SPEAKERS - *PLEASE PRINT CLEARLY*

NAME: CHUCK WADE

AFFILIATION: NONE

SESSION: ☐ Afternoon ☒ Evening ☐ Both

Providing a document to add to transcript? ☒ Yes ☐ No

WISH TO ENTER WEB-SITE

Add you to our mailing list? ☐ Yes ☒ No

ADDRESS: ALREADY FILLED OUT ANOTHER CARD

CHUCK WADE, BOX 27

GALLUP, N.M. 87305

EXHIBIT #1

WEB SITE OF DR TOM BEARDEN

www CHENIERE.ORG

"ENERGY FROM THE VACUUM"

PPR FOR:
ADAPTED NRAM EFFECT
PLACED INTO PUBLIC DOMAINE
JULY 2006, AND GIVEN TO
THE PEOPLE OF THE WORLD.

COP = 18

EXHIBIT #1

SEE PAGE 4 FOR DIAGRAM OF: ADAPTED "NAAM" EFFECT. B.W.

(Chuck Wade)

ENERGY

from the

VACUUM

(EFTV)

Is: **THE ENERGY IN SPACE ITSELF**

The vacuum is not inert and featureless, but **alive** with throbbing energy and vitality.

Inventors, using nanotechnology and other means, have discovered how to tap the Energy from the Vacuum!!!
There is still serious work to be done on controlling this inexhaustible energy supply. Once the energy from the vacuum is tapped and controlled, the impact upon our civilization will be incalculable. Oil, coal, nuclear, hydropower will become **obsolete**—and so will many of our worries about pollution of our environment.*

* Energy from the Vacuum, Dr. Tom Bearden, Chapter 4

A Sampling of the Many Energy-Related Items Found on Tom Bearden's Website
www.cheniere.org

August 4, 2004 Correspondence by Dr. Tom Bearden points out that Dr. Bearden is a Retired Lt. Colonel (U. S. Army). He was held in high esteem in the development of the Patriot Missile and other projects to safeguard our wonderful country. Now he is working toward the acceptance of self-powering generators that ONLY use Energy from the Vacuum (EFTV) to solve our Unnecessary Energy Crisis.

July 13, 2001 Paper by Dr. Tom Bearden states, "All the coal, oil, natural gas, etc. ever burned, and all the nuclear fuel rods ever used, and all the hydroelectric dams ever built, have directly added NOT ONE SINGLE WATT to the power line. Not one!"

July 16, 2000 Letter from Dr. Tom Bearden to several different professors and others. He states, "**Any competent physics department or electrical engineering department....ought to be able to replicate a MEG example and test it successfully.**"

August 11, 2002 Paper by Dr. Tom Bearden, "Oceans of Free Energy," explains the processes to capture and control both the "A" and "B" waves.

January 28, 2006 Correspondence by Dr. Tom Bearden. "As pointed out by eminent scientists such as Feinman, Wheeler, and many others, the standard CEM/EE model taught to all our electrical engineers is the biggest **piece of scientific junk** ever propagated by the scientific community."

2006 Paper by Dr. Tom Bearden, "Engineering the Active Vacuum," on the Asymmetrical Aharonov – Bohm Effect and Magnetic Vector Potential "A" vs. Magnetic Field "B."

December 2, 2002 Paper by Dr. Tom Bearden, "Source Charge, Van Flandern Waterfall, and Leyton Geometry" discusses "the source charge problem."

May 30, 2006 Correspondence by Dr. Tom Bearden: "What is the Source Charge (simple version)." "Okay, we'll try. But first, please understand that, since the source charge problem's solution resisted the scientists for nearly 100 years, it obviously isn't going to be "too simple." Otherwise those sharp young doctoral candidates and post-docs would have solved it long ago."

May 28, 2006 Paper by Dr. Tom Bearden explains the difference between the definitions of zero point energy (ZPE) and energy from the vacuum (EFTV). [***Note by Chuck Wade: Up till now I have used these two energy terms interchangeably, but no more. There is a huge difference. Zero point energy is "observable", while energy from the vacuum is "virtual","non-observable."***]

Undated Excerpted from Dr. Tom Bearden's book, Excalibur Briefing. This article explains that Dr. T. Henry Moray had a working **SELF POWERING GENERATOR**, and that he applied for a patent for the device July 13, 1931 (seventy-six years ago). The patent has not been issued to this date, although the Morays still keep the application current.

Books & Booklets by Tom Bearden and others

http://www.cheniere.org/books/

1. **Energy from the Vacuum: Concepts and Principles**
   September 2002 951 pages *Details the science of the Motionless Electromagnetic Generator, U.S. Patent No. 6,362,718.*
2. **Free Energy Generation**
   Circuits & Schematics — 20 Bedini - Bearden Years
   October 2006 *Details how to build a quick-charging battery charger and reveals the real secrets of Negative Energy.*
3. **Excalibur Briefing**
   Explaining Paranormal Phenomena
   Second Edition - Revised and Expanded
   1980, 1988
4. **Oblivion**
   America at the Brink
   October 2005
5. **The Secret World of Magnets**
   by Howard Johnson
   originally published in 1970
6. **Towards a New Electromagnetics**
   Part IV: Vectors and Mechanisms Clarified
   1983 Downloadable from www.cheniere.org

Other Resources

1. **Internal Combustion**
   by Edwin Black
   How corporations and governments addicted the world to oil and derailed the alternatives - 2006
2. **The Free-Energy Device Handbook**
   A compilation of patents and reports,
   compiled by David Hatcher Childress – 1994
3. **thejoecell.com**
   One of many inventions proposing to generate overunity effects, the Joe Cell is a type of electrostatic generator.

Energy from the Vacuum™
A Documentary Series

available from Cheniere Press, www.cheniere.org

1. Disc 1 released in 2006, now available.
2. Disc 2 to be released in 2007.

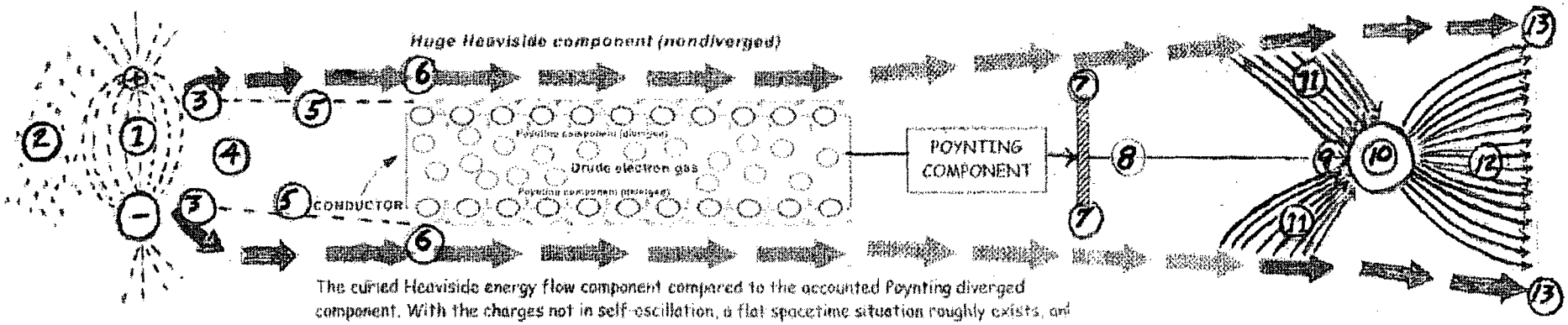
Be extremely cautious and safety conscious when working with or around Energy from the Vacuum devices. There is so much energy involved, one can be seriously electrocuted or burned. Example: The MEG can easily spike over 25,000+ volts. Heat amplification can put out 18 times more energy than is put in at over 2000°F. The quick-charging battery charger can put out peak pulse power of 300 kW that is useable and achievable, with most of the energy being freely furnished from the vacuum environment via the E-amp effect. Don't be afraid to experiment with these devices, but DO BE SAFE, and Good Luck with your experiments.

ADAPTED NEGATIVE RESONANCE ABSORPTION OF THE MEDIUM

ENERGY FROM THE VACUUM SECTION

INCREASING THE COEFFICIENT OF PERFORMANCE OF ELECTROMAGNETIC POWER SYSTEMS BY EXTRACTING AND USING EXCESS EM ENERGY FROM THE HEAVISIDE ENERGY FLOW COMPONENT

A Provisional Patent Application for the NRAM process was placed on the website www.cheniere.org in July 2006 and freely given to the people of the world.



The curled Heaviside energy flow component compared to the accounted Poynting diverged component. With the charges not in self-oscillation, a flat spacetime situation roughly exists, and none of the Heaviside component is diverged to increase the Poynting diverged energy flow component.

1. THE DIPOLE IS FORMED BY THE ROTATING SHAFT OF THE GENERATOR. A DIPOLE IS 2 OPPOSITE CHARGES SEPARATED BY A LITTLE BIT OF DISTANCE.

2. VIRTUAL PARTICLES CAN NOT BE SEEN, MEASURED, OR USED. THEY ARE IN CHAOS.

3. VIRTUAL PARTICLES CONSOLIDATE UNTIL THEY ARE EJECTED OUT OF THE DIPOLE AS VISIBLE, MEASUREABLE, USEABLE PHOTONS.

4. BROKEN SYMMETRY: WHERE SOMETHING VIRTUAL HAS BECOME OBSERVABLE.

5. POYNTING COMPONENT

6. HEAVISIDE COMPONENT

7. INFRARED LIGHT TUBE

8. POYNTING COMPONENT HAS TRANSFORMED INTO INFRARED HEAT ENERGY.

9. INFRARED LIGHT ENERGY ENTERS THE MEDIUM.

10. MEDIUM: NANO-SIZED PARTICLE WITH DIAMETER OF MID-SECTION OF INFRARED FREQUENCY. ONE PART HEAT AT INFRARED FREQUENCY IS ABSORBED BY THE MEDIUM. THE MEDIUM WILL SELF RESONATE AT WHICH TIME 17 PARTS (17 TIMES AS MUCH) OF THE HUGE HEAVISIDE COMPONENT DIVERGES AND IS ABSORBED INTO THE SELF RESONATING CHARGED MEDIUM, THEN IT IS RE-RADIATED OUT AS USEABLE HEAT: COP = 18

11. NEGATIVE HEAVISIDE COMPONENT DIVERGED

12. 18 TIMES MORE HEAT ENERGY IS RE-RADIATED THAN THE ONE PART OF POYNTING COMPONENT FROM THE INFRARED HEAT SOURCE: THE EXCESS HEAT ENERGY COMES FROM THE HEAVISIDE COMPONENT THAT HAS BEEN TRANSFORMED INTO HEAT ENERGY.

13. REMAINDER OF HEAVISIDE COMPONENT GOES BACK INTO THE VACUUM, BEING WASTED FROM OUR USE.

Energy Density of the Vacuum

The energy density of the vacuum potential is enormous, even mind-boggling. While scientists have estimated that energy by various means, a reasonable calculation is given by Wheeler and Misner in their *Geometrodynamics*. In that calculation, Wheeler and Misner apply the formalism of general relativity to the zero point energy of vacuum. The fabric of space appears as a turbulent virtual plasma consisting of particles whose size is on the order of Planck's length—some 10^{-33} cm. The energy density of the electric flux passing through each particle is enormous: It is 10^{93} grams per cubic centimeter, expressed in mass units (i.e., the energy per cubic centimeter has been divided by c^2).

And that's just using the *spatial energy* density (the "decompressed" or ordinary energy). The energy density of the vacuum is appreciably greater than what physicists normally calculate, because they do not calculate the additional *time-energy* density portion of the vacuum stress. If we also allow for the time-energy (the "compressed" energy), we restore that c^2 division factor, producing on the order of 10^{110} grams per cubic centimeter, or—in energy terms—on the order of 10^{127} joules per cubic centimeter.

J. A. Wheeler and C. Misner, *Geometrodynamics*, Academic Press, New York, 1962.

Tom Bearden comments:

There are many ways to extract energy from the seething vacuum. Unfortunately, at present our scientific community takes a bizarre stance. In particle physics it is well known that the active vacuum is incredibly energetic. Calculations by leading physicists such as Wheeler show that a cubic centimeter of vacuum (about the tip of one's little finger in volume) has so much raw energy in it that, if condensed into matter, there would be more matter than is observable in the universe through the largest telescope! So even a tiny efficiency of tapping could and will extract all the energy anyone could wish.

However, in classical Maxwell Heaviside electrodynamics (as used in electrical engineering), the same scientific community now assumes in the model that the vacuum is absolutely inert!

The model also assumes that the local spacetime is flat, so no energy from curved spacetime can be forthcoming, according to that inane model. Then the model assumes that all EM fields, potentials, and every joule of EM energy in the universe is produced by their associated source charges—right out of nothing at all, with no energy input to the charge at all, but with continuous energy flow from it.

Hi John,

Just for information, and I hope things go well with you.

Cheers,
Tom

From: Tom Bearden [mailto:soliton@bellsouth.net]
Sent: Sunday, July 23, 2006 6:29 PM
To: Correspondent
Subject: RE: New Page Created

Dear (correspondent):

Got a real chuckle out of the "word to the wise" advice. The NEC stated:

"A Word to the Wise:
You've heard the saying, "He who is one step ahead is a genius; he who is two steps ahead is a crack pot." That saying applies to the world of ideas. In the marketplace, it can be rephrased as follows: "He who is one step ahead is very rich; he who is two steps ahead is very dead -- or at least very persecuted." If you have a "two steps ahead" technology that is nearly ready for introduction into the market, you might consider purposely ratcheting it back a notch or two so that is resembles a "one step ahead" technology. Then, once you have your foot in the door, and your reputation established firmly, the "two steps ahead" will only be one step ahead. Probably the only way a two-steps-ahead technology could be introduced would be through open source, where a simple set of plans for an easy-to-build device are published openly for the world, impossible to stop by the powers that be."

Right on!

