent by VOLUME.

WATER ELECTROLYSIS REACTIONS

I. $2NaCl + 4HOH \longrightarrow 2NaOH + 2H_2(g) + Cl_2$

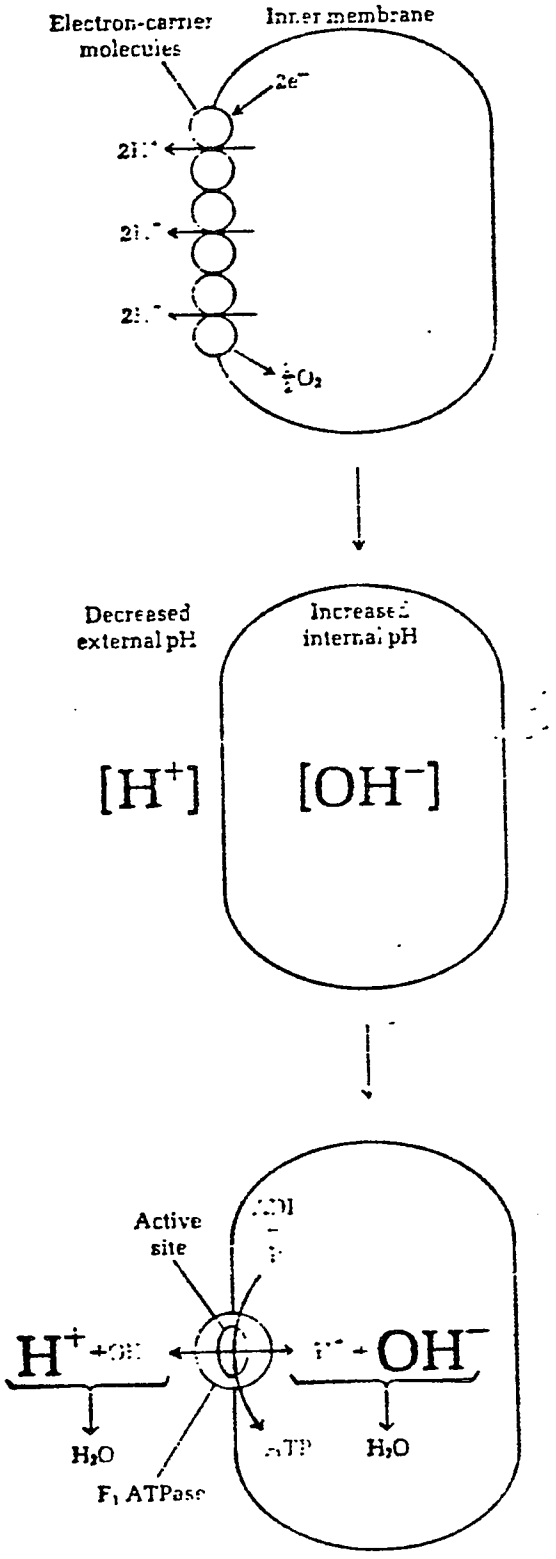
$Fe + Cl_2 \longrightarrow FeCl_2$

II. $3FeCl_2 + 4HOH \xrightarrow[\text{CATALYST}]{Cu} FeO \cdot Fe_2O_3 + 6HCl + H_2(g)$

III. $Fe_3O_4 + 8HCl \longrightarrow 3FeCl_2 + 4HOH + Cl_2$

IV $2Cl_2 + 2HOH \rightarrow 4HCl + O_2(g)$

Figure 19-16
Simplified representation of the chemiosmotic-coupling hypothesis.



Electron transport causes H^+ ions to be pumped outward, across the inner membrane of the mitochondrion, to yield a gradient of H^+. This phase is shown in more detail in Figure 19-17.

The H^+ gradient is the energy-rich state into which electron-transport energy is transformed. The inner compartment becomes alkaline, the outer compartment more acid.

