

# Electrically Induced Explosions in Water

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## ABSTRACT

A 2  $\mu\text{F}$  capacitor was charged to voltages in the 1 - 10 kV range and discharged into a water column through a 38  $\mu\text{H}$  inductor. At voltages up to about 6 kV, the water acted as a relatively high resistance and the circuit decayed as an overdamped RLC circuit. Resistance decreased with time. When the resistance dropped below about 10  $\Omega$ , the water would explode if the capacitor still had sufficient energy. The loudness was distinctly greater than an equivalent amount of gunpowder.

During the explosion, resistance would drop still more, so the circuit would become underdamped and oscillatory. Remaining water droplets are cool to the touch, so there is no evidence that the water has boiled into steam, although that has to remain a possibility. A low impedance arc in air sometimes forms after the explosion so the explosion is not necessarily caused by an air arc.

## INTRODUCTION

For many years, a number of researchers have sought a completely new energy source, one freely and widely available. Tesla, Moray, and Bearden are among the better known of these searchers [1].

It is likely that some energy will have to be expended in order to tap into this source, perhaps in a manner similar to a heat pump. A heat pump is able to move several units of heat energy from the outdoors to air conditioned space for the cost of a single unit of electrical energy. The heat energy is readily and freely available, but requires an electrical input to move it to a desired location. The ratio of heat energy output to the electrical energy input is called the Coefficient Of Performance (COP) and is well over unity. So "over unity" machines are already widely used. But is there another source of energy in the ambient besides sensible heat? If there is, we would expect some experiments to yield more output energy than the known energy input. There would probably be nonlinear and threshold effects, which would help explain why the new source has not been previously identified. High voltages, high currents, and/or resonant phenomena may

be necessary. Experiments which may be operating in an "over unity" mode need to be carefully reported and then replicated by other researchers.

One such phenomenon which deserves a careful examination is electrically induced explosions in water. It has not been proven that the energy released by the explosion is greater than the electrical energy supplied (and doing so will be difficult), but there are certainly unexpected effects associated with the high voltage and high current operation. There is also an arc, which may be important in developing the new energy source [2].

A careful investigation of the phenomenon may yield new insight into basic electromagnetic theory, such as the longitudinal Ampere's force proposed by Graneau. It may illuminate a method of tapping into a new energy source, assuming the energy developed in the explosion is greater than the energy originally stored in the capacitor. And even if it can be fully explained by classical physics, it may still offer a technique for protecting the contacts of high voltage switches. With a water channel in series, the switch will close into a moderately high impedance, with minimal arcing. After a small time delay (allowing the switch to be fully closed), a plasma arc is established in the water, providing a low impedance path to the load.

## GRANEAU'S EXPERIMENTS

Peter Graneau, a physics professor at Northeastern University, and his associates, have performed several experiments with water-plasma explosions [3,4]. The basic circuit for all the experiments is shown in Fig. 1. The capacitor  $C$  is charged, and then discharged through an inductor  $L$  and a water column with effective resistance  $R_w$ . [3] describes a 0.5  $\mu\text{F}$  and a 2  $\mu\text{F}$  capacitor charged at voltages up to 10 kV, while [4] describes a 8  $\mu\text{F}$  capacitor charged at voltages up to 30 kV. The inductance was 876  $\mu\text{H}$  in [3] and 11.1  $\mu\text{H}$  in [4].

The discharge from a small voltage was silent, with no noticeable movement of the water. They call this type an *electrolytic* discharge. As either the voltage or the capacitance increased, an arc discharge would form, with audible noise. Arc formation seemed to depend on the total charge



passing through the water. A float above the arc would be forced upward, but the impulse seemed to terminate with the arc. No followthrough push from expanding steam nor any vapor escape from the water could be discerned.

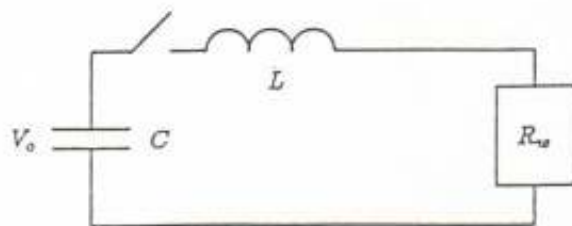


Figure 1: Water Arc Discharge Circuit

In two cases with the same stored energy, a  $0.5 \mu\text{C}$  capacitor charged to  $6 \text{ kV}$  and a  $2 \mu\text{C}$  capacitor charged to  $3 \text{ kV}$ , the second case resulted in an arc explosion while the first did not. In both cases, the heat dissipated in the water was less than one calorie, in a container of about 120 grams of water. Their conclusion, based on measurement, calculation, and visual observation, was that the explosion was not based on thermal effects. They conclude, rather, that the explosion was due to longitudinal Ampere forces. This concept of a tension force in a single conductor due to the current flow in the conductor is not taught in introductory electromagnetic theory courses, but Graneau makes a good case for such longitudinal forces in [5].