There is a very important overunity energy technology in that "two steps ahead" region that could indeed be fairly quickly developed, that provides a heat amplification process (with the excess energy for the amplification freely received from the local excited vacuum – from the long-neglected giant Heaviside curled energy flow component that Lorentz arbitrarily discarded circa 1894). The basic overunity energy process and its results are strongly documented and **solidly replicated experimentally** in the hard physics literature (optical physics) since 1967. COP = 18 results are routinely achieved for the optimized IR experiments every year, in various labs and universities around the world. But those researchers do not know of the presence (or existence!) of the long-discarded giant Heaviside energy flow component. So they still do not really comprehend where and how the *excess input energy* is received by the self-oscillating charged particles in the experiment. It is not received from the usual

1.

and normal Poynting component, **but instead is received in the unusual and almost unknown giant *non-Poynting* energy flow component**. So the scientists in that field never discuss the thermodynamics of the process, lest they be called "crackpots" and "dirty old perpetual motion nuts". They hardly dare say "excess emission". Instead, they use the term "negative resonance absorption" instead of "excess emission". They only discuss the "increase in reaction cross section" of the self-resonant charges of the absorbing and re-radiating medium.

And they *emphasize* use of the tortuous term, **"negative resonance absorption of the medium" (i.e., NRAM for short)**.

Two scientists were responsible for the independent discovery of EM energy flow through space, in the 1880s. Before then, that concept does not appear in the theory. The two scientists were Heaviside and Poynting. Poynting got the direction wrong by 90 degrees, assuming the energy flow directly into the wire. So he considered on the diverged component of the energy flow. But he published prestigiously, since he was an important professor. Heaviside, who never even attended university and was self-taught, considered the entire energy flow component experienced with circuits, including not only the very tiny diverged Poynting component, but also an additional extraordinarily large nondiverged curled energy flow component that just remains flowing through space outside and along the conductors, and does not get diverged into the conductors (normally). This latter component is a startling billion to a trillion times as large in magnitude as is the familiar but relatively "tiny" Poynting diverged component. This huge curled Heaviside component is normally nondiverged since *usually* the local spacetime is reasonably flat, vector EM applies and the divergence of the curl is zero.

Faced with the fact that every generator and battery already outputs tremendously more energy than is input to the generator by cranking its shaft, or by the battery by its internal processes, Lorentz simply disposed of the problem since he could not solve it. He reasoned that *"it has no physical significance"*, because it does not interact and thus does nothing at all. He thus simply integrated the overall energy flow vector around a closed surface arbitrarily assumed around any volume element of interest. That neatly disposes of the nondiverged giant Heaviside component, while retaining the far smaller Poynting component that gets diverged into the circuit to power it.

One can see how Lorentz did it in H. A. Lorentz, Vorlesungen über Theoretische Physik an der Universität Leiden, Vol. V, Die Maxwellsche Theorie (1900-1902), Akademische Verlagsgesellschaft M.B.H., Leipzig, 1931, "Die Energie im elektromagnetischen Feld," p. 179-186. Figure 25 on p. 185 shows the Lorentz concept of integrating the Poynting vector around a closed cylindrical surface surrounding a volumetric element. This is the procedure which arbitrarily selects only a small component of the ongoing total energy flow associated with a circuit—specifically, the small Poynting component being diverged into the circuit

to power it—and then treats that tiny component as the "entire" energy flow. Thereby Lorentz arbitrarily discarded all the extra Heaviside circuital energy transport component which is usually not diverged into the circuit conductors at all, does not interact with anything locally, **and is just wasted**.

Quoting Oliver Heaviside: *"It [the energy transfer flow] takes place, in the vicinity of the wire, very nearly parallel to it, with a slight slope towards the wire… . Prof. Poynting, on the other hand, holds a different view, representing the transfer as nearly perpendicular to a wire, i.e., with a slight departure from the vertical. This difference of a quadrant can, I think, only arise from what seems to be a misconception on his part as to the nature of the electric field in the vicinity of a wire supporting electric current. The lines of electric force are nearly perpendicular to the wire. The departure from perpendicularity is usually so small that I have sometimes spoken of them as being perpendicular to it, as they practically are, before I recognized the great physical importance of the slight departure. It causes the convergence of energy into the wire."* [Oliver Heaviside, Electrical Papers, Vol. 2, 1887, p. 94].

Heaviside later realized that his giant curled energy flow component had gravitational significance. See H. J. Josephs, "The Heaviside papers found at Paignton in 1957," The Institution of Electrical Engineers Monograph No. 319, Jan. 1959, p. 70-76. Heaviside's hand-written notes containing his theory of electrogravitation, based on his theory of energy flow containing both the Poynting diverged energy flow component and the giant Heaviside curled energy flow component. The papers were found beneath the floor boards in his little garret apartment. His trapped EM energy flow loops were gravitational.

Laithwaite felt that Heaviside's postulation that a flux of gravitational energy combines with the (EXH) electromagnetic energy flux, could shake the foundations of physics. Extracting from Laithwaite: *"Heaviside had originally written the energy flow as S = (EXH) + G, where G is a circuital flux. Poynting had only written S = (EXH). Taking p to be the density of matter and e the intensity of a gravitational force, Heaviside found that the circuital flux G can be expressed as pu – ce, where u represents the velocity of p and c is a constant."* [E. R. Laithwaite, "Oliver Heaviside – establishment shaker," Electrical Review, 211(16), Nov. 12, 1982, p. 44-45].

To see how present electrodynamicists still arbitrarily discard the giant Heaviside curled energy flow component, and use Lorentz's inadequate "no physical significance" argument to justify it, we quote Jackson:

"...the Poynting vector is arbitrary to the extent that the curl of any vector field can be added to it. Such an added term can, however, have no physical consequences. Hence it is customary to make the specific choice …" [J. D. Jackson, Classical Electrodynamics, Second Edition, Wiley, 1975, p. 237].

So there really is a nearly totally unaccounted "giant curled Heaviside energy flow component" (**proven by the NRAM experiments**) associated with every Poynting energy flow from every EM system! But it is just customary to discount it and **account only the very small Poynting diverged component**.

However, NRAM experiments prove that the Heaviside energy flow component really is there, and at least a little bit of it can be freely tapped and extracted. if the curvature of spacetime is rhythmically curved in oscillating fashion at the same frequency as the curled component input, then some of that giant Heaviside component is diverged into the medium anyhow. This of course is an extra, totally "free" energy input, in other-than-Poynting form. The self-resonating charged particles absorb both diverged components a priori, so thus re-emit more *Poynting* energy flow than was in the original input Poynting energy flow component. The self-resonating particles *do not* emit more energy than they absorb, from both the "known" input component and the presently "unknown" input component. And so the conservation of energy law is conserved, and the thermodynamic *efficiency* is always less than 100%, yet the COP = 18. That of course is permissible if the external environment freely inputs extra energy into the system, in addition to the operator's "paid" energy input.

So the process is quite analogous to a common home heat pump, which has an efficiency of about 50% and yet a COP = 3.0 to 4.0. That is because additional heat energy is received freely (or almost freely) from the external environment, in addition to the operator's paid electrical energy input.

For the NRAM process, my colleague Ken Moore and I solved the "source" problem of where and how the excess energy is input in non-Poynting form, so that more Poynting energy emission occurs than is in the input Poynting component. **We also obtained (in October 2005) a provisional patent application on the adapted NRAM process, particularly for application to steam boilers of current on-line electrical power plants (and other applications)**. That covers most of the hydrocarbon-combustion plants and also the nuclear power plants (**which are just glorified heaters**, providing heat to heat the boilers to make the steam that powers the steam turbines that power the generators).

It appears that a reasonable COP = 4.0 or so could be obtained in a real power plant steam boiler by the less-than-optimum adapted NRAM process.

In that case, were the adapted process successfully developed (which would cost probably about $40 million), it could be applied to most of our present electrical power plants, to reduce their consumption of hydrocarbon fuel (or nuclear fuel rods) by about **75%**, while providing the normal heat to the boilers, thus furnishing the normal steam and so the normal electrical power to the grid. One notes immediately the huge economic advantage of using and retaining present power plants, but just making them much more productive, and also

dramatically reducing the fuel or fuel rods consumed. Further, the adaptation can be "staged" to increase the amplification (the COP) past COP = 4.0.

Also, a simple additional change allows the use of controlled feedback with a staged unit, so that – once the improved power plant is on line and smoothly powering its grid and its loads – the controlled feedback can be switched in. At that point, all further consumption of fuel (or fuel rods) can cease, and the system will become "**self-powered**", taking all the required input heat energy directly from the long-neglected Heaviside component (of the modified vacuum).

Since Ken and I are a bit long in the tooth for any vast new projects and all the hassle involved, we then just placed the PPA on my website, www.cheniere.org, and **freely donated it to the public domain – to everyone. So anyone worldwide, who wishes to develop and use the process, is quite free to do so.** We were hoping that some of the giant electrical power companies and large labs in a foreign nation (our own DoE and national labs obviously **are not going to do anything at all fundamentally to permanently solve the energy crisis**) would take an interest and get it done. To many of them, spending $40 a year on a new big research project is peanuts.

The PPA is T. E. Bearden and K. D. Moore, "**Increasing the Coefficient of Performance of Electromagnetic Power Systems by Extracting and Using Excess EM Energy from the Heaviside Energy Flow Component**," October, 2005. It is attached (*pages 7-42*) and available freely for downloading at http://www.cheniere.org/techpapers/PPA%20Increasing%20COP%20by%20addnl%20extractn%20from%20flow1a.doc.

Let's hope someone picks up the NRAM heat amplification ball and runs with it. The process also could of course be added in to modified home, office, and building heat pumps etc., and to a number of basic heating processes and heating needs. One should even be able to make the steam car viable again, with nearly unlimited range, etc.

By passing the PPA and its adapted process into public domain, anyone who wishes to can pick it up and run with it.

I also suggest they check into the literature on this area, listed in the PPA. Ironically, one of the scientists in the field titled a paper very provocatively: It's Craig F. Bohren, "How can a particle absorb more than the light incident on it?" American Journal of Physics, 51(4), Apr. 1983, p. 323-327. The abstract states that, under nonlinear conditions, a particle can absorb more energy than is in the light incident on it. [**Comment: That obviously is false**, since it would contradict the conservation of energy law. The correct statement would be: "Under nonlinear conditions, a particle can absorb more energy than is in the Poynting light component incident on it. That is because the long-unaccounted giant Heaviside curled component is also incident on it.] Metallic particles at ultraviolet

frequencies are one class of such particles and insulating particles at infrared frequencies are another. **For independent replication**, see also H. Paul and R. Fischer, [Comment on "How can a particle absorb more than the light incident on it?']," Am. J. Phys., 51(4), Apr. 1983, p. 327. *This report is also attached (pp. 43-47).* The [optimized] Bohren experiment is **repeatable and produces COP = 18. In other words, for IR one uses a medium comprised of certain sized dielectric particles that are charged. One feeds that medium with a laser, and the particles of the medium go into self-resonance at the frequency being fed. These self-resonating particles absorb 18 times as much energy as was in the normal Poynting energy flow input, so that the self-resonating medium now emits some 18 times as much IR Poynting energy flow as was in the Poynting component fed into it.**

The original papers in the NRAM field – that in fact stimulated the field itself – appear to be Russian; they are:

V. S. Letokhov, "Generation of light by a scattering medium with negative resonance absorption," Zh. Eksp. Teor. Fiz., Vol. 53, 1967, p. 1442.

V.S. Letokhov, "Generation of light by a scattering medium with negative resonance absorption," Sov. Phys. JETP, 26(4), Apr. 1968, p. 835-839.

V. S. Letokhov, "Stimulated emission of an ensemble of scattering particles with negative absorption," ZhETF Plasma, 5(8), Apr. 15, 1967, p. 262-265.

Very best wishes,

Tom

CHUCK WADE

P.O. BOX 27 · GALLUP, NEW MEXICO 87305 · (505) 722-3377 wades@cia-g.com

Thursday, August 3, 2006

A brief index with commentary for the PPA document follows.

o Pages 1-10	References cited, and comments
o Pages 10-22	Background of the invention

The adage that "a picture is worth a thousand words" is so true in the following three figures, which show that energy can be extracted from the vacuum:

o Page 23	Figures 1 and 2 show the difference between the small Poynting (diverged) energy flow component (which is the only wave that is caught to furnish the electricity in use today) and the HUGE Heaviside component (non-diverged) which is being completely ignored up to today.
o Page 24	Figure 3 shows the HUGE Heaviside component (some diverged) and shows that part of the Heaviside wave can be caught.
o Pages 24-29	Figures 4 – 12 show how the NRAM is configured.
o Pages 30-32	Detailed Description of the Preferred Embodiment gives detailed information for the preceding figures.
o Pages 32-35	Summary Ramifications and Scope summarizes the PPA and the NRAM process.