The H^+ gradient is the immediate driving force for the phosphorylation of ADP, which proceeds with the removal of HOH. The relatively high internal OH^- concentration pulls H^+ (color, from the active site of the F_1 ATPase and the relatively high external H^+ concentration pulls OH^- in the outward direction. Since the ion product of water ($K_w = [H^+][OH^-]$) is very low (10^{-14}), the sinks of OH^- and H^+ generated by electron transport are very effective traps for H^+ and OH^-, respectively. ATP formation is shown in more detail in Figure 19-18.

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NUCLEAR MAGNETISM:
Order and Disorder

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1982

$\beta_Z = 0$, which gives for *any* t the same expectation values of Z and $\mathcal{H}_D$? The answer is yes if the time t is long compared to T_2, no if t is much shorter than T_2.

The first answer is based solely on experiment. After *preparing* the spin system by a pulse $(\pi/2, 0y)$ and a pulse $(\pi/4, 0x)$ separated by a time τ it is possible to *look* at it by a pulse $(\theta, 0x)$ t seconds later. When $t \gg T_2$ it has indeed been found experimentally (Jeener and Broekaert, 1967) that $\langle I_y \rangle = 0$ and that the time-dependence of $\langle I_x(t) \rangle$ is given by (1.44) where β has the value given by (1.184):

$$\langle I_x(t') \rangle = -\beta_Z'' \frac{\omega_0}{2D^2} \sin\theta \cos\theta \, \mathrm{Tr}\{I_x^2\} \left(\frac{dG}{dt}\right)_{t=\tau} \left(\frac{dG}{dt}\right)_{t=t'}. \quad (1.185)$$

Its dependence on τ and t' is $(dG/d\tau)(dG/dt')$.

The second answer is a straightforward consequence of quantum mechanics. If the observation pulse $(\theta, 0x)$ occurs shortly after the pulse $(\pi/4, 0x)$, then $\sigma(\tau, t)$ does *not* behave at all as a spin-temperature matrix. As an example assume that the observation pulse $(\theta, 0x)$ occurs immediately after the pulse $(\pi/4, 0x)$ and that θ is given the value $-\pi/4$. The two pulses cancel each other and t' seconds later:

$$\begin{aligned}\langle I_x(t') \rangle &= -\beta_Z'' \omega_0 \, \mathrm{Tr}\{I_x \exp(-i\mathcal{H}_D t') \exp(-i\mathcal{H}_D \tau) I_x \exp(i\mathcal{H}_D \tau) \exp(i\mathcal{H}_D t')\} \\ &= -\beta_Z'' \omega_0 \, \mathrm{Tr}\{I_x^2\} G(\tau - t'), \end{aligned} \quad (1.186)$$

a dependence on τ and t' quite different from (1.185). This discrepancy is due to the fact that while $\langle Z \rangle$ and $\langle \mathcal{H}_D \rangle$ are unaffected by the off-diagonal matrix elements of $\sigma(\tau, t)$ in (1.181), the transverse component $\langle I_x \rangle$ is, and one must therefore wait for the randomization of the phases before attempting a measurement of β_Z and β.

(c) *Phase refocussing: the magic sandwich*

1. *The argument for irreversibility*

In the early years of magnetic resonance Erwin Hahn had performed an experiment, the spin echo, which to the uninitiated, had appeared little short of miraculous. The transverse nuclear magnetization of a liquid sample, precessing in an inhomogeneous magnetic field, once it had decayed to zero, could be restored to its full, or almost full value, by an appropriate r.f. pulse, and this after a time far longer than the decay time.

The principle of Hahn's spin echo is too well known to be discussed here in any detail. The gist of it is that the Larmor precession frequencies of the different parts of the sample, although spread over an interval $\Delta\omega$, whence their destructive interference and the magnetization decay in a time of the order of $(\Delta\omega)^{-1}$, are constant in *time*. A π pulse, by reversing at a time

$\tau \approx (\Delta\omega)^{-1}$ after the beginning of the precession all the phase angles accumulated by the various spins, brings them automatically into phase again at time 2π if the precession velocities have remained constant, whence comes the "resurrection" of the magnetization.