They discovered that tap water produced explosions about twice as strong as those in saturated saltwater. The explosions in distilled water were even stronger, except that it was difficult to initiate the arc in distilled water.

The calculated pressure in the chamber in the last test in [4] was 27000 atm. Their comment was "This explains why the cartridge was split." They defined a figure of merit as the strength of the explosion per unit action integral of the current pulse, and found that the figure of merit for their system was three times as high as the very best railgun performance. Railguns have better acceleration characteristics than chemical explosives, so water arcs have more "bang per buck" than any other explosive, save perhaps nuclear.

Water arcs are therefore interesting to study. At a minimum, they would indicate that Ampere's force law needs to have a longitudinal component. It is conceivable, however, that careful experimental studies will show that the total energy emitted from the explosion is greater than the input electrical energy. This would certainly support the concept that the vacuum has a high energy density and that we might be able to extract some of this energy with the right equipment.

## HOME WORKSHOP EXPERIMENT

No well equipped high energy laboratory was available, so it was decided to replicate as much as possible of Graneau's water arc experiments in a home workshop. The water column length and diameter would be varied and any instrumentation problems would be noted. No attempt would be

made to do any calorimetry measurements. These are far beyond the capability of this particular home workshop.

Two  $0.5 \mu\text{F}$ , and a  $1 \mu\text{F}$ ,  $25 \text{ kV}$ , power factor correcting capacitors were purchased from the local junk yard. A 120:7200 volt potential transformer was purchased at an auction. Some  $7.5 \text{ kV}$  diodes were obtained from a surplus electronics catalog. No good high voltage switch was available, so a 100 A knife switch was borrowed from the electrical engineering department. The bakelite base would not withstand  $10 \text{ kV}$ , so the metal parts of the switch were mounted on a 6 inch PVC end cap, which worked quite well. The switch lever was extended about a foot with a section of PVC pipe to increase the clearance from the high potential parts.

The inductor consisted of 19 turns of 4 gauge wire on a piece of 6 inch PVC pipe, with inductance of  $38 \mu\text{H}$ . The exact value seems to be noncritical, since the primary purpose is to lower the resonant frequency to the point where the oscilloscope and other instrumentation can keep up with the oscillations.

Water contacts were made with two hollow brass structures about 1 cm in diameter that were obtained from a local lighting supplies store. These were approximately spherical where contact with the water was made. Heavy wire or copper tubing with bolted or soldered connections were used throughout to keep the circuit resistance to a minimum. The equivalent series resistance of the capacitors, the inductor, the switch, and the wiring was calculated to be  $0.6 \Omega$  from the oscillation obtained by discharging the capacitor into a short.

The oscilloscope used was a Phillips PM3350, rated at 50 MHz and 100 Megasamples per second, with the Phillips PM9355 current probe, rated at 7 ns rise time. Voltage was measured with a Keithley 602 Electrometer with a 30 kV probe. This high impedance probe was necessary to keep the measuring circuit from discharging the capacitors prematurely.

Ear plugs were essential. The reports were loud enough that operating in a typical campus building would be impossible during regular office hours.

## FALSE TRIGGERING

The contact arc at the switch and the current of several hundred amperes in the circuit emitted a strong electromagnetic pulse, adequate to cause false triggering in the scope. The scope would appear to collect data, but it was either before or after the event of interest. Filters were placed on both the probes and on the power lines, but made no difference. The radiation was entering the scope through its case rather than through the leads. Moving the scope further away helped, but not enough. A copper screen room was needed but none was available.