Hoping this information will be of benefit to you---

Chuck Wade

Chuck Wade

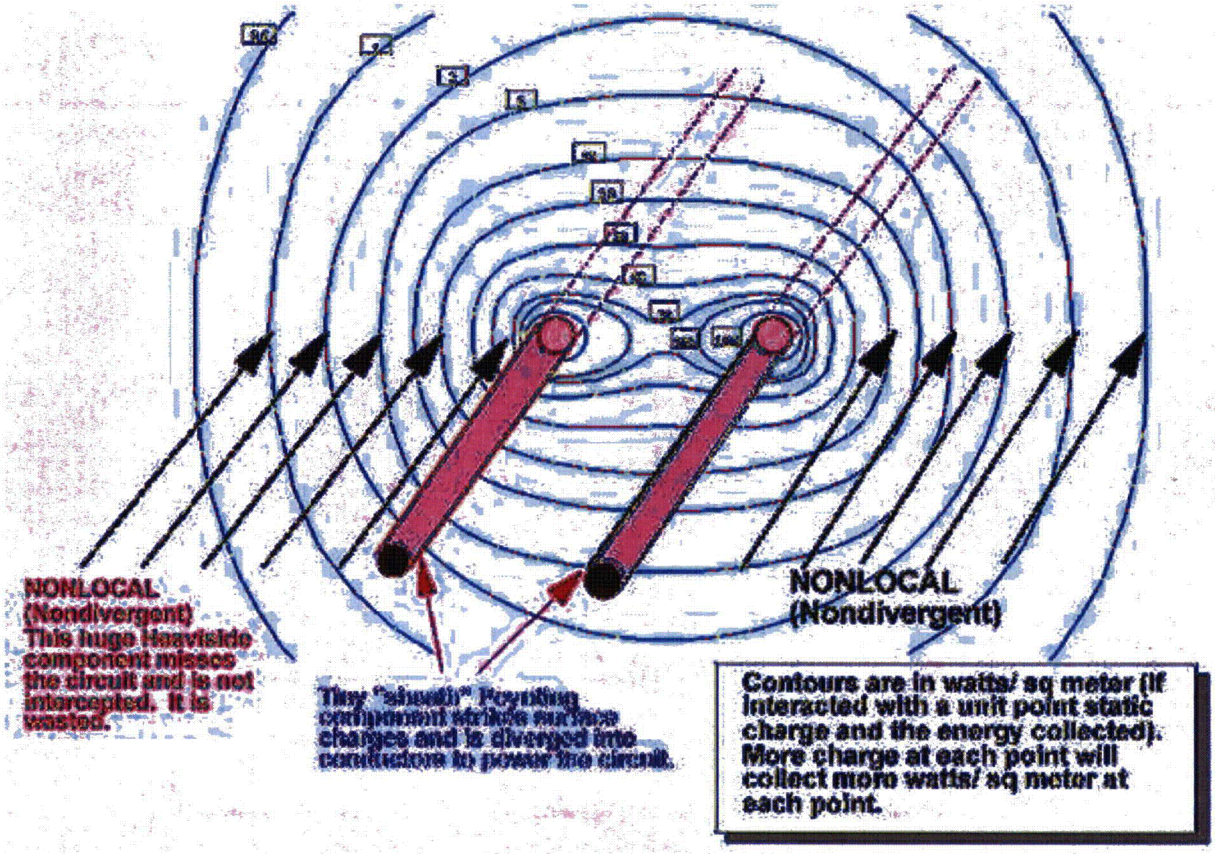


Figure 4. Energy flow contours surrounding a transmission line.

7A

Provisional Patent Application of
Thomas E. Bearden and Kenneth D. Moore

Increasing the Coefficient of Performance of Electromagnetic Power Systems by Extracting and Using Excess EM Energy from the Heaviside Energy Flow Component

Inventors: Thomas E. Bearden
Huntsville, AL 35801-1351

Kenneth D. Moore
Huntsville, AL 35801

Address correspondence to:
Thomas E. Bearden
Huntsville, AL 35801-1351

References Cited:

1. Bearden, Thomas E. (2005) "Errors and Omissions in the CEM/EE Model", available from http://www.cheniere.org/techpapers/CEM%20Errors%20-%20final%20paper%20complete%20w%20longer%20abstract4.doc . The paper presents and discusses known serious errors and falsities that have been in the classical EM and electrical engineering model since it was put together in the 1880s, and since 1892 when the already-seriously-curtailed Maxwell-Heaviside equations were further arbitrarily symmetrized by Lorentz. By his symmetrical regauging, Lorentz obtained simpler equations easier to solve analytically, but in so doing he arbitrarily discarded all *asymmetrical* Maxwellian systems. Nature does not discard them; Lorentz did and our electrical power engineers still do, as shown by any current classical electrodynamics text such as Jackson's Classical Electrodynamics.

   Comment: The present invention deliberately uses an asymmetrical Maxwellian system to provide a novel excess EM energy collection directly from a previously unaccounted free flow of EM energy from the external vacuum environment. In addition to the accounted Poynting energy flow, there also is and always has been an unaccounted and huge Heaviside curled component of energy flow which was also discarded arbitrarily by Lorentz, and continues to be discarded to the present day. By using not only the Poynting energy component input paid for by the operator, but also using an *extra and free input of additional Poynting energy flow* gained from converting some of the previously unaccounted Heaviside energy flow input into Poynting (diverged) energy flow, the absorbing system is enabled to absorb and emit more Poynting energy than the *operator alone* inputs and pays for in his *Poynting input component only*. Conservation of energy is obeyed. The resulting system does not ever emit more energy than its *total energy input*, when one understands and accounts the previously unaccounted huge Heaviside input component always accompanying the Poynting

input component but ignored since Lorentz arbitrarily discarded it. Thus the thermodynamic efficiency ξ of the resulting system always remains $\xi \leq 100\%$, but its thermodynamic coefficient of performance COP is permitted to be COP > 1.0 because the *asymmetric* system now receives an extra free and usable EM energy input from its environment.

2. Bearden, T. E. (2000) "Giant Negentropy from the Common Dipole," Proceedings of Congress 2000, St. Petersburg, Russia, Vol. 1 (86-98). Also published in Journal of New Energy, 5(1), Summer 2000, p. 11-23. Also carried on website www.cheniere.org. This paper presents the solution to the long-vexing source charge problem: how a charge can continually pour out real observable EM energy (real photons) at light speed in all directions, but have no observable output. The charge absorbs disordered virtual state energy from the virtual state vacuum, reorders them, coherently integrates the virtual state energy excitations into the next quantum level excitation, and then abruptly decayse by emitting an observable photon. Iteration of the process gives the observed emission of observable photons, with no observable energy input since the energy input is in the virtual state form.

3. Bearden, T. E. (2002) Energy from the Vacuum: Concepts and Principles, Cheniere Press, Santa Barbara, CA. Chapter 3. "Giant Negentropy, Dark Energy, Spiral Galaxies and Acceleration of the Expanding Universe".

4. Bohren, Craig F. (1983) "How can a particle absorb more than the light incident on it?" Am. J. Phys. 51(4). (323-327). Under nonlinear conditions, a charged particle can absorb more energy than is [conventionally considered to be] in the light incident on it. Metallic particles at ultraviolet frequencies are one class of such particles and insulating particles at infrared frequencies are another. [We strongly note that the conventional view only accounts the Poynting energy flow component of the total energy input, and ignores the huge Heaviside input component that is nonetheless present and many orders of magnitude greater.] **Comment**: When the charged particles in a medium are self-resonant at the same frequency of the light energy that is input to the medium, the medium can re-radiate up to 18 times as much energy as is in the Poynting component of the input energy. The conventional model (i) assumes field strength determined by absorption due to the reaction cross section of a *static* charge, and (ii) completely neglects the enormous Heaviside curled energy flow component, while considering only the Poynting energy flow component as determined by an absorbing *static* charged particle. For working in the IR and thus with heat energy, the "charged particles" in the medium are charges existing on insulating particles, where the charged particles are deliberately made self-resonant at the proper IR frequency or band. For broader band introduction of heat (IR) energy input, the overall gain reduces from the optimal 18, but still may be greater than 1.0 due to the increase of the overall reaction cross section of the absorbing charges where some are in self-oscillation. Gains of 3.0 to 4.0 can be achieved in conventional practice, and under certain circumstances the optimum 18 can be approached by multiple stages each having cross-feed forward and backward with all the rest.

5. Electrician, The. (1891) Editorial, "The transfer of energy." The Electrician, Vol. 27 (270-272). Quoting: *"...the idea that energy is located at all, and that, when it changes its position, it must move along a definite path, is quite a new one. The law of the conservation of energy implies that energy cannot disappear from one place without appearing in equal quantity somewhere else; but, although this fact has long been accepted, it is only within the last few years that the idea of transference of energy has been developed, or that anyone has*

attempted to trace out the actual path along which energy flows when it moves from place to place. The idea of an energy current is of more recent date than the electro-magnetic theory, and is not to be found explicitly stated anywhere in Maxwell's work. We believe that the first time it was applied to electrical theory was in the pages of The Electrician, by Mr. Oliver Heaviside, to whom so much of the extension of Maxwell's theory is due. The idea was also independently developed and brought to the notice of the Royal Society in a Paper by Prof. Poynting."

6. Evans, D J. and Lamberto Rondoni (2002). "Comments on the Entropy of Nonequilibrium Steady States," J. Stat. Phys., 109(No. 3-4), Nov. 2002, p. 895-920. The authors rigorously demonstrate that in thermodynamics theory physical systems capable of continuously producing negative entropy are theoretically permissible and possible, though unknown. **Comment**: Bearden has previously solved the source charge problem (Bearden, 2000), and has formally proposed the source charge and the source dipole as the first two known physical EM systems that continuously produce just such negative entropy. In modern physics, the "classically isolated charge" polarizes its surrounding vacuum, so any classical charge is *a priori* a dipolar assembly. Two infinite charges and two infinite energies are actually involved (see Weinberg), even for a single charged particle such as a single electron. Obeying the broken symmetry of opposite charges (Lee and Yang, experimental proof by Wu et al.), any charge or dipole consumes positive entropy of the disordered virtual fluctuations of the vacuum, and produces negative entropy in the observable state—by continuously emitting real observable photons in all directions but receiving no observable energy input. It does receive the necessary energy input, but from the seething virtual state vacuum. Since the "isolated charge" involves two infinite charges and two infinite energies, a steady and finite flow of energy for any finite time can and will be sustained by the charge's infinite energies without any diminishing of the energy flow.

7. Evans, M. W. et al. (2000) "Classical Electrodynamics without the Lorentz Condition: Extracting Energy from the Vacuum," Physica Scripta, 61, (513-517). This paper rigorously proves that an asymmetrical system not obeying the Lorentz symmetry condition does freely receive excess energy currents from its vacuum environment, and thus is permitted to *receive and use* excess energy from said environment.

8. Feynman, Richard P., Robert B. Leighton, and Matthew Sands, The Feynman Lectures on Physics, Addison-Wesley, Reading, MA, Vol. 1, 1964, p. 12-2. Quoting: *"...in dealing with force the tacit assumption is always made that the force is equal to zero unless some physical body is present... One of the most important characteristics of force is that it has a material origin..."*

9. Feynman et al., *ibid.*, Vol. 1, p. 2-4. Quoting: *"...the existence of the positive charge, in some sense, distorts, or creates a "condition" in space, so that when we put the negative charge in, it feels a force. This potentiality for producing a force is called an electric field."*

10. Feynman et al., *ibid.*, Vol. 2, p. 1-3. Quoting: *"We may think of E(x, y, z, t) and B(x, y, z, t) as giving the forces that would be experienced at the time t by a charge located at (x, y, z), with the condition that placing the charge there did not disturb the positions or motion of all the other charges responsible for the fields."*

11. Halliday, David and Robert Resnick, with assistance of John Merrill. (1988) Fundamentals of Physics, Third Edition Extended, Vol. II, p. 743, 753, 766-767. For the self-induced EMF in a coil by changing the current (or the voltage), only the *rate of change* counts, not the amount of change. Thus a large momentary magnetic field can be produced by an abrupt change of a very small current or of a very small voltage. The rate of change of the magnetic field also creates an electric field, and so the more abrupt the magnetic field change, the greater the momentary E-field that is produced. Lenz's law shows that the sign of the induced EMF and MMF is always opposing the change.

12. Halliday, David and Robert Resnick, *ibid.*, p. 858. The intensity of the Poynting vector **S** varies as the square of the E-field. In turn, the magnitude of the momentary E-field varies as the abruptness of change of the magnetic field. Thus for an abrupt Lenz law change of voltage (by an abrupt small current change) across a small double surface, a very large E-field momentarily results. The resulting momentary pulse of Poynting energy flow intensity is proportional to the square of that momentary large E-field. It can be seen that the Poynting energy pulse is proportional to the square of the magnitude of the abrupt Lenz reaction fields. It follows that such a giant pulse of Poynting energy flow suddenly propagating across substantial intercepting charges q leads to interception and absorption of energy on charges q, leading to the potentialization of charges q and therefore to their asymmetrical regauging.

13. Heaviside, Oliver. (1885, 1886, 1887) "Electromagnetic Induction and Its Propagation." The Electrician, 1885, 1886, 1887, and later. A series of 47 sections, published section by section in numerous issues of The Electrician during 1885, 1886, and 1887.

14. Heaviside, Oliver. (1887) Electrical Papers, Vol. 2 (94). Quoting p. 94: *"It [the energy transfer flow] takes place, in the vicinity of the wire, very nearly parallel to it, with a slight slope towards the wire... . Prof. Poynting, on the other hand, holds a different view, representing the transfer as nearly perpendicular to a wire, i.e., with a slight departure from the vertical. This difference of a quadrant can, I think, only arise from what seems to be a misconception on his part as to the nature of the electric field in the vicinity of a wire supporting electric current. The lines of electric force are nearly perpendicular to the wire. The departure from perpendicularity is usually so small that I have sometimes spoken of them as being perpendicular to it, as they practically are, before I recognized the great physical importance of the slight departure. It causes the convergence of energy into the wire."*

    Comment: Here one can see that the Poynting component is only a very slight diverged fraction in magnitude, compare to the otherwise nondiverged giant energy flow remaining. The actual diverged Poynting energy flow into the wire is only a "slight departure" from the outside energy flow discovered by Heaviside. So a much larger usually nondiverged Heaviside energy flow remains, in addition to the small Poynting energy flow component usually entering the circuit to potentialize the charges q and excite the circuit for its collection of potential energy.

15. Heaviside, Oliver. (1893) "On the Forces, Stresses, and Fluxes of Energy in the Electromagnetic Field." Phil. Trans. Roy. Soc. London, 183A, p. 423-480. Heaviside discusses the Faraday-Maxwell ether medium, outlines his vector algebra for analysis of vectors without quaternions, discusses magnetism, gives the EM equations in a moving medium, and gives the EM flux of energy in a stationary medium. On p. 443, he credits

//.

Poynting with being first to discover the formula for energy flow, with Heaviside himself independently discovering and interpreting this flow a little later by himself in an *extended form*.