On the contrary, in a solid where the decay of the nuclear magnetization is due to the dipolar interaction $\mathcal{H}'_D$, this decay has been for a long time considered as completely irreversible.

The case for this irreversibility has rested on various arguments, some more convincing than others.

(i) It has been argued that in the solid each spin precesses in the local field of its neighbours. Because of flip-flops between the spins this field is not constant in time but fluctuates in a random and hence, irreversible manner: the accumulated phase lags or advances cannot be retrieved. One must beware of arguments of that type. It was a similar argument which, before the historical spin temperature experiment of Pound, had led to the belief that the loss of magnetization after a demagnetization into zero field was always irreversible: it was argued that in zero field fast random reversals of one spin, or of two spins in the same direction, (processes forbidden by energy conservation in high field but allowed in zero field), would destroy for ever the magnetization in a time T_2, a conclusion that contradicts both the experiment and the spin temperature theory.

(ii) A second argument is to state that because of the bilinear nature of the dipolar Hamiltonian $\mathcal{H}'_D$ the refocussing effect of a pulse *à la* Hahn would be nil. This is quite true but only shows that the decayed precessing magnetization cannot be retrieved by *that* particular method.

(iii) By far the most cogent argument for irreversibility was the spin temperature assumption.

Immediately after a $\pi/2$ pulse around 0x the density matrix of the spin system is, in the rotating frame: $\sigma(0) = 1 - \alpha\omega_0 I_y$ and the transverse magnetization:

$$\langle I_y \rangle_0 = \mathrm{Tr}\{I_y \sigma(0)\} = -\alpha\omega_0 \,\mathrm{Tr}\{I_y^2\}. \tag{1.187}$$

After a time $t \gg T_2$ the transverse magnetization has completely disappeared and according to the spin temperature assumption and to all the experimental evidence backing this assumption we expect $\sigma(t)$ to be represented with good accuracy by the expression: $\sigma = 1 - \beta_Z \omega_0 I_z - \beta \mathcal{H}'_D$ where the quasi-invariants $\mathcal{H}'_D$ and $Z = \omega_0 I_z$ have the same expectation values:

$$\langle Z \rangle = -\beta_Z \omega_0^2 \,\mathrm{Tr}\{I_z^2\}. \qquad \langle \mathcal{H}'_D \rangle = -\beta \,\mathrm{Tr}\{\mathcal{H}'^2_D\} \tag{1.188}$$

as at the time $t = 0$:

$$\langle Z \rangle_0 = \omega_0 \,\mathrm{Tr}\{I_z \sigma(0)\} \qquad \langle \mathcal{H}'_D \rangle = \mathrm{Tr}\{\mathcal{H}'_D \sigma(0)\}. \tag{1.189}$$

The latter however are clearly zero and so therefore are β_7 and β. The spin temperature density matrix should thus be the unit matrix and no magnetic signal could seemingly be extracted from it.

'Nothing will come out of nothing.' And yet ····.

2. *The magic sandwich*

After a pulse $(\pi/2.0x)$ at time $t = 0$ and once the precessing magnetization has disappeared presumably for ever, the following sequence of pulses called 'magic sandwich' is applied (Rhim *et al.* 1971):

(i) At time $T_A \gg T_2$ a pulse $(\pi/2.0y)$ followed by the sudden application for a duration $T_B \gg T_2$ of a strong r.f. field $H_1 = -\omega_1/\gamma$ along $0x$.

(ii) At time $(T_A - T_B)$ the field H_1 is cut off and a pulse $(-\pi/2.0y)$ applied.

After the magic sandwich sequence one looks for the appearance of a signal. Indeed if $T_B \gg T_2$, has been chosen greater than $2T_A$ a signal shaped like an echo of the initial decay, does appear at a time $T_C = \frac{1}{2}T_B - T_A$ after the magic sandwich!