A poor man's screen room was built from two junk microwave ovens. These were identical units of a decade or more ago, when microwave ovens tended toward large and heavy, with a steel case. The insides were removed, and the front cut off from one and the rear cut off from the other. The two cases were then mated together with sheet metal screws. The final result looked like an unusually



deep microwave oven, complete with the door in working order. The scope would easily fit inside. A power line filter was added where the power cord entered the modified oven. The signal was brought in by a small 50  $\Omega$  coaxial cable through a small hole. The scope would be armed to collect data, the door closed, and then the knife switch closed. The door would then be opened and the trace examined. This technique eliminated the false triggering up to the limits of the experiment, approximately 10 kV and 1000 A.

## CURRENT PROBE

The Phillips PM9355 current probe is only rated to about 4 A peak, so some method of current division had to be used. The manufacturer suggested placing several identical wires in parallel, and measuring the current in one of the wires. This technique did not work because the probe would insert additional impedance into the wire being measured, causing the current to divide unequally. This effect is called the burden of the meter.

The solution was to put a 0.1  $\Omega$ , 10 W resistor in series with the water arc. A 50  $\Omega$  coaxial cable was connected across the resistor. The other end of the cable was terminated with a 50  $\Omega$  resistor inside the oven. Current through this resistor was then measured with the PM9355 probe. The 0.1  $\Omega$  resistor was placed inside an aluminum box to reduce the transient electric field effects. The burden of the probe was small compared with 50  $\Omega$  so this technique worked rather well.

## WATER COLUMN

Three different sizes of plastic tubing were obtained, with nominal inside dimensions of 1/8, 5/32, and 7/32 inches. These were cut in lengths of 1 and 2 cm. The tube was filled with saturated salt water or tap water and placed in a horizontal position between the two electrodes. Surface tension of the water was usually adequate to keep the water in place in an otherwise dry and clean piece of tubing. The electrodes were held in place by the stiffness of a few inches of 4 gauge copper wire. That is, the electrodes were free to move when an explosion occurred. For some tests, the electrodes were held to the tubing with large rubber bands. This would help keep the tubing in place for small water arcs, but seemed to have little difference on the results.

## RESULTS

Preliminary tests were performed with 1  $\mu$ F of capacitance and voltages up to 10 kV, on the shortest and thinnest piece of tubing. At voltages up to 7 or 8 kV, there would be little or no sound, but the water may be blown out of the tubing. At 9 kV there was a small "pop" part of the time. At 10 kV there was a larger pop, similar to a small firecracker. Tap water may have been slightly louder than salt water, but certainly not much. Low resistance arcs were hard to establish, so all the remainder of the tests were performed with 2  $\mu$ F of capacitance.

The circuit acts as an overdamped RLC circuit when the resistance of the water column is greater than about 3  $\Omega$ . The water resistance decreases with time and with the applied voltage, making it difficult to present specific values with broad application. Examples would be the 7/32 inch ID by 1 cm long tubing which had a resistance of 27  $\Omega$  at 6 kV and 17  $\Omega$  at 10 kV, at 10  $\mu$ s after switching, and the 5/32 inch by 1 cm long tubing which had a resistance of 55  $\Omega$  at 6 kV and 32  $\Omega$  at 10 kV, also 10  $\mu$ s after switching. Only if a low impedance arc forms will the resistance drop below 3  $\Omega$  and the current become oscillatory. This takes time to develop and will not occur consistently even for apparently identical conditions.

For example, compare two consecutive tries at 10 kV on the 1/8 inch ID by 2 cm long tubing. Both produced a loud bang, similar in loudness. In the first try, the current was 50 A at 5  $\mu$ s after switch closing, 80 A at 50  $\mu$ s, a peak of 130 A at 130  $\mu$ s, and went to zero at 153  $\mu$ s. In the second try, the current was 24 A at 5  $\mu$ s, 72 A at 50  $\mu$ s, and went to zero at 166  $\mu$ s. At 138  $\mu$ s, however, an arc was apparently initiated, so there was what appeared to be a half cycle of an underdamped wave between 138 and 166  $\mu$ s. The peak current of this half cycle was 540 A.

Longitudinal Ampere forces vary as the square of the current, so if the explosion is due to these forces we would expect a significant difference in loudness. Since little or no difference was noted in the explosion, there remains a question whether the longitudinal Ampere forces are even a major cause of the explosion.

Another observation was that of small bubbles forming in the tubing, with no arc and no noise. At 6 kV, a 7/32 inch by 1 cm piece of tubing would show a very small (less than 1 mm diameter) bubble. At 8 kV, the same tubing would show a bubble about 2 mm in diameter. The presence of a bubble will lower the arc inception voltage. That is, with the bubble in place, the next firing at 8 kV may be adequate to cause an arc with an oscillating waveform. Increasing the capacitance also lowers the arc inception voltage.