Comment: In the present invention we deliberately take advantage of that huge but usually nondiverged Heaviside energy flow remaining after the typical small Poynting energy flow is diverged into the circuit. By deliberately using self-oscillation of the intercepting charges rather than the (assumed) fixed (static) charge utilized in the standard definition for field and charge interaction, the additional Lenz law effect produced by the sharp change of charge location and interception dramatically increases the reaction cross section of the now-self-oscillating charges compared to the same charges in "static" condition. This results in a very sharp, strong gradient applied to the Heaviside energy flow component, in fact diverging some of its usually unavailable energy into the circuit to overpotentialize the self-oscillating charges. The result is that up to 18 times the usual Poynting energy flow onto these charges to potentialize them, is realized and made available for the system's use. It is strongly accented that this is a method of utilizing part of a known (but usually unaccounted) huge excess energy flow that is universally made to every present circuit but ignored. Thus the thermodynamic efficiency of the system never exceeds 100% under any circumstance, but its coefficient of performance (COP) is permitted to appreciably exceed COP = 1.0. In short, the external environment containing the usually unaccounted and ignored extra Heaviside energy flow component is stimulated to freely provide and excess and extra Poynting energy flow component to the self-oscillating charges. The system becomes analogous to any EM system freely receiving excess EM energy from its environment, in addition to that standard accounted input by the operator. As a comparison, because of its *usable* excess energy input from its environment, a home heat pump with an efficiency of 50% will usually produce a COP = 3.0 to 4.0. By triggering an additional usable excess energy input from the environment's normally unusable Heaviside energy flow component, the present invention is permitted a maximum theoretical COP = 18. For real systems with losses, the achieved COP will be lower than 18, but can still be appreciably greater than COP = 1.0. E.g., achievement of COP = 2.0 to 5.0 are rather readily achievable, and in multi-staged systems the optimum COP = 18 can be approached.

16. Heaviside, Oliver. Unpublished notes. See Josephs (1959). Heaviside realized that his enormous extra nondiverged energy flow component had substantial gravitational consequences, since it was a substantial change in the local density flow of space, and thus a curvature of spacetime. Heaviside went back to quaternion theory, and worked out an electrogravitational theory could conceivably re implemented in circuits and EM practice.

    Comment: We cite these notes to point out that use of excess energy from the Heaviside component involves use of a deliberately curved spacetime, and this effect does not appear in normal CEM/EE where only special relativity is involved and the model assumes spacetime to be flat.

17. Jackson, J. D. (1999) Classical Electrodynamics, 3rd Edn., John Wiley and Sons, New York (249, 246). For the vacuum, Maxwell's equations reduce to two coupled equations, shown as equations 6.10 and 6.11 on p. 246. The Lorentz regauging condition is applied by Jackson on p. 240, resulting in two inhomogeneous wave equations given as equations 6.15 and 6.16. The Lorentz condition is given in equation 6.14 on p. 240. On page 240, Jackson erroneously

states that *"Equations (6.15) and (6.16), plus (6.14), form a set of equations equivalent in all respects to the Maxwell equations."* **Comment**: To the contrary, they are not equivalent at all. Indeed, by symmetrizing the equations, all asymmetrical Maxwellian systems including those capable of exhibiting COP > 1.0 (i.e., all asymmetrical systems far from equilibrium with their local environment consisting of the local active vacuum and the local curved spacetime) have been arbitrarily eliminated by Lorentz and thus by Jackson. What is true is that the fields are invariant, and even that statement needs qualification: Two new, free fields and their energy have been arbitrarily added, but carefully so that they are equal and opposite. So the overall *stress and therefore the stress energy of the system* itself—which does not appear in the Maxwell-Heaviside-Lorentz equations—has been changed. In short, the curvature of local spacetime and the local active vacuum have been deterministically structured so that they produce the two extra equal but antiparallel forces. In effect, to gain simpler equations easier to solve, field energy has been added and changed into stress potential energy, which curves the local spacetime and also alters the local vacuum.

18. Jackson, J. D. (1975) Classical Electrodynamics, Second Edition, Wiley, New York (219-221; 811-812.), In symmetrically regauging the Heaviside-Maxwell equations, electrodynamicists assume that the potential energy of a system can be freely changed at will (i.e., that the potential of a system can be *asymmetrically* regauged). **Comment**: This freedom to arbitrarily change the potential energy in a system, work-free, is also included under one of the major principles of quantum field theory, known as *gauge freedom*. Following Lorentz, the classical electrodynamicists and electrical engineers *arbitrarily* do *two* asymmetrical regaugings of the Maxwell-Heaviside equations simultaneously. But they carefully select only a very special combination of these "two asymmetrical regaugings" such that the two new free fields that emerge are equal and opposite. Thus they use only the symmetrical special case where there is no *net* resulting force which can be used to *asymmetrically* dissipate the free excess system energy resulting from regauging, and thereby perform work in a load without simultaneously performing equal work to destroy the "external" source of free potential energy flow. So the electrodynamicists and engineers arbitrarily discard all that entire class of Maxwellian systems which asymmetrically regauge by changing their own potential energy and *also producing a net nonzero free force field*. These latter *asymmetric* systems are open dissipative EM systems, freely receiving regauging energy from their active external environment. In principle such systems are permitted to asymmetrically dissipate that excess regauging energy in their external loads to power them freely. Hence the performance of the class of *arbitrarily-excluded* Maxwellian systems is not limited by classical equilibrium thermodynamics, but must be described by Nobelist Prigogine's disequilibrium thermodynamics of an open dissipative system. Such open disequilibrium systems can (i) self-organize, (ii) self-oscillate, (iii) output more energy than the operator himself inputs (the excess is freely received from the external active environment) (iv) freely "power" its own losses and an external load simultaneously (*all* the energy to operate the system and the load is received freely from the external active environment), and (v) exhibit negative entropy.

Quoting Jackson, p. 237: *"...the Poynting vector is arbitrary to the extent that the curl of any vector field can be added to it. Such an added term can, however, have no physical consequences."* **Second Comment**: This statement by Jackson is true in vector analysis in the special case of a rigorously flat spacetime. *It is not true in general, however*, since the

additional curled field energy density (as does any change in local energy density of space) is a general relativistic *curvature of spacetime*, where vector analysis fails and where the divergence of the curl is then not necessarily zero. In short, the divergence of an extra "curled" component of EM energy flow accompanying the uncurled Poynting energy flow, is not zero for a curved spacetime situation. For a significant curvature of spacetime, the usual "flat spacetime" curl-free Poynting energy flow component may be increased by an extra amount furnished by violation of the flat spacetime assumption—in which case the divergence of the curl *is not zero*. Jackson's statement is *approximately* true only so long as the spacetime is almost flat, so that the divergence of the curl remains essentially zero. But by deliberately curving the local spacetime, the new Poynting energy flow can be augmented by an extra added *diverged* component from the curled energy flow component. In short, *this produces an additional nonzero Poynting (divergent) energy flow component from the usually nondivergent Heaviside curled flow component*, since the divergence of the curl need not be zero in that case. The system receives (absorbs) more divergent Poynting energy than the operator himself input in his ordinary Poynting energy input. So the Heaviside curled energy flow component can indeed be induced to produce an additional usable and diverged Poynting EM energy flow component. By deliberately creating *nonnegligible* spacetime curvature (via the oscillating free sharp energy gradients introduced by self-oscillation of the absorbing charges) that differs from that of the normal Heaviside flow region of interest, it is indeed possible to extract (diverge) extra EM energy freely from the Heaviside energy flow component accompanying every Poynting energy flow, but unaccounted. This capability and change is not modeled in, or possible in, the inadequate vector algebra used in the Maxwell-Heaviside theory and equations. Hence the mechanism for this invention does not appear in classical electrodynamics and electrical engineering, although it has been well established (but not properly understood) in physics since 1967 (Letokhov, Bohren, and others.)

19. Josephs, H. J. (1959) "The Heaviside papers found at Paignton in 1957." The Institution of Electrical Engineers Monograph No. 319, Jan. 1959, p. 70-76. This is the IEE's publication of Heaviside's hand-written notes containing his theory of electrogravitation, based on his theory of EM energy flow containing the huge extra curled energy flow component. The papers were found beneath the floor boards in Heaviside's little garret apartment some 32 years after his death. His trapped EM energy flow loops were gravitational, because they constitute excess energy density in spacetime, thus curving spacetime. The late Professor Laithwaite and others (including the present inventor) were convinced that the secret of practical electrogravity starts with Heaviside's energy flow theory where a trillion times more EM energy density of space is available to work with on the bench. For a highly successful antigravity experiment using the negative energy variant of Heaviside's huge energy flow component, see Sweet and Bearden (1991).

20. Kondepudi, Dilip and Ilya Prigogine. (1999) Modern Thermodynamics: From Heat Engines to Dissipative Structures. Wiley, New York, 1998, reprinted with corrections 1999. Areas known to allow violating the second law thermodynamics are given on p. 459; one such area is a *strong gradient*. Indeed, the gauge freedom axiom of quantum field theory, in establishing that the potential energy of an EM system can be freely increased without work, is one specification for violation of the hoary old second law of thermodynamics which must be corrected.

21. Laithwaite, E. R. (1982) "Oliver Heaviside—establishment shaker." Electrical Review, 211(16), Nov. 12, 1982, p. 44-45. Since—contrary to standard CEM/EE—altering the energy density of space does have gravitational ramifications, Laithwaite felt that Heaviside's postulation that a flux of gravitational energy combines with the (**E**×**H**) electromagnetic energy flux, could shake the foundations of physics, and it may yet do so if physicists again begin accounting the huge Heaviside energy flow component and its consequences, particularly its gravitational consequences after they finally learn to manipulate it. Heaviside had realized these revolutionary gravitational implications before he died, and left unpublished papers and notes pointing it out. Quoting Laithwaite: *"Heaviside had originally written the energy flow as* $S = (E \times H) + G$*, where* G *is a circuital flux. Poynting had only written* $S = (E \times H)$*. Taking p to be the density of matter and e the intensity of a gravitational force, Heaviside found that the circuital flux* G *can be expressed as* $pu - ce$*, where* u *represents the velocity of p and c is a constant."*

22. Lee, T. D. (1986) "Question of Parity Conservation in Weak Interactions," Physical Review, 104(1), Oct. 1, 1956, p. 254-259. The question of parity conservation in β decays and in hyperon and meson decays is examined. Possible experiments are suggested which might test parity conservation in these interactions. Also in T. D. Lee, Selected Papers, Gerald Feinberg, Ed., Birkhauser, Boston, 1986, Vol. 2, p. 239-243. Errata are given in *ibid.*, p. 244 and in Phys. Rev. 106(6), June 15, 1957, p. 1371.

23. Lee, T. D., Reinhard Oehme, and C. N. Yang. (1957) "Remarks on Possible Noninvariance under Time Reversal and Charge Conjugation," Physical Review, 106(2), p. 340-345. Also in T. D. Lee, Selected Papers, Gerald Feinberg, Ed., Birkhauser, Boston, 1986, Vol. 2, p. 251-256. Interrelations between the nonconservation properties of parity, time reversal, and charge conjugation are discussed. The results are stated in two theorems.

24. Letokhov, V. S. (1967) "Generation of light by a scattering medium with negative resonance absorption." Zh. Eksp. Teor. Fiz., Vol. 53. (1442).

25. Letokhov, V. S. (1968) "Generation of light by a scattering medium with negative resonance absorption." Sov. Phys. JETP, 26(4). (835-839).

26. Letokhov, V. S. (1967) "Stimulated emission of an ensemble of scattering particles with negative absorption." ZhETF Plasma 5(8) (262-265).

27. Letokhov, V. S. (1995) "Laser Maxwell's Demon." Contemp. Phys. 36(4). (235-243).

28. Lorentz, H. A. (1931) Vorlesungen über Theoretische Physik an der Universität Leiden, Vol. V, Die Maxwellsche Theorie (1900-1902), Akademische Verlagsgesellschaft M.B.H., Leipzig, "Die Energie im elektromagnetischen Feld," p. 179-186. Figure 25 on p. 185 shows the Lorentz concept of integrating the Poynting vector around a closed cylindrical surface surrounding a volumetric element. This is the procedure which arbitrarily selects only a small component of the energy flow associated with a circuit—specifically, the small Poynting component being diverged into the circuit (in a flat spacetime) to power it—and then treats that tiny component as the "entire" energy flow. Thereby Lorentz arbitrarily discarded all the extra Heaviside circuital energy transport component which is usually not diverged into the circuit conductors at all, does not interact with anything locally, and is just wasted. To justify his arbitrary discarding of the huge but usually nondivergent Heaviside energy flow

component, Lorentz reasoned that it "had no physical significance, because it does nothing." Electrodynamicists (see Jackson, 1975) are still using that same phraseology to justify not considering such an extra and massive, but curled, energy flow component. **Comment**: It follows that any procedure or mechanism that converts part of this huge but usually unavailable Heaviside energy flow component into a free, extra Poynting energy flow component arbitrarily discarded by Lorentz, can permit COP>1.0 operation in such systems, even though the thermodynamic efficiency ξ remains $\leq 100\%$.

29. Maxwell, James Clerk (1878). "Tait's Thermodynamics II," Nature 17 (278–280) Quoting: *"The truth of the second law is ... a statistical, not a mathematical, truth, for it depends on the fact that the bodies we deal with consist of millions of molecules... Hence the second law of thermodynamics is continually being violated, and that to a considerable extent, in any sufficiently small group of molecules belonging to a real body."*

30. Paul, H. and R. Fischer. (1983) {Comment on "How can a particle absorb more than the light incident on it?'}." Am. J. Phys. 51(4). (327). The two authors independently validated the Bohren-type experiment, which is repeatable and produces COP = 18.

31. Poynting, J. H. (1885) "On the transfer of energy in the electromagnetic field," Phil. Trans. Royal Soc. Lond. Vol. 175, Part II. (343-361). Poynting got the direction of the flow wrong by 90°, which was corrected by Heaviside. Poynting only considered that small component of the energy flow outside the conductor that was diverged into the conductor to power the electrons, and never even considered any remaining nondiverged component of the surrounding energy flow.

32. Sweet, Floyd and T. E. Bearden. (1991) "Utilizing Scalar Electromagnetics to Tap Vacuum Energy," Proc. 26th Intersoc. Energy Conversion Eng. Conf. (IECEC '91), Boston, Massachusetts (370-375). Sweet's device produced 500 watts for a 330 microwatt input, thus having a COP = 1,500,000.