The theory of this echo is actually quite straightforward. The unit operator $U_M(T_B)$ which corresponds to the magic sandwich is:

$$U_M(T_B) = R_y^{-1}\left(\frac{\pi}{2}\right)\exp\{-iT_B(\omega_1 I_x + \mathcal{H}'_D)\}R_y\left(\frac{\pi}{2}\right)$$

$$= \exp\left\{-iT_B R_y^{-1}\left(\frac{\pi}{2}\right)[\omega_1 I_x + \mathcal{H}'_D]R_y\left(\frac{\pi}{2}\right)\right\}$$

$$= \exp\left\{-iT_B\left[\omega_1 I_z + R_y^{-1}\left(\frac{\pi}{2}\right)\mathcal{H}'_D R_y\left(\frac{\pi}{2}\right)\right]\right\}. \qquad (1.190)$$

According to (1.10*a*),

$$R_y^{-1}\left(\frac{\pi}{2}\right)\mathcal{H}'_D R_y\left(\frac{\pi}{2}\right) = -\tfrac{1}{2}\mathcal{H}'_D + G_2 + G_{-2}, \qquad (1.191)$$

where G_2 and G_{-2} transform under rotation like the tensor operators T_2 and T_{-2}. If $\omega_1 I_z \gg G_2, G_{-2}, \mathcal{H}'_D$, that is if $H_1 \gg H'_L$ we can within first order perturbation theory disregard the effects of the off-diagonal terms $G_2 + G_{-2}$ whence:

$$U_M(T_B) = \exp\{-i(-\tfrac{1}{2}\mathcal{H}'_D + \omega_1 I_z)T_B\}. \qquad (1.192)$$

If furthermore we choose T_B such that $\omega_1 T_B = 2n\pi$ (which, as a more elaborate discussion shows, is not really necessary) $U_M(T_B)$ becomes:

$$U_M(T_B) = \exp\{-i[-\tfrac{1}{2}\mathcal{H}'_D T_B]\}. \qquad (1.193)$$

The magic sandwich has the uncanny property of reversing the effective sign of $\mathcal{H}_D$, which is equivalent to making the time flow backwards (at half

the normal speed). The evolution operator of the system at time $T_A + T_B + T_C$ becomes:

$$U'(T_A + T_B + T_C) = \exp(-i\mathcal{H}'_D T_C) U'_M(T_B) \exp(-i\mathcal{H}'_D T_A)$$
$$= \exp(-i\mathcal{H}'_D (T_C - \tfrac{1}{2}T_B + T_A)). \quad (1.194)$$

The magic sandwich is thus capable of cancelling the sum of the phase $-i\mathcal{H}'_D T_A$ accumulated before it and of the phase $-i\mathcal{H}'_D T_C$ accumulated after it if:

$$T_A - T_C = T_B/2. \quad (1.195)$$

It thus restores the initial density matrix $\sigma(0)$ and the initial signal $\langle I_x(0)\rangle$ (Fig. 1.6).

It would thus appear that a decayed precessing magnetization can always be retrieved whatever the time elapsed after its decay (within the limitations caused by spin-lattice relaxation). There are actually other limitations. The formula (1.192) for the effect of the magic sandwich is only approximate. The effective Hamiltonian for U'_M is:

$$\mathcal{H}_{eff} = \omega_1 I_z - \tfrac{1}{2}\mathcal{H}'_D + G_2 + G_{-2}. \quad (1.196)$$

The off-diagonal term $G_2 - G_{-2}$ does induce a departure of $U_M(T_B)$ from the approximate expression (1.192).