Loudness was found to be inversely proportional to the tubing area. The loudest reports were from the 1/8 inch ID tubing. Changing from salt water to tap water did not make nearly as great a difference.

Some numerical results are shown in Table 1. The voltage  $V$  is in kV, the maximum current is in A, and  $t$  is in  $\mu$ s after the switch is closed. The size is the nominal inside diameter in inches by the length in cm. The loudness of the bang varied from just noticeable to very loud as the voltage increased and the volume of water decreased.

Only the 1/8 inch ID tubing yielded waveforms that were partly oscillatory, and then only at 8 and 10 kV. Otherwise, the waveforms looked like a classic RC discharge curve, except that  $R$  is decreasing with time. This tends to flatten the curve, or even to let it rise to a peak sometime after the switching.

Another comparison on the longitudinal Ampere forces can be made from the 8 kV test of the 7/32 $\times$ 1 and 5/32 $\times$ 1 samples. The available energy was the same and the current waveforms were similar in appearance. The peak current for the 7/32 $\times$ 1 was 272 A, with no noise, while the



peak current for the 5/32x1 was 196 A, which produced a good pop. The current density for the smaller tubing was about 40 % greater than for the larger tubine, so perhaps current density is more important to a water explosion than the actual current.

TABLE 1  
Maximum Current and Time to Maximum

V	size	$i_{max}$	t	bang?
6	7/32x2	62	4	No
8	7/32x2	84	4	No
10	7/32x2	111	30	No
6	5/32x2	30	50	No
8	5/32x2	46	75	No
10	5/32x2	71	75	Yes
6	1/8x2	26	100	No
8	1/8x2	45	140	Yes
10	1/8x2	136	125	Yes
10	1/8x2	420	140	Yes
10	1/8x2	130	130	Yes
10	1/8x2	540	150	Yes
6	7/32x1	180	10	No
8	7/32x1	272	20	No
10	7/32x1	468	18	Yes
6	5/32x1	111	30	No
8	5/32x1	196	30	Yes
10	5/32x1	456	50	Yes
6	1/8x1	91	45	Yes
8	1/8x1	530	75	Yes
10	1/8x1	940	45	Yes

## CONCLUSIONS

Electrically induced explosions in water are relatively easy to produce with a 2  $\mu$ F capacitor charged to 10 kV. Expanding steam does not seem to be the main cause. Similar explosions are obtained with significantly different peak currents, which raises questions about the longitudinal Ampere forces being the primary cause. It is therefore conceivable that we are tapping a new energy source.

More experiments need to be performed to demonstrate this one way or the other. A better screen room, larger capacitors, and a better high voltage switch would be helpful. A variety of electrode and water channel configurations need to be tested to separate out the effects of water arcs and water explosions. A calorimeter test would be interesting. A microphone pickup to electronically determine loudness would be useful.

Of course, even if water explosions are tapping into a new energy source, this technique may not be the optimum one to extract this energy. But it could lead us toward a better understanding of this source.

## REFERENCES

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# Searchers for a New Energy Source

*Tesla, Moray, and Bearden*

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**T**esla, Moray, Bearden, and others have claimed the existence of another source of energy besides those presently in use. Like sun and wind, this source is available without regard to political boundaries. If true, the development of this energy source would be one of the most important events of the century.

It seems that every time mankind reaches a limit of growth due to exhaustion of inexpensive energy supplies, another energy source is discovered and developed. England had essentially depleted its resource of timber when the technology to mine and burn coal was developed, for example. After coal, technologies for oil, gas, hydro, nuclear fission, wind, photovoltaic, etc. were developed. With each new development, the world was able to support a greater population at a higher standard of living than before.

Today, however, many developing countries have reached a limit in improving the quality of life, due in part to the lack of an adequate and economical energy supply. The developed nations are worried about global warming, acid rain, and nuclear waste. The recent excitement about cold fusion illustrated the keen desire for a new energy source, one operating on scientific principles that perhaps are unknown or poorly developed at the present time.

A number of researchers have claimed that such a new energy source exists. This source would be in addition to cold fusion if cold fusion is shown to be valid. Three of the most famous researchers with this belief have been Tesla, Moray, and Bearden. This article discusses each of their concepts.