33. Wu, C. S., E. Ambler, R. W. Hayward, D. D. Hoppes and R. P. Hudson, (1957) "Experimental Test of Parity Conservation in Beta Decay," Physical Review, Vol. 105, p. 1413. Reports the experimental proof that the weak interaction violates parity (spatial reflection). Comment: This experimentally proved Lee and Yang's prediction of broken symmetry in physics. So revolutionary was broken symmetry that in great haste the Nobel Committee awarded Lee and Yang the Nobel Prize in Dec. 1957, the same year that Wu and her colleagues experimentally proved the prediction.

Increasing the Coefficient of Performance of Electromagnetic Power Systems by Extracting and Using Excess EM Energy from the Heaviside Energy Flow Component

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates to the field of electromagnetic power generation. Specifically it relates to systems (i) receiving some of their EM energy from the operator while also freely receiving additional excess EM energy from the active environment, thereby (ii) outputting more useful EM energy than is input by the operator alone, and thus (iii) acting as an *energy amplifier* or an *energy amplifying stage* that channels and directs and uses additional energy from the environment in addition to that energy furnished by the operator, thereby freely increasing the COP of the system beyond COP = 1.0. The receipt of excess EM energy freely from the environment is from the previously unaccounted giant Heaviside curled energy flow component, far greater than the accounted Poynting energy flow component.

This giant Heaviside curled energy flow component accompanying every EM system was discovered by Heaviside in the 1880s, but it posed a great puzzle due to (i) its enormity, as compared to the feeble Poynting energy flow component, and (ii) its certification that from any generator, battery, or other energy source there pours forth enormously more EM energy flow than the energy that is contained in the relatively feeble mechanical energy input to the shaft of the generator or the feeble chemical energy dissipated in a battery. Since the problem could not be solved (the physics was not as yet even born that explained it), this bothersome Heaviside component was arbitrarily discarded by Lorentz in the 1890s because—since it was normally nondiverged and did nothing—it was thought to have "no physical significance". Actually Lorentz's discarding of that component was motivated by the desperate need to just get rid of it, in order to "save" the conservation of energy law since all electrodynamicists erroneously believed (and most still erroneously believe to this day) that the only energy input to an operating generator is the mechanical shaft energy.

Free receipt by a system of usable excess *converted* Heaviside energy flow violates Lorentz symmetry of the system. Thus the standard Lorentz invariant vector equations of classical electromagnetics and electrical engineering cannot and do not describe the operation of the system in such mode because they already exclude any accounting of the experimentally proven Heaviside component and any such free contribution from it.

The present invention is the first electrical power invention which deliberately utilizes excess energy freely received from the universally-available Heaviside nondiverged energy flow component, converting a portion of it to an *extra* Poynting diverged energy flow freely available and usable by the system in powering its loads.

2. Summary of the Invention's Operation

The *excess* EM energy necessary for the amplified output (and for COP>1.0) is freely furnished from the external dynamic EM environment rather than by the operator, and conservation of energy is obeyed at all times. The system is therefore *asymmetric*, so that it is one of those Maxwellian asymmetric systems arbitrarily discarded by Lorentz and by present electrical engineering. The operation of the invention operation is analogous to that of a common heat pump. The *thermodynamic efficiency* ξ of the system is $\xi \leq 100\%$, but because

of the free input of excess energy from the environment the system can permissibly produce COP > 1.0. It produces more energy output than the energy input by the operator, but never greater than the *total* energy input by both operator and environment. Hence the "energy amplification" effect with respect to the operator's input separately considered. The system operates analogously to a vacuum tube triode amplifier in which the grid signal energy is furnished and paid for by the operator,while the cathode energy input is freely received from the environment. Due to the disequilibrium exchange of energy across the system boundary, the system is not an *isolated* thermodynamic system, but it is an asymmetric system receiving this excess environmental energy input freely in addition to receiving any energy the operator inputs. The energy amplifying system thus obeys the nonequilibrium thermodynamics of an open dissipative system freely receiving excess energy from its active environment.

A multiple of such energy amplifier stages in series or in common interaction each with the other can be used to further increase the amplification factor, thereby increasing the total extraction of excess energy from the environment, and thus increasing the overall energy amplification magnitude of a circuit or system well past COP = 1.0.

With sufficient energy amplification, a portion of the overall amplified energy output may be extracted and fed back to the operator's energy input section. By using clamped positive feedback and adjusting and controlling the feedback as the system input energy needs vary, the feedback energy input may be made equal to the otherwise necessary operator's input and in phase, whereupon the operator's input may be disconnected so that the system is "self-powered", with all its energy input being furnished by the active environment. The self-powering system is a *nonequilibrium steady state (NESS) thermodynamic system freely receiving all its EM energy from the environment*, and outputting a large fraction of that environmental energy input as a free energy output to usefully power loads or furnish energy that is transferred to other systems and processes.

The operation of the self-powering energy amplifying system with clamped positive feedback is analogous to the operation of a solar cell array power generation system, a windmill-powered electrical power system, or a hydroelectric power system—where all the input energy is freely furnished from the active environment—except that, instead of wind currents, solar radiation, or water currents, a previously ignored giant energy flow component already present in every EM circuit's electromagnetic environment is utilized to furnish the energy. This usually nondivergent Heaviside energy flow is made partially divergent by the invention's use of curved spacetime so that divergence of the curl is not equal to zero, and thus part of the curled Heaviside energy flow component is partially converted to ordinary and usable *extra* diverged Poynting energy flow freely received and used by the system.

The importance of the invention is that a vast new ubiquitous source of EM energy—the previously ignored Heaviside energy flow component—is locally tapped at any location in the universe, to produce excess EM energy input to the system directly from the environment. The amount of energy that can be produced is essentially limited only by the state of development of the new electrical power engineering technology arising from the invention. The invention thus is capable of being rapidly developed and deployed so as to first reduce then quickly and permanently eliminate the emerging world energy crisis.

3. Background

Accompanying every accounted *diverged* Poynting linear energy flow in and around EM circuits and systems there is an accompanying but unaccounted much larger—but usually

nondiverged—Heaviside *curled* energy flow, discovered by Oliver Heaviside in the 1880s [Heaviside, 1885-1887] and arbitrarily discarded by Lorentz circa the 1890s [Lorentz, 1931]. By sufficiently curving local spacetime and thus violating the "flat spacetime" assumption of classical electrodynamics, the curled Heaviside energy flow component develops a divergent component since in curved spacetime vector analysis is incomplete and the divergence of the curl is not zero. The invention opens a new field for extracting and using divergent EM energy flow from the vast but *usually* nondivergent and ignored Heaviside curled energy flow component accompanying every Poynting energy flow component.

By divergence of extra energy from the usually ignored Heaviside energy flow component, the invention is enabled to operate for periods of time as an open system freely receiving additional energy from its activated curved spacetime environment. This type of EM operation does not appear in the classical EM model because of its assumption of a *flat* spacetime environment and its arbitrary discardingof all accounting of the Heaviside component. Such curved spacetime operation does, however, appear in physics and the fundamental mechanism is experimentally proven in that area known as *negative resonance absorption of the medium (NRAM)*, though inadquately understood because the Heaviside component is not accounted by scientists working in that area.

Because of the *work-free* receipt of excess energy from its environment, the energy amplifying system is thermodynamically a nonequilibrium steady state system. Accordingly, it can permissibly increase its thermodynamic coefficient of performance (COP) to COP > 1.0, analogous to the common home heat pump, even though the overall thermodynamic efficiency ξ of the overall system is always $\xi < 100\%$.

By diverting a *small fraction* of the amplified output energy of the amplifier system, using controlled positive energy feedback to the operator's input section, the operator's energy input can be replaced by the feedback energy made available. Thus the unit can also produce "self-powering" or what is known as a nonequilibrium steady state (NESS) system in thermodynamics, freely receiving all its energy from the environment similar to the operation of a windmill or solar cell array generating system. Hence in a NESS system, permissibly the COP—defined as total useful energy output, divided by only the *operator's* energy input—can be COP = ∞, precisely as is the COP of common systems such as the hydroelectric electrical power system complete with its distribution lines and distant loads. Conservation of energy, thermodynamics, and physics are not violated by such performance, so long as the environment freely furnishes and inputs all the energy subsequently dissipated by the system.

The performance of such freely and *asymmetrically* regauging systems obeys the thermodynamics of Prigogine's dissipative systems far from thermodynamic equilibrium. The system violates the conventional CEM assumption of Lorentz symmetry since that symmetry is broken by any appreciable curvature of spacetime and by any excess extra energy input from the environment. It permissibly violates the "near equilibrium" second law of thermodynamics, which only applies to the entropic decay of previously excited systems from near-equilibrium back to equilibrium, and fails to account for the previous negative entropy operation that lowered the equilibrium systems entropy by moving the system out of equilibrium in the first place. Violation of the restricted second law is already known and accepted for steady state systems far from equilibrium, and for many other effects such as statistical fluctutions and a variety of cases listed by Kondepudi and Prigogine (1999) in their standard textbook Modern Thermodynamics, p. 459. Even Maxwell long ago pointed out that

every many-particle system continually violates the second law of thermodyamics (Maxwell, 1878).

Accordingly, the conventional classical electrodynamics (CEM) model with its arbitrary Lorentz-invariant equations cannot and does not describe the asymmetric operation of the invention. No laws of physics or thermodynamics are violated in such open dissipative systems exhibiting increased COP>1.0 and thus acting as energy amplifiers. The conservation of energy law is rigorously obeyed at all times, as it is in the common home heat pump with its efficiency ξ of $\xi = 50\%$, but nevertheless demonstrating COP = 3.0 to 4.0 and thus showing "energy amplification" of its operator-furnished energy input, by means of the excess additional input freely received from the external environment.

The invention seems to be the first active electromagnetic power system deliberately designed to receive additional EM energy freely from its available *Heaviside* energy flow environment, and operated as an open dissipative system far from equilibrium, freely outputting more energy (or work) than the operator's energy input alone would allow. All electrodynamicists (e.g. Jackson, referenced) routinely utilize free asymmetrical regauging, but conventionally and arbitrarily *assume* two such asymmetrical regaugings simultaneously occurring just precisely so as to produce Lorentz symmetry, so that Lorentz invariant equations can continue to be utilized. Because of its Lorentz symmetry, the standard closed current loop circuitry and CEM/EE model allow no *free, net translation force field* to be created in the regauging system, since that force field would be capable of dissipating any net excess energy received by the system in its two asymmetrical regaugings. Instead, because of the arbitrary Lorentz symmetry, such such net free energy received is *a priori* locked up as additional *stress in the system*. This completely arbitrary procedure thus selects a *subset* of Maxwellian systems which receive and collect no *usable* excess energy from their environment. Such systems cannot exhibit COP > 1.0, nor can they exhibit COP = ∞(self-powering).

6. Related Art.

There is believed to be no prior understood art in such *asymmetrically* self-regauging EM power systems deliberately utilizing excess energy input from the active *Heaviside* energy flow component—previously unaccounted in every system's environment—in order to produce an EM energy amplifier with respect to the operator's EM energy input.

However, those optical scientists working in the area of physics known as *negative resonance absorption of the medium* (NRAM) appear to be unwittingly generating the basic effect (curving local spacetime sufficiently by the self-resonant charges), thereby unwittingly producing a nonzero divergence from the long-unaccounted curled Heaviside energy flow component without understanding it. Scientists in that field are unaware of the long-neglected Heaviside energy flow component, and apparently none of them has recognized the basic spacetime curvature mechanism providing their surprising but well proven (since 1967) results. Instead of discussing the thermodynamics of the process, they discuss only the change in reaction cross section of the collecting charge, once it is in self-oscillation instead of static as in the conventional assumption. Extending and clarifying their proven results in thermodynamic terms, since 1967 they have found that a medium comprised of self-resonating charged particles that go into self-resonance at the frequency of the energy fed into the medium (at UV or at IR frequencies, typically) will then output from the medium some

18 times as much *Poynting energy flow* as was contained in the *Poynting component* of the energy flow that was input by the operator. The NRAM scientists do not discuss the thermodynamics of the process, but only the change in the reaction cross section of the particle absorbing the energy. They are completely unaware of also having unwittingly input an enormous extra Heaviside curled energy flow which, under *nonresonant* medium conditions, does not diverge and thus has no effect in increasing the re-radiated energy component.

7. Advantages of the Invention

By deliberately applying the principles of this invention to extract and use unrecognized Heaviside energy flow as well as recognized Poynting energy flow, it is possible to produce one or more "self-amplifying serial stages" where in each stage the recognized input energy initiates extra input energy from the Heaviside energy flow component, thereby producing a greater energy flow output from the stage than the recognized energy input to the stage. The output of each stage, of course, is the sum of the normal Poynting input energy plus the extra diverged Heaviside energy input, minus any losses in the stage circuitry. By using multiple serial amplifying stages, the overall amplified energy output from multiple stages can be raised to a substantial multiple of the operator's input energy, while rigorously obeying the conservation of energy law, the laws of physics, and the laws of nonequilibrium thermodynamics. The maximum gain is 18 for multiple optimized stages each interacting with the other.

The utility of this "energy throughput amplification" feature is pointed out. E.g., in already on-site large electrical power plants it can dramatically reduce the burning of hydrocarbons, consumption of nuclear fuel rods, etc. in our standard electrical power plants of today, while allowing the same power output onto the distribution grid. The process allows the direct substitution of "additional free input of energy from the environment itself" for much of the operator's input energy that formerly had to be provided by hydrocarbon combustion, consumption of nuclear fuel cells, etc.

As the technology further develops, it is foreseen that methods of exceeding the optimized COP = 18 will be achieved, producing COP > 18 by *paralleling* multiple NRAM systems each producing COP > 1.0. This will allow very small conventional EM energy sources (such as a small battery bank) to feed large paralleled energy amplifier arrays whereby the total amplified system output powers homes, factories, large buildings, etc. The huge amplification may be referred to as "passive" amplification in that the operator himself does not have to furnish and pay for the extra energy added for the increased energy output in each amplification stage. One foresees the eventual use of a small rechargeable battery the size of an automobile battery, e.g., to feed a decentralized and paralleled set of individual energy amplifiers whose freely amplified output powers a home, an office, or any other building. Or an electrical automobile. The excess energy comes from the ubiquitously present external Heaviside energy flow environment, and the operation of the energy amplifier is very analogous to that of a home heat pump.