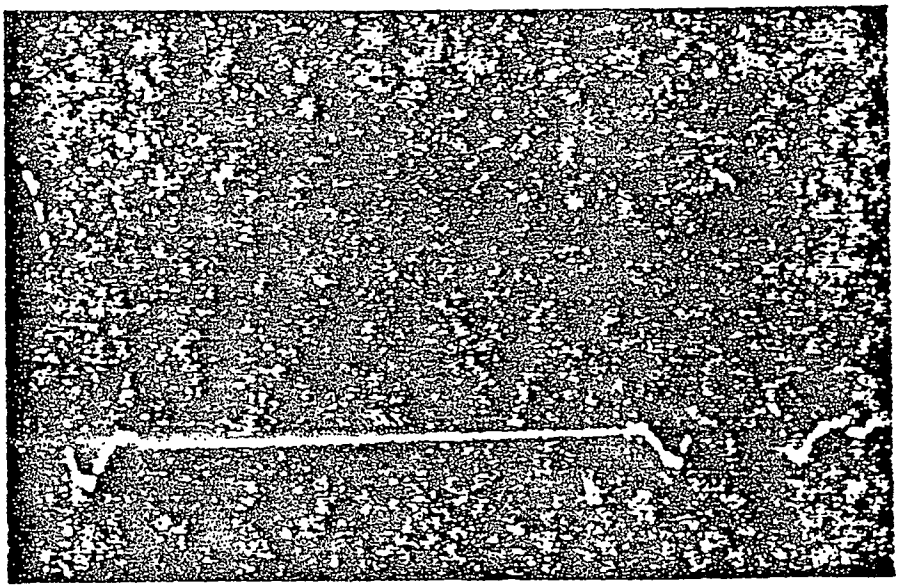

FIG. 1.6. 'Magic sandwich' experiment in CaF_2 with $H_{\parallel}$[111]. Free induction decay and 'magic' echo of ^{19}F spins. (After Rhim *et al.*, 1971.)

The longer the time T_R during which it acts, the larger the departure of $U_M(T_R)$ from (1.192) and either, the poorer the phase cancellation by the magic sandwich, or conversely the larger the value required for ω_1 to maintain this cancellation.

Eventually, the magnetization would be lost because its retrieval would require impossibly high values of the r.f. field H_1, and irreversibility wins.

Still this experiment shows that phase coherence in the spin system may persist for times much longer than was thought previously.

Does it mean that one should give up the concept of spin temperature, such as it has been used successfully in innumerable experiments? The answer in the opinion of the authors is no. The point is not whether after a time of the order of a few T_2 the off-diagonal matrix elements of the density matrix have 'disappeared', a philosophical question, but whether their existence can have observable consequences in a given experimental situation. It turns out that unless an elaborate experiment, like the magic sandwich, has been designed with the express purpose of tracking down these off-diagonal matrix elements, the usual criterions for the validity of the spin temperature assumption keep their usefulness.

The new contribution of the magic sandwich experiment is to deepen our understanding of the meaning of the spin temperature assumption and to call for a careful assessment of the experimental conditions lest an accidental refocussing of the phases occurs.

D. Spin-lattice relaxation

At various places in the foregoing eqn (1.25), eqn (1.38) we have introduced as phenomenological parameters spin-lattice relaxation times for various spin operators, such as T_{1z} and T_{1D} for the Zeeman and dipolar energies and T_{1x} for the relaxation of the transverse magnetization. A detailed microscopic theory of spin-lattice relaxation can be found in Abragam (1961), chapters VIII and IX and, with special reference to spin temperature, in Goldman (1970), chapter 3.

In this section we shall show how the formalism of spin-lattice relaxation can be derived as a consequence of the generalized Provotorov equations of **B**(*c*).

The principle is very simple. In order to study the spin-lattice relaxation of an operator Q of the spin system such as, say, I_z or I_x (in the rotating frame) or $\mathcal{H}_D$ we choose this operator as an 'operator of interest' in the sense of the sections **B**(*b*) and **B**(*c*). As a second 'operator of interest' we choose the Hamiltonian $\mathcal{H}_L$ of the 'lattice' which is a physical system whose variables commute with those of the nuclear spin system.

The lattice is assumed to be at all times in internal thermal equilibrium with an inverse 'lattice' temperature β_L. In the course of the coupling

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Dear Mr. Valone:

Sorry I missed you on Friday....as coincidence would have it Andrija had just flown into town and I was with him. Here is a copy of the paper Andrija said you wanted.

Sincerely,

Solveig

Solveig Clark