The exact words used to describe the energy source differ among the three men, partly due to the different time periods involved. However, the basic outline seems to be as follows. Consider a small, apparently empty volume in front of your face. Ask a child what is in the volume, and you will get a puzzled look and a reply that *nothing* is in the volume. Based on the senses of touch, smell, sight, hearing, and tasting, it would certainly appear that the small volume is indeed empty. Ask the same question of a sophomore engineering student and the answer may include oxygen, nitrogen, argon, water vapor, photons, radio waves, a few ions, and perhaps a neutrino. Empty appearing space is really not so empty. We just had to build detectors or receivers to determine what is already there.

These three researchers would claim that our small volume also contains energy, which can be extracted with the proper receiver. Philosophically, this receiver would be no different from a photovoltaic cell, which merely converts nonelectrical energy into electrical energy, or perhaps a heat pump, which uses a small amount of electrical energy to

pump a larger amount of ambient thermal energy from one place to another. We just need to discover how to build such a receiver or energy pump.

## Tesla

Nikola Tesla was born July 9, 1856, in Smiljan, Lika, Serbia (now Yugoslavia). His father was a Serbian Orthodox priest. Tesla became an electrical engineer and went on to invent (or discover) more important devices or concepts than perhaps any other man in history. The idea of the polyphase induction motor came to him while in Budapest, and he built the first model in 1883. He came to the United States soon after and tried to sell his idea to Thomas Edison. Edison was doing well with his dc system, so he was not interested in an ac machine. Tesla soon sold his idea to George Westinghouse. An entire polyphase ac system of generators, transformers, and protective devices was developed and has changed life throughout the world.

In addition to inventing the ac power system, Tesla did pioneering work in radio, robotics, amplifiers, and refrigeration. He had 112 U.S. patents and a total of about 700 patents worldwide. He was selected for the Nobel prize in 1912, but refused the honor because it was to be shared with Thomas Edison, for whom he had little professional respect [1, page 20]. Without question, he was a good engineer.

However, about 1900, Tesla started investigating a number of advanced concepts that were not accepted by the scientific community at the time, and, in most cases, are still not accepted. This effort caused the loss of his funding from John P. Morgan. He then spent the last years of his life in near poverty before dying in 1943. His personal papers disappeared at that time, with a fraction of them appearing later in his native Yugoslavia. Specifics of his work on these advanced concepts are, therefore, not available to us, but perhaps are known to some Eastern European countries.

Regarding the idea that space itself contains energy, the following statement by Tesla to the Institute of Electrical Engineers in London is instructive [2, page 58]. "Ere many generations pass, our machinery will be driven by a power obtainable at any point of the universe. This idea is not novel. Men have been led to it long ago by instinct or reason. It has been expressed in many ways, and in many places, in the history of old and new. We find it in the delightful myth of Antheus, who derives power from the earth, we find it among the subtle speculations of one of your splendid mathematicians, and in many hints and statements of thinkers of the present time. Throughout space there is energy. Is this





Nikola Tesla (photo courtesy of the Smithsonian Institution)

energy static or kinetic? If static our hopes are in vain, if kinetic (and this we know it is, for certain), then it is a mere question of time when men will succeed in attaching their machinery to the very wheelwork of nature. Of all, living or dead, Crookes came nearest to doing it. His radiometer will turn in the light of day and in the darkness of the night, it will turn everywhere where there is heat, and heat is everywhere. But, unfortunately, this beautiful little machine, while it goes down to posterity as the most interesting, must likewise be put on record as the most inefficient machine ever invented!"

Like many other of his ideas, Tesla was not as specific about this kinetic energy in space as we would like. He had two related patents, No. 685,957, *Apparatus for the Utilization of Radiant Energy*, and No. 685,958, *Method of Utilizing Radiant Energy*, both issued November 5, 1901. The basic concept seems to be that this radiant energy would strike one plate of a large capacitor, perhaps causing electrons to be ejected to the surroundings so that the plate would have a net positive charge. This positive charge would then be used to supply a current through various electrical loads.

He shows a Roentgen Tube as a possible source for the radiant energy in the patent drawings. We know that xrays can have adequate energy to eject electrons from metals, so that it is theoretically possible to convert xrays into electrical power by this method. The efficiency would be low, however. It appears from his later statement that was quoted above that Tesla did not believe he had invented a machine of the necessary efficiency. But, as he said, "it is a mere question of time when men will succeed in attaching their machinery to the very wheelwork of nature."