With sufficient "energy stage amplification", it is easily possible to extract a small fraction of the increased energy output of the amplified system, use clamped positive feedback to provide the fundamental operator's energy input, disconnect the operator's input from the

external power line once the amplifier is in operation, and thus transition to a fully self-powered system exhibiting COP = ∞(analogous to the solar cell array power system, windmill-powered electrical power system, hydroelectric power system, etc.), taking all its energy from the local but huge Heaviside energy flow component, while obeying the laws of physics, nonequilibrium steady state thermodynamics, and the conservation of energy law at all times.

SUMMARY OF THE INVENTION

It is a principal object of the present invention to provide a system for providing increased electrical power and mechanical shaft power to power loads, using excess energy freely furnished from the previously untapped and unaccounted Heaviside curled energy flow component available in every system but previously unused.

It is another object of the present invention to provide a system for asymmetrically regauging itself by converting a fraction of the available Heaviside curled energy flow into diverged Poynting energy flow, and thereby changing its available and usable Poynting energy, wherein said energy conversion is via a medium of charged particles in self-oscillation at the center frequency of the conventional EM energy input to said medium.

It is another object of the present invention to provide a system for increasing its energy collecting reaction cross section in a given Poynting energy flow input, so that an oscillating curvature of local spacetime is produced by the oscillating energy density of the charged particle, hence inducing an oscillating curvature of spacetime affecting and diverging a portion of the Heaviside energy flow component, and thus converting a portion of that usually nonreactive curled energy flow component into normal diverged Poynting energy flow output by the conversion stage (the energy amplifying stage).

It is another object of the present invention to provide a means whereby additional Poyngint (diverged) energy is freely received by the system from the huge unaccounted and unused Heaviside energy flow component, thereby enabling COP > 1.0 operation as an open nonequilibrium steady state (NESS) thermodynamic system freely receiving usable excess energy from its active external environment.

It is another object of the present invention to provide an asymmetric Maxwellian system, of the type discarded by Lorentz's and electrical engineering's arbitrary symmetrization of the Maxwell-Heaviside equations, so that the invention operates beyond the symmetrized limitations imposed by Lorentz symmetry and Lorentz invariant equations.

It is another object of the present invention to provide a system for freely amplifying the energy input to the system by the operator, by also receiving and using excess energy freely input to the system from a previously unused but ubiquitous part of the system's energy flow environment.

It is another object of the present invention to provide an energy-amplifying system stage, utilizing excess energy freely input by the system's active environment,and whereby such stages induce a momentary sharply increased pulsations of Poynting energy flow across the collecting charges, so that said collecting charges are thereby potentialized to a greater degree, thereby increasing the collected potential energy absorbed by and upon said collecting charges.

It is another object of the present invention whereby such energy-amplifying stages may be connected in series to provide overall amplification whose overall gain approaches the optimized COP = 18.

It is another object of the present invention whereby such energy-amplifying stages may be paralleled to provide overall amplication whose overall gain exceeds the series-optimized COP = 18.

It is another object of the present invention to provide an energy-amplifying system whereby useful energy output by the system is greater than the operator's energy input, with the extra input energy being freely furnished from the system's EM energy flow environment by forced divergence from the accompanying but previously unaccounted Heaviside energy flow component.

It is another object of the present invention to provide said energy-amplifying system whereby useful energy output by the system is greater than the operator's energy input, with the extra input energy being furnished by forced divergence from the accompanying but previously unaccounted Heaviside energy flow component, and wherein a portion of the output energy can be extracted and fedback in controlled manner to the operator's input section, and whereby said operator's input can be disconnected so that the operator's input is a proper part of the overall system load, and whereby the system becomes "self-powering" with COP = ∞ and slightly reduced total usable energy output, so that all the necessary energy input to power the system's losses and its loads is freely furnished by the active external environment. In this case the system operates as a nonequilibrium steady state (NESS) system analogous to a solar-cell array powered electrical power system.

It is another object of the present invention to provide the above system attributes in a system suitable for addition to and modification of present steam boilers in conventional electrical power plants, whether nuclear or hydrocarbon burning. In this fashion the said boiler can provide the same amount of ouput heat energy but with appreciably reduced consumption of hydrocarbons or nuclear fuel.

It is another object of the present invention to provide the above system attributes in a system suitable for addition to and modification of present steam boilers in conventional electrical power plants, whether nuclear or hydrocarbon burning, and wherein the said boiler can provide the same amount of ouput heat energy but with appreciably reduced consumption of hydrocarbons or nuclear fuel, and wherein feedback of a portion of the output heat energy can be provided to the input section, whereby self-powering operation is achieved as a NESS system, and whereby all input heat energy is freely furnished by the active environment.

It is another object of the present invention to provide an add-on system wherein the coefficient of performance and hence the output of a solar-cell powered EM system is increased by first converting the solar cell output to IR heat, and then applying the IR heat to an energy-amplifying boiler system as prescribed by the invention, whereby the output of the said system is increased to overcompensate for the solar cell array's poor efficiency, by producing an overall system having a COP > 1.0 or even greater than COP > 18 with parallel staging.

It is another object of the present invention to provide an add-on system wherein the coefficient of performance and hence the output of a standard electrical power generating system,

whether nuclear, hydrocarbon-burning, solar cell-array powered, windmill powered, or hydroelectric powered, can be increased without increasing the consumption of nuclear fuel rods, hydrocarbon fuels, solar radiation, wind power, or water power. Indeed, in the paralleled stages application, the use of fuel, solar radiation, wind, or water current can be halted once the system with paralleled energy-amplifying stages is in sustained operation with the necessary heat input feedback.

It is another object of the present invention to provide an electromagnetic power system that self-regauges asymmetrically so as to constitute an open dissipative thermodynamic system not in thermodynamic equilibrium, and that utilizes additional energy gained freely from its active external environment by its asymmetrical self-regauging, and that utilizes excess energy from forced divergence of some of the normally nondiverged Heaviside energy flow component accompanying the standard Poynting energy flow of every EM system, but presently unaccounted.

It is another object of the present invention to provide an energy-amplifying system which may be added onto a conventional hydrocarbon-consuming electrical power system to dramatically reduce or even halt its consumption of hydrocarbon fuel, while simultaneously maintaining or increasing the normal electrical power output by freely receiving and utilizing excess energy from its external environment, and specifically from the previously unaccounted and unused Heaviside energy flow component of said external environment.

It is another object of the present invention to provide an energy-amplifying system which may be added onto a conventional nuclear-powered electrical power system to dramatically reduce or halt its consumption of nuclear fuel rods, while simultaneously maintaining or increasing the normal electrical power output by freely receiving and utilizing excess energy from its external environment, and specifically from the previously unaccounted and unused Heaviside energy flow component of said external environment.

It is another object of the present invention to provide an energy-amplifying system which may be added onto a conventional solar cell array driven electrical power system to dramatically reduce or halt its consumption of solar radiation, while simultaneously maintaining or increasing the normal electrical power output by freely receiving and utilizing excess energy from its external environment, and specifically from the previously unaccounted and unused Heaviside energy flow component of said external environment.

It is another object of the present invention to provide an energy-amplifying system which may be added onto a conventional windmill-powered electrical power system to dramatically reduce or halt its consumption of wind power, while simultaneously maintaining or increasing the normal electrical power output by freely receiving and utilizing excess energy from its external environment, and specifically from the previously unaccounted and unused Heaviside energy flow component of said external environment.

It is another object of the present invention to provide an energy-amplifying system which may be added onto a conventional geological heat-powered electrical power system to dramatically reduce or halt its consumption of geological heat, while simultaneously maintaining or increasing the normal electrical power output by freely receiving and utilizing excess energy from its external environment, and specifically from the previously unaccounted and unused Heaviside energy flow component of said external environment.

It is another object of the present invention to dramatically decrease the present pollution of the environment by contaminations and byproducts of hydrocarbon-powered and nuclear powered electrical power systems, by dramatically decreasing the consumption of hydrocarbon or nuclear fuel while maintaining or increasing the electrical power output of the systems.

It is another object of the present invention to provide an energy-amplifying system which may be added onto a conventional nuclear-powered electrical power system to dramatically reduce or halt its consumption of nuclear fuel rods, while simultaneously maintaining or increasing the normal electrical power output by freely receiving and utilizing excess energy from its external environment, and specifically from the previously unaccounted and unused Heaviside energy flow component of said external environment.

It is another object of the present invention to provide an energy-amplifying system which may be added onto a conventional battery-powered electrical power system, such as in an electric automobile, truck, electric locomotive, etc., to dramatically reduce or halt its consumption of operator-furnished battery power and its number and size of batteries to power it, while simultaneously extending the range and time that a given set of batteries can initiate the powering of the automobile, and while simultaneously maintaining or increasing the normal electrical power output of the electrical power system by freely receiving and utilizing excess energy from the external environment, and specifically from the previously unaccounted and unsued Heaviside energy flow component of said external environment.

It is another object of the present invention to provide an energy-amplifying system which may be added onto a conventional steam-powered ship's boiler and electrical power system, so as to dramatically reduce or halt its consumption of fuel while simultaneously extending the range and time that a given amount of fuel can enable, and while simultaneously maintaining or increasing the normal electrical power output of the electrical power system and the heat of the boiler system by freely receiving and utilizing excess energy from the external environment, and specifically from the previously unaccounted and unused Heaviside energy flow component of said external environment.

It is another object of the present invention to provide an energy-amplifying system which enables a fuel-free jet engine, using compressed and superheated input air, so as to dramatically reduce or halt its consumption of hydrocarbon fuel while simultaneously extending the range and speed of the aircraft, by freely receiving and utilizing excess energy from the external environment, and specifically from the previously unaccounted and unused Heaviside energy flow component of said external environment.

It is another object of the present invention to provide an energy-amplifying system which enables a battlefield mobile vehicle to dramatically reduce or halt its consumption of hydrocarbon fuel while simultaneously extending the range and speed of the vehicle, by freely receiving and utilizing excess energy from the external environment, and specifically from the previously unaccounted and unused Heaviside energy flow component of said external environment. This accomplishes a dramatic reduction in the logistics effort required by ground forces, making them ever more mobile and sustainable, and dramatically increases the tooth-to-tail ratio of strike forces in the field.

Advantages of the energy amplifier and COP-increasing process and embodiments are:

- Dramatic reduction or elimination of hydrocarbon fuel consumption, wind power consumption, nuclear fuel consumption, solar radiation power consumption, water power consumption, and geological heat consumption in present power systems.
- Dramatic reduction of present atmospheric pollution and biospheric damage from energy-related power systems, including by modifying those appropriate power plants already installed and operating.
- Dramatic reduction of hydrocarbon fuel costs, nuclear fuel costs, by standard hydrocarbon or nuclear electrical power plants.
- Use of a vast new ubiquitous source of EM energy—the previously ignored Heaviside energy flow component which exists for any EM circuit or system, and which can be locally tapped at any location in the universe—to produce excess EM energy input to the system directly from the environment. The amount of energy that can be produced at any location (including in deep space) is essentially limited only by the state of development of the new electrical power engineering technology arising from the invention.
- Providing a ready means of adjusting to periodic surges and declines in electric power demand by adjusting the overall gain of the staged energy amplifier sections.
- Ability for electrical power systems to become self-powering in operation, freely drawing all their necessary energy input from the ubiquitous and enormous Heaviside component created in surrounding space by the system itself, but previously ignored and unaccounted.
- Use of a startling and free new ubiquitous source of EM energy, where the process for receiving usable excess EM energy from it is already proven in physics though still misunderstood prior to this invention.
- Stabilizing and maintaining the desired ouput of windmill electrical power generating farms and solar array powered generating systems during periods of less wind or less solar radiation, including sustained periods of absence of same.
- Dramatic lessening of the dependence of present electrical power systems upon their present oil, coal, natural gas, and nuclear fuel resources, so that the world usage of such fuels will dramatically decline, such that the supply of said fuels will then remain adequate even as the total available world supply of said fuels peaks and declines. This is particularly significant in view of the rapidly increasing needs and demands for energy from many nations such as India, China, African nations, etc.
- Elimation of the increasing pressure for energy wars and forceful competition to secure minimum requirements for increasingly limited energy fuels, fuel transport, oil refining, and other related energy processes.
- Stability in the prices and maintenance of required energy demands so that national economies can remain strong and based on cheap, clean energy while simultaneously cleaning up the biosphere from present harshly polluting energy-related processes and facilities.

It can be seen that there are many other advantages and applications of the foregoing energy-amplifying power systems, but the foregoing listed example advantages and applications suffice to show the highly beneficial impact of using these new power systems and processes made possible by the invention in a wide variety of applications.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention is described in detail in the Detailed Description, while attributes and typical applications are shown in the drawings. Preferred Embodiments should be read in conjunction with the following set of drawings. The first three drawings. Figures **1-3** give the background for the conventional view of only the diverged Poynting EM energy flow, the actual normal situation with the additional giant but nondiverged Heaviside curled energy flow component, and the curved spacetime situation where a small bit of the Heaviside curled energy flow component is diverged due to the spacetime curvature. Thus an additional Poynting energy flow component is freely received and utilized by the asymmetric system in curved spacetime, producing excess emission from the absorbing medium whose charged particles are in self-oscillation at the frequency of the input Poynting energy component. Figures **4-6** show the thermodynamics involved in COP > 1.0 processes and specifically in the invention. Figure **7** illustrates the basic mechanism used in the invention, while Figure **8** shows the experimentally proven optimal situation where the frequency of the input energy is very sharp. Figure **9** shows a single stage application to a boiler of a power plant. Figure **10** shows serial multiple staging. Figure **11** shows a different kind of multiple staging where each stage contributes to all the others, resulting in an overall gain greater than would be achieved by simple serial stages. When the gain is made sufficient, then the system can be converted into a nonequilibrium steady state self-powering system where all the input energy is freely received from the active Heaviside energy flow environment once the process is ongoing. This application is shown in Figure **12**.

Figure **1** shows the conventional view of the energy flow outside the conductors in an EM circuit operating in a reasonably flat spacetime, where only the diverged Poynting energy flow component is shown and accounted.

Figure **2** shows the actual situation of the circuit in Figure **1**, in a reasonably flat spacetime, where the nondivergent curled Heaviside component is present, even though unaccounted and noncontributing. In the flat spacetime case assumed in the standard electrical engineering model, this extra component has no divergence. So in the flat spacetime case, except for minor gravitational effects it is usually immaterial whether the Heaviside energy flow component is accounted or not, since for its *electrical power* contributions Lorentz's infamous statement that *"it does nothing, therefore it has no physical significance"* applies.

Figure **3** shows the same circuit situation in a more curved spacetime, with the standard Poynting divergent energy flow component now being increased by a newly divergent extra Poynting energy flow component freely diverged and received from the Heaviside energy flow component. This *extra* Poynting energy flow component is freely received from the active environment (from the Heaviside component in curved spacetime) and so the absorbing potentialized charges can and will re-emit more EM energy than the conventional CEM/EE textbooks prescribe and calculate. This mechanism actually is what accounts for the "negative

resonance absorption of the medium" effect that has been well-known but misunderstood since 1967 (see Letokhov, Bohren).

Figure **4** is a block diagram showing that a thermodynamic system (i) with real losses so that its efficiency $\xi < 100\%$, and (ii) operating in an *inactive* environment that does not input extra energy, will have COP < 1.0. Indeed, numerically $|\xi| = |\text{COP}|$.

Figure **5** is a block diagram giving the thermodynamic requirement for a system with efficiency $\xi \leq 100\%$ to produce COP > 1.0. The requirement is that sufficient additional energy input must be received by the system from its active environment to make up for any system losses (the inefficiencies) and still have additional input energy remaining. In that case, the output energy to the loads themselves will be greater than the operator's input of divergent Poynting energy flow, so that thermodynamic COP > 1.0 is permitted. The system thus becomes a nonequilibrium steady state (NESS) system freely receiving excess energy from its active environment. For such a system, it is well-known in nonequilibrium thermodynamically that a less than 100% efficient system is permitted to nevertheless exhibit COP > 1.0.

Figure **6** shows a system with efficiency $\xi \leq 100\%$ but still capable of powering itself and its load, so that the operator inputs nothing and the system permissibly produces COP = ∞. The requirement is that sufficient energy input must be received by the system from its active environment to furnish (i) that component of energy usually input by the operator, plus (ii) that component of energy that is dissipated in the system losses, and (iii) that component of energy that is dissipated in the loads to perform useful work. In that case, the system is said to be *self-powering* in that it powers itself with energy freely received from its environment and also powers its load with energy freely received from its environment. In short, this is the case where all the input energy is freely received from the active environment. The system thus becomes a nonequilibrium steady state (NESS) system freely receiving excess energy from its active environment to freely power itself and its load. As such, thermodynamically a system with $\xi < 100\%$ is permitted to nevertheless exhibit COP = ∞. This is in fact true, e.g., of a solar-cell-array powered electrical power system where all the input energy is freely input by the sun, as well as a windmill-powered electrical power system where all the input energy is freely input by the wind. A hydroelectric power plant is another example where all the input energy is freely input by the river's current.

Figure **7** shows the basic operation of a "negative resonance absorption of the medium" (NRAM) system. The self-oscillation of the charged particles produces an increased reaction cross section of the charge as pointed out by present NRAM physics literature. The present NRAM researchers have not considered the arbitrarily neglected Heaviside energy flow component or the curved spacetime effect, hence they have been unaware of the extra energy being input by divergence from a usually divergence-free energy flow component that is always present in addition to the standard Poynting energy flow component. Thus the present researchers have largely not discussed the thermodynamics of the process, but have merely discussed the change in reaction cross section of the self-resonant charges as the initiating factor. Nonetheless, the standard physics literature already shows proven optimal experimental results for 18 times as much EM energy output by the NRAM medium, as was input by the operator to the medium. In the present invention, we identify the unsuspected source of the extra input energy, as well as the process that diverges it into the system as an additional Poynting energy flow input component.

Figure **8** shows that in the IR or UV, an optimized NRAM system has been shown capable of producing COP = 18. In our application, we have focused upon the heat or IR aspects. However, we are fully aware of the same extra input component for the UV aspects, and intend to address that frequency range either in the final formal patent application or in a separate patent application.

Figure **9** shows a preferred typical application of a single stage energy amplifying NRAM system to the boiler of an electrical power plant whose generators are powered by steam turbines in turn powered by steam from the boiler. This type of system may be utilized in the modified boiler of the standard hydrocarbon-burning power plant, the nuclear power plant, and the geological heat-powered plant. The application is non-optimized in that the heat furnished conventionally to the boiler is not sharply in one region of the IR. Hence instead of a gain of 18, a more reasonable gain of 4 to 8 is achievable. This will readily allow a COP improvement of the boiler itself in the vicinity of COP = 2.0 to 4.0. In turn, this will reduce the burning of the hydrocarbon for input heat, or the consuming of nuclear fuel rods for input heat, by from 50% to 75% since the boiler will require operator heat input of some 50% to 75% less that without the process.

Figure **10** shows a serial four stage diagram of an energy amplifier NRAM unit which would be capable of lowering fuel consumption, necessary to heat a boiler to the desired degree, by a factor of from 1/16.

Figure **11** shows a different and non-serial "multistaging" application with self-feedback, to a steam boiler in a power plant, where the NRAM self-oscillating charges are in several pipes internal to the fluid in the boiler. In this case, some nonlinear "staging" of the various pipes are evidenced between any pipe and all the rest of them. This type of installation can approach the lowering of the fuel consumption by the amount indicated in Figure **11** above. By regulating some cooling control of these pipes, self-powering can be achieved as shown in Figure **12**.

Figure **12** shows a self-powering NRAM unit. Once in operation, the heat from use of fuel can be eliminated by ceasing burning of the fuel, and the active energy flow environment furnishes all the required input heat energy. This is made possible by the receipt of appreciable extra input heat energy from the usually inert Heaviside energy flow component.

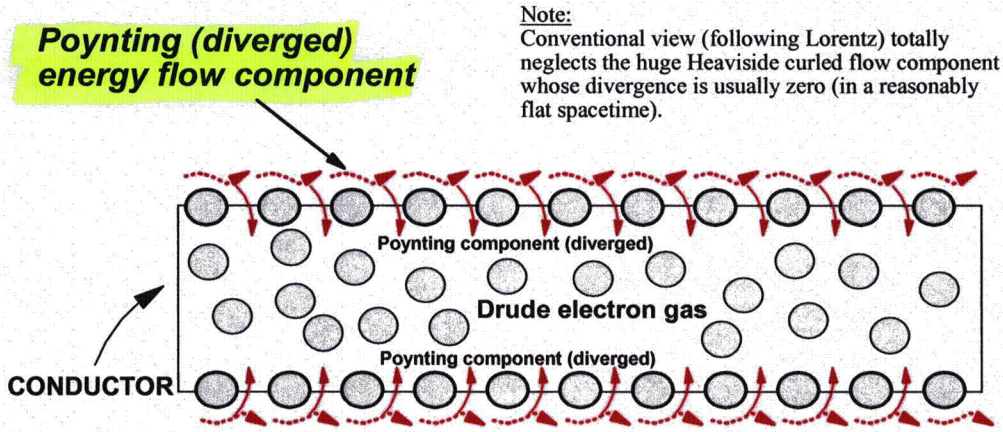


Figure 1. Conventional Poynting energy flow through space along the conductor, and its divergence into the conductor to potentialize the electrons. The remaining stupendous Heaviside energy flow component is arbitrarily discarded.

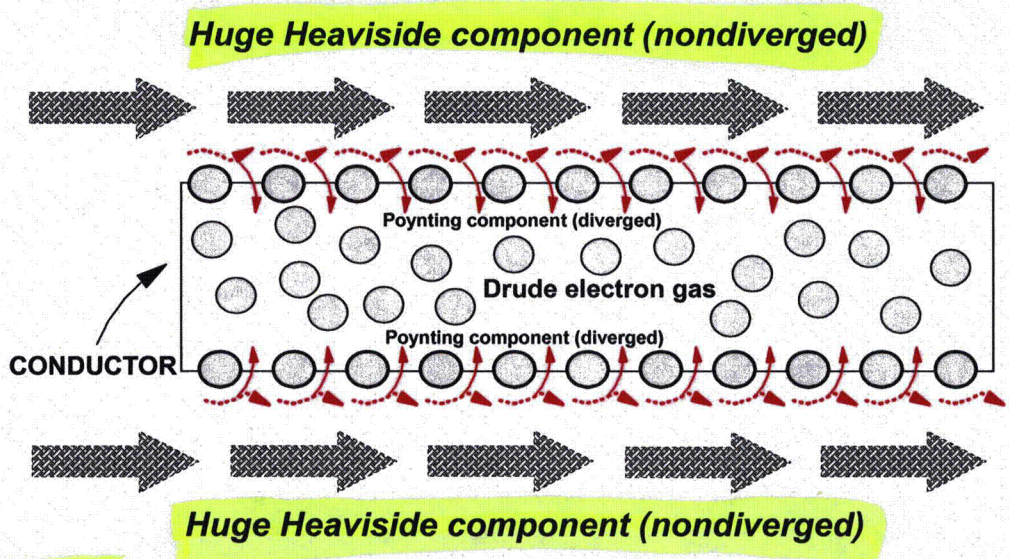


Figure 2. The curled Heaviside energy flow component compared to the accounted Poynting diverged component. With the charges not in self-oscillation, a flat spacetime situation roughly exists, and none of the Heaviside component is diverged to increase the Poynting diverged energy flow component.

30.

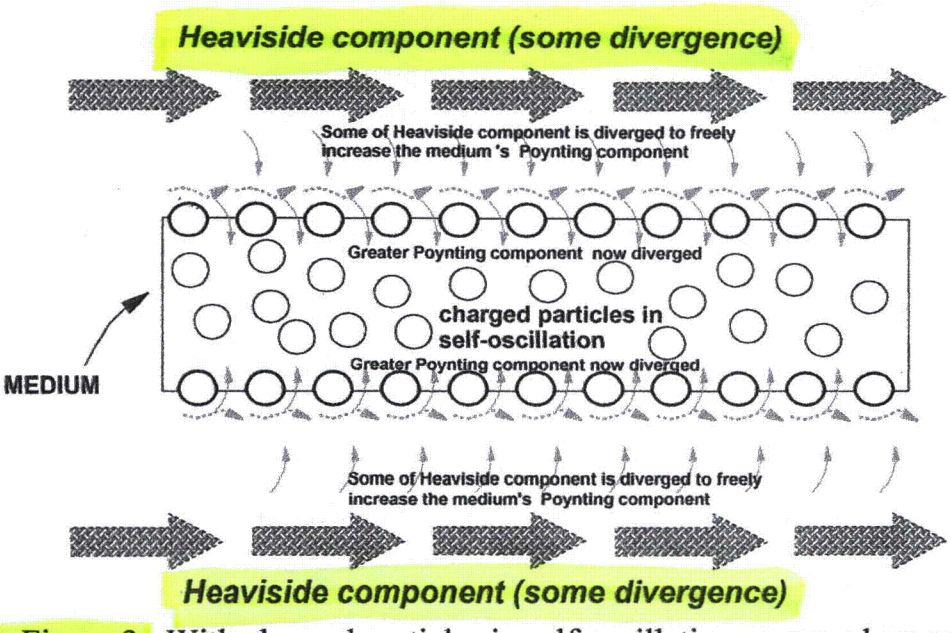


Figure 3. With charged particles in self-oscillation, a curved spacetime situation exists. The curled Heaviside energy flow component can and will have a diverged component that freely increases the diverged Poynting energy flow component. This freely inputs excess usable (Poynting) energy from the environment.

1

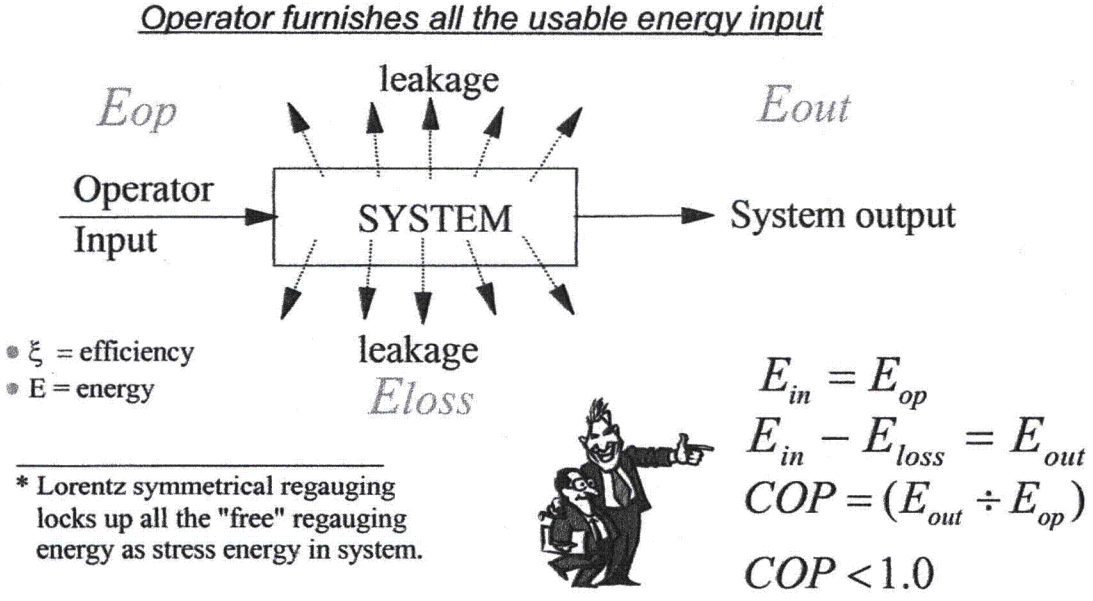


Figure 4. System with $\xi < 100\%$ and COP < 1.0. Operator furnishes all the input energy and the environment does not furnish any excess input energy at all.