## Moray

T. Henry Moray was born August 28, 1892, about the time Tesla was developing the ac power system. His parents were emigrants, a Swedish mother and an Irish father. His interests were in electricity and electrical engineering, but his formal education was limited to correspondence courses and

on a mission for the Church of Jesus Christ of Latter-Day Saints in that country.

Moray started his work on a new energy system in 1909. Soon he was able to report [3, page 20] the following. "During the Christmas Holidays of 1911, I began to fully realize that the energy I was working with was not of a static nature, but of an oscillating nature. Further I realized that the energy was not coming out of the earth, but instead it was coming to the earth from some outside source. These electrical oscillations in the form of waves were not simple oscillations, but were surgings, like the waves of the sea, coming to the earth continually, more in the daytime than at night, but always coming in vibrations from the reservoir of colossal energy out there in space."

Finally in 1925, Moray developed a working model. It was of the size and shape of a AM radio receiver of the day. It required an antenna and ground for operation. One installation used a ground pipe of 0.5-inch water pipe driven about 7 feet into the ground and a wire antenna about 87 feet long [3, page 40]. A rather lengthy tuning process was used, wherein a hand-held magnet was stroked across what appeared to be another magnet mounted on the radiant energy receiver for a period of up to ten minutes. Once tuned into the energy source, the output was used for standard light bulbs, electric irons, fans, and other electrical loads. The receiver was able to deliver several hundred watts for an indefinite period, up to several days in length. The output appeared to be high frequency, rather than dc or 60 Hz.

Moray demonstrated his receiver to many people, and several of the demonstrations were documented by photographs and affidavits. In fact, nearly half of his book is made up of photocopies of affidavits. It was demonstrated at his home and laboratory as well as in remote locations selected by the observers. Except for certain proprietary components (possibly semiconducting valves), the receiver was available for inspection by the observers. A typical affidavit is the following, sworn to by Mr. A.B. Jensen [3, page 112] on January 31, 1963. "I accompanied a group of people consisting of Mr. J.C. Jensen, Mr. Greely Snyder, Dr. Moray, and myself (I recall one other person also was with us but will not give the name, as I am not sure whether I am correct). We drove out past St. Johns in Tooele County, Utah, and then 25 to 30 miles southwest of Johnson's Pass. At that time there was no installation at Dugway, no telephone or electric wires in the vicinity, merely desert land.

"Dr. Moray had packed his equipment and tools necessary to erect it. We selected a spot 50 to 75 feet from our automobile. We assisted in driving a steel rod about 6 feet into the ground. With a blow torch, wires were soldered to the steel rod. We erected two tent poles and fastened an antenna made of #10 stranded copper wire.

"The wire from the antenna was fastened to the box containing the Moray Radiant Energy Equipment and the ground wire that had been soldered to the steel rod was also fastened.

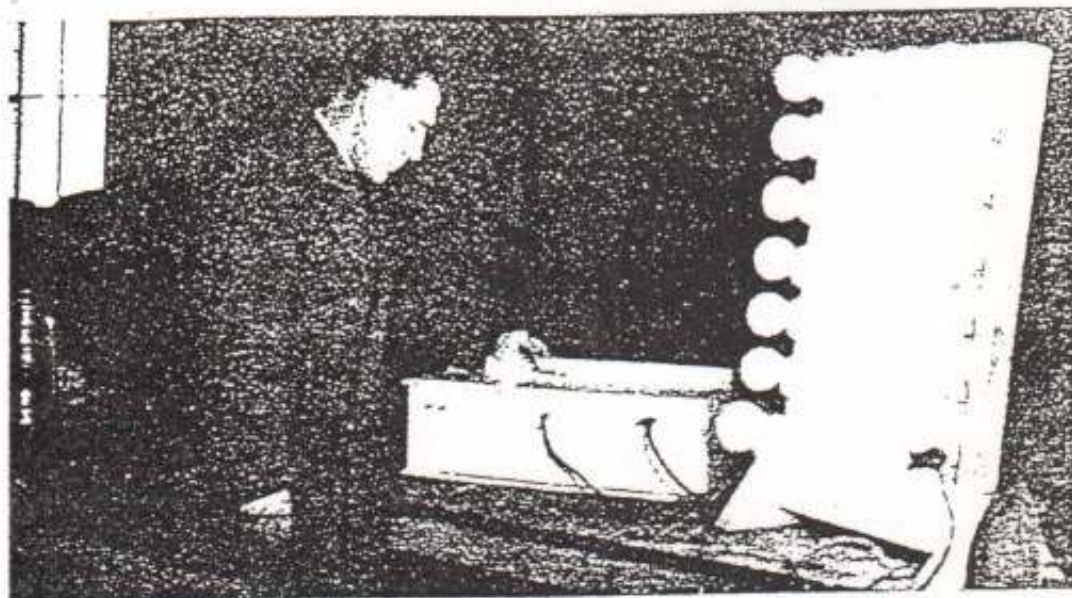
"Dr. Moray had brought a board with about 35 150-watt lamps mounted thereon, a high frequency motor, a 1,000-watt Taylor's iron, and I believe a heater or fan.

"After he connected the ground and antenna to the box, Dr. Moray plugged in the lamps, iron, motor, etc. The energy from the box lighted the lamps, heated the iron, ran the motor, etc.

We all examined the equipment and determined there were no batteries; there were no hidden connections to electric outlets, as we were miles from any power lines; Mr. J.C. Jensen drove the automobile and selected the location for the demonstration, thus there could have been no prior preparation at the test site by Dr. Moray.

"Although the demonstration took place nearly 25 years ago, I still vividly recall the reaction of all who witnessed it.





Henry Moray in front of his receiver and a load bank of light bulbs

It was our firm conviction that the Radiant Energy Equipment was truly as represented by Dr. Moray."

Moray made a total of seven patent applications regarding his Radiant Energy Device. All were rejected by the Patent and Trademark Office. The reasons given were basically that the device did not fit the physics known at that time. For example, part of the application was for a solid state device like a transistor. In 1931, transistors had not been invented and electron flow required a hot cathode in existing devices, so Moray's device obviously could not work. Also, the Patent Examiner stated [3, page 162], "No natural source of electric wave energy is known to the Examiner and proof of the existence of such a source is required." That is, it was not enough to develop a device to tap into an unknown source of energy. The source of energy must also be fully described. Moray was not able to do this, so the patents were denied.

The story involves considerable intrigue, including communist agents and people in black sedans shooting at the Moray automobile. Moray was betrayed by a number of friends who were supposedly helping him with his invention. One working model was destroyed by an employee. He was unable to bring his invention to the market, although two of his sons, John and Richard, now operate a company called Cosray Research Institute, with the hope of yet getting Henry Moray's invention to the world. John Moray recently commented [4, page 5-21] as follows. "The fact remains, Dr. Moray's work is well documented. The motor did run. There was no question. It would even run on the portable antenna my father would rig up in his laboratory. The radio did work. He could bring in Admiral Byrd from Little America, even when normal radio transmission was difficult.

"In the past decade, we spent over one-half million dollars, both our own money and from a feasibility study for the U.S. Air Force. We did a lot of work without giving away all the family jewels. We collected together all the notes that had been distributed throughout the United States and Canada and evaluated them, after which we sent them back to storage. We reproduced a few of the original parts and built a number of our own. We tried to do them first of all the way by father would have done them and then adapted to the so-called state of the art.

"We have identified at least 36 semiconductors in the six tubes used in Dr. Moray's power unit. We believe there may have been at least one superconductor. It is only a matter of time and money until we complete a viable unit."

"perpetuum mobile," could easily result in a scenario such as that described in Moray's book. There seems to be no compelling reason not to believe that the pictures, affidavits, and accounts of witnesses are valid and that T. Henry Moray did indeed stumble upon a device to extract free energy from the surroundings.

## Bearden

Thomas E. Bearden, born December 17, 1930, has been perhaps the most important leader in the area of free energy for the last decade or more. He has written several books in the area. He has a good technical background (MS in Nuclear Engineering) and a good military background (Lieutenant Colonel, U.S. Army, Retired). He speaks widely at meetings of free energy enthusiasts. He has developed a theory explaining the source of energy, which we will attempt to summarize.

He calls his theory *scalar electromagnetics*. It is a unified field theory in that gravity is included along with the usual electric and magnetic fields. The starting point for his theory is the nature of the vacuum itself, a concept shared by a number of other physicists. Bearden explains it [5, page 20] as follows. "The modern concept of the vacuum is that it is like a seething plasma or gas. However, it's a very strange gas, for each particle arises spontaneously out of nowhere (according to quantum mechanics), and almost immediately turns into something else and/or disappears. Thus the vacuum plasma or gas is rather peculiar, the particles comprising it appear and disappear so rapidly that they cannot individually be detected. However, while a virtual particle exists, it is in motion, and so a violent flux of these *phantom particles* comprises the vacuum/spacetime.

"Quantum mechanics assumes that the violent flux of vacuum ghost particles is totally randomized. That is, no deterministic pattern exists in the flux. These virtual changes collect or cohere statistically, not deterministically, in the standard assumption. When they happen to collect/cohere sufficiently, the threshold of an observable quantum change is breached, and a quantum change occurs."

That is, Bearden believes that the vacuum is not the quiet, empty space that most of us have assumed it to be. Rather, it consists of *particles* too small to be detected and moving in and out of our four dimensional space too quickly to be detected. By definition, there is no way to directly prove (or disprove) his theory. It would remain just another interesting



concept of modern physics, unless a second concept of his should prove experimentally true, that particles can be cohered into a large enough collection to produce observable results. By analogy with lasers, this could require a pumping action wherein energy must be introduced to start the action. Once started, energy could flow from the vacuum through a receiver into a load. The random flux of virtual particles around the receiver would recharge or replace the energy being removed.

But what physical effects would tend to cohere the vacuum? Bearden believes that we should start with two (or more) opposing magnetic fields such that the opposing fields cancel each other. He maintains, however, that the individual fields can interact with the vacuum even though the combined field is zero.

In classical electromagnetic theory, the fields are considered the causa and the potentials are considered the effect. We obtain the potential  $V$  by integrating the electric field  $E$  over some path. The force on a charged particle is zero when  $E$  is zero, regardless of the value of  $V$ . Since most of our instruments measure the force on a charged particle rather than some absolute value of  $V$ , we tend to think of potentials as being a necessary side effect of fields. Quantum mechanics, on the other hand, starts with the potential as the cause and the field as the effect. In most cases, one gets exactly the same answer with either interpretation. The question in those cases is a philosophical one, rather like the question whether light is a wave or a particle. But, what about the case of a nonzero potential and a zero field, with an observable effect that implies some sort of absolute reality to the potential? Such appears to be the situation in the Aharonov-Bohm Effect [6].

One way of getting opposing magnetic fields is to wind two coils on the same cylinder, one on top of the other, one right-handed and the other left-handed, and operate them in parallel across the same voltage source. The magnetic field inside the cylinder will be very close to zero. However, as one looks at the field vectors, it appears that the space inside the cylinder is either in tension or compression. The analogy is to take a stiff rod in both hands and either push the two ends toward each other or attempt to pull them apart. The net force on the rod is zero so it is not translating in space. However, the internal stress is not zero while the individual forces are in place. If this stress exceeds the limits of the rod material, the rod will be changed in length, even though the net translating force has remained zero. Similarly, Bearden believes that the internal stress produced by the opposing magnetic fields will cause a cohering of the virtual particles of space such that macroscopic effects will be observed. It is plausible that special frequencies, waveforms, and coil configurations will be required. There may be a minimum signal level before any effect is observed, much like the Zener effect. Feedback may be required, so that the effect will build up like an oscillator.

It is obvious that, even if Bearden's hypothesis is correct, it may be very difficult to get reproducible experiments. It is rather like trying to build an oscillator. One needs an amplifier, a method for feedback, and the correct circuit layout. As many students can testify, even with a good amplifier and the proper theory, poor circuit layout can easily keep the oscillator from working. So we would expect to see reports of working devices and other reports of nonworking devices until equipment and theory are much better developed. A given inventor may have a working prototype, but may not be able to scale up to an economical size because of the lack of an adequate theoretical development. This may be the case with Bearden and his associates, since he states [5, page 22] the following. "Several inventors, three of whom I work with in one respect or another, now have demonstra-

tion models of such machines, which take diverse forms." This was written in December 1987, but there has not yet been any public display, implying a hangup either in reproducibility or in patenting the concept.

## Summary

We have looked at three leaders in the search for a new energy source, whose work spans a full century. There have been dozens of other searchers and several organizations devoted to publishing literature on the subject. Involvement ranges from the backyard inventor with no technical background up to the PhD-level engineer or physicist. There is a great deal of noise in the literature. Some concepts are obviously nonsense. Others will prove to be in error. But, is there any signal in all the noise? There is, if Tesla, Moray, and Bearden are correct. The potential payoff is enormous, so the search should be continued if there is any chance at all of success.

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