31.

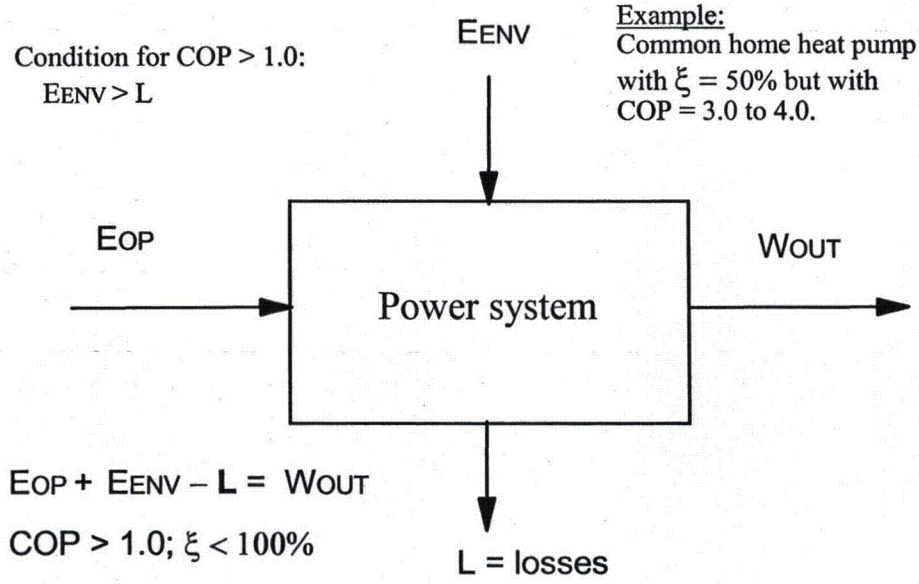


Figure 5. System with $\xi < 100\%$ and COP > 1.0. Operator furnishes some of the input energy and the environment furnishes the rest. If the environment furnishes more energy than the system losses, COP > 1.0 while $\xi < 100\%$.

1. Gabriel Kron, "Electric circuit models of the Schrödinger equation," *Phys. Rev.* 67(1-2), Jan. 1 and 15, 1945, p. 41.

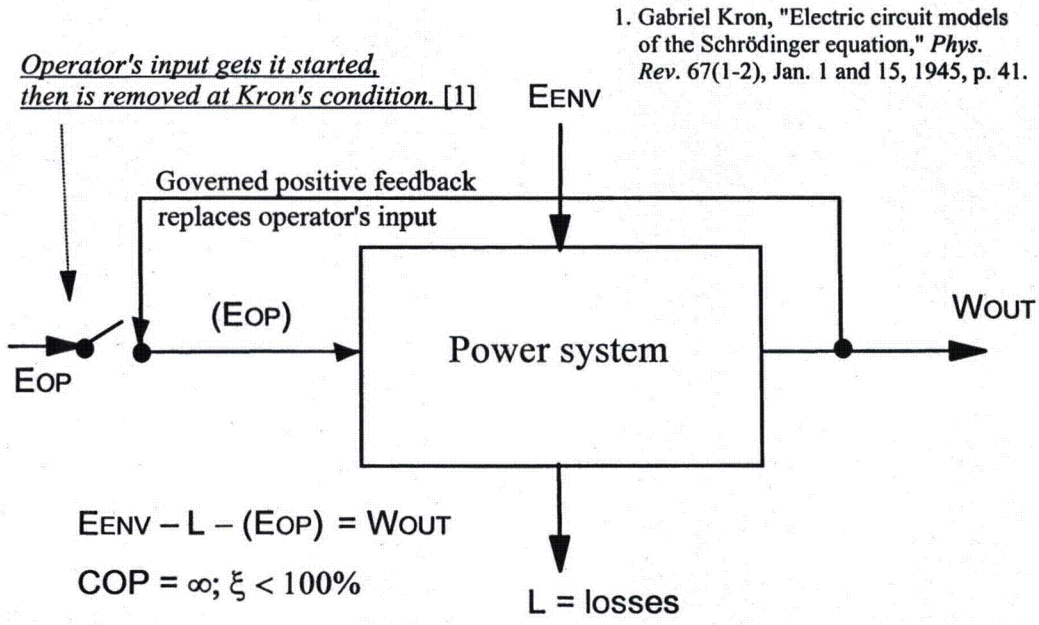
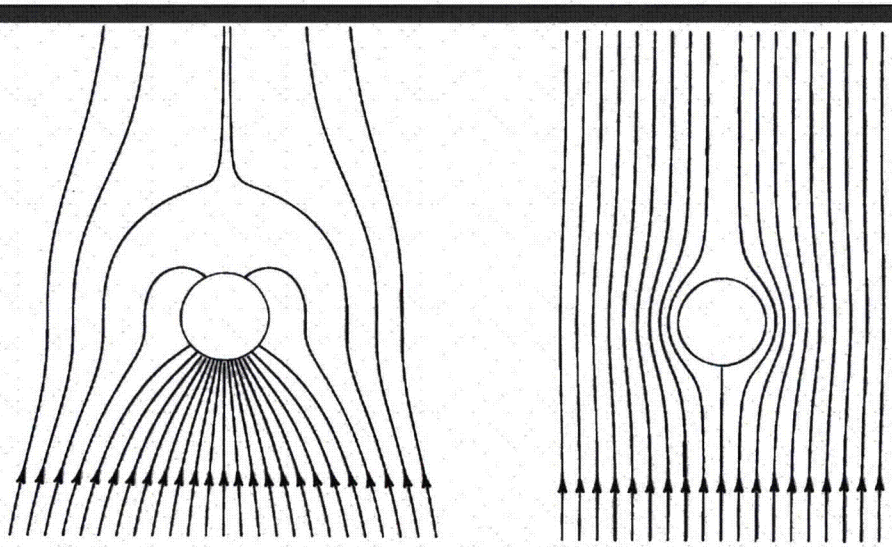


Figure 6. System with $\xi < 100\%$ and COP = ∞. Once system is running stably, operator input is disconnected and the environment furnishes all the input energy. In that case, COP = ∞, even though $\xi < 100\%$.

At or near resonance frequency, in the *conducting* charged particle case shown the energy collection fraction (reaction cross section) increases dramatically in the UV region to some 18 times the energy input in the normal Poynting energy flow alone. For a *dielectric* charged particle case, the energy collection fraction (reaction cross section) increases dramatically in the IR (heat) range.

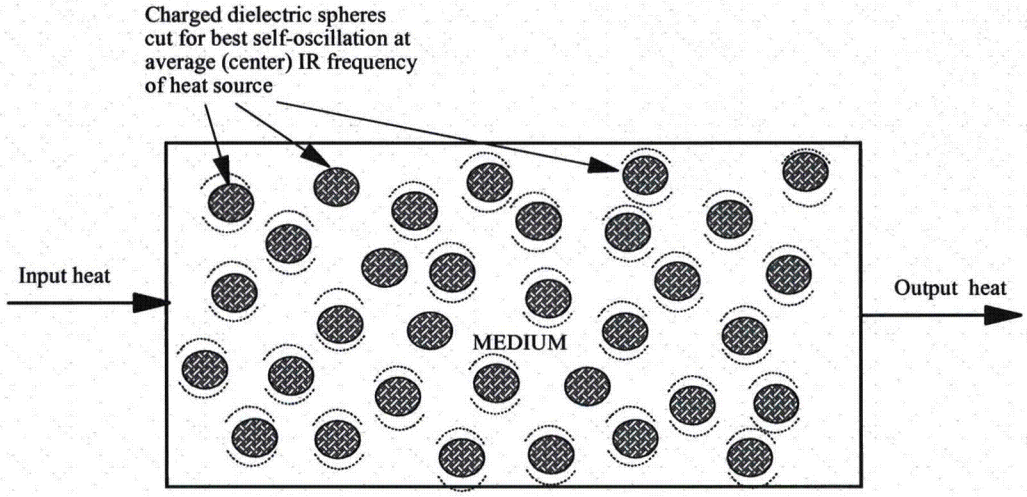


a. Around an aluminum sphere at light energy 8.8 eV. Absorption efficiency = 18.00.

b. Around an aluminum sphere at light energy 5eV. Absorption efficiency = 0.1.

These changes in reaction cross section are given by Craig F. Bohren, "How can a particle absorb more than the light incident upon it? ", American Journal of Physics, 51(4), Apr. 1983, p. 326.

Figure 7. Basic operation of the "negative resonance absorption of the medium" (NRAM) effect. At optimum, COP = 18 for infrared (heat) input energy and charged dielectric spheres.



Note: COP (practical application) may range between
COP = 3.0 and COP = 8.0.

Figure 8. System with IR heat input and IR heat output. Since the input is a band of frequencies in the IR and not a precisely tuned frequency, COP < 18 which is optimum. In practice, achieved COP may range from COP = 3.0 to COP = 8.0.

1

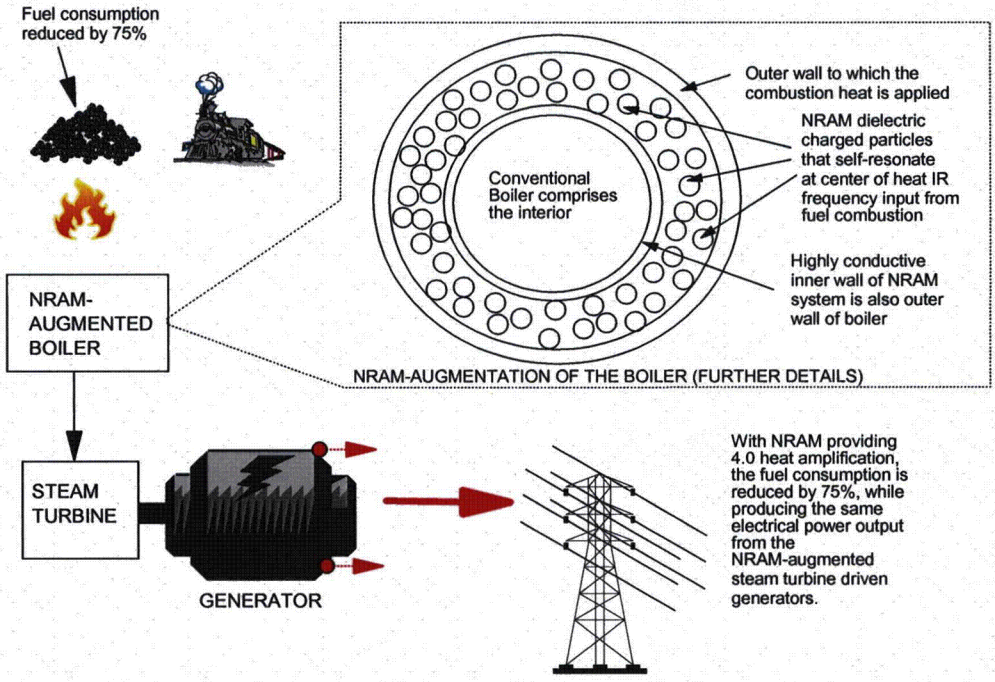


Figure 9. Typical application of a single stage of NRAM energy amplification to the boiler of an electrical power plant (nuclear, hydrocarbon-fueled, etc.) using steam-turbine-driven generators. Practical amplification example is 4.0.

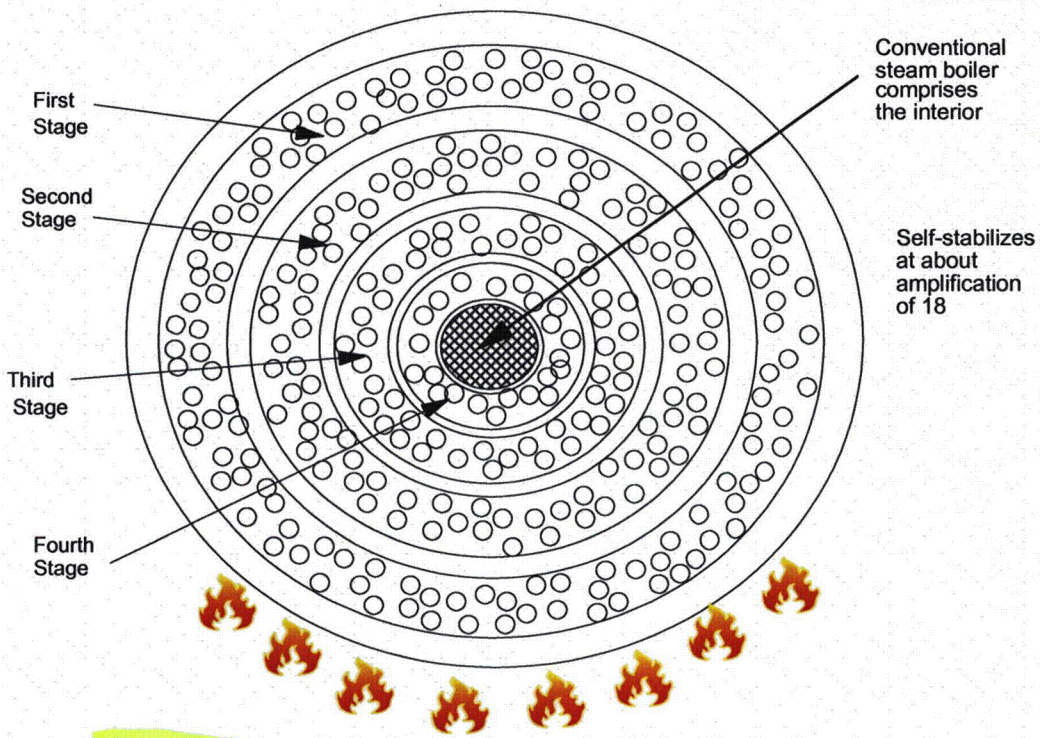


Figure 10. Four-stage NRAM energy amplification boiler. Practical amplification limit is 18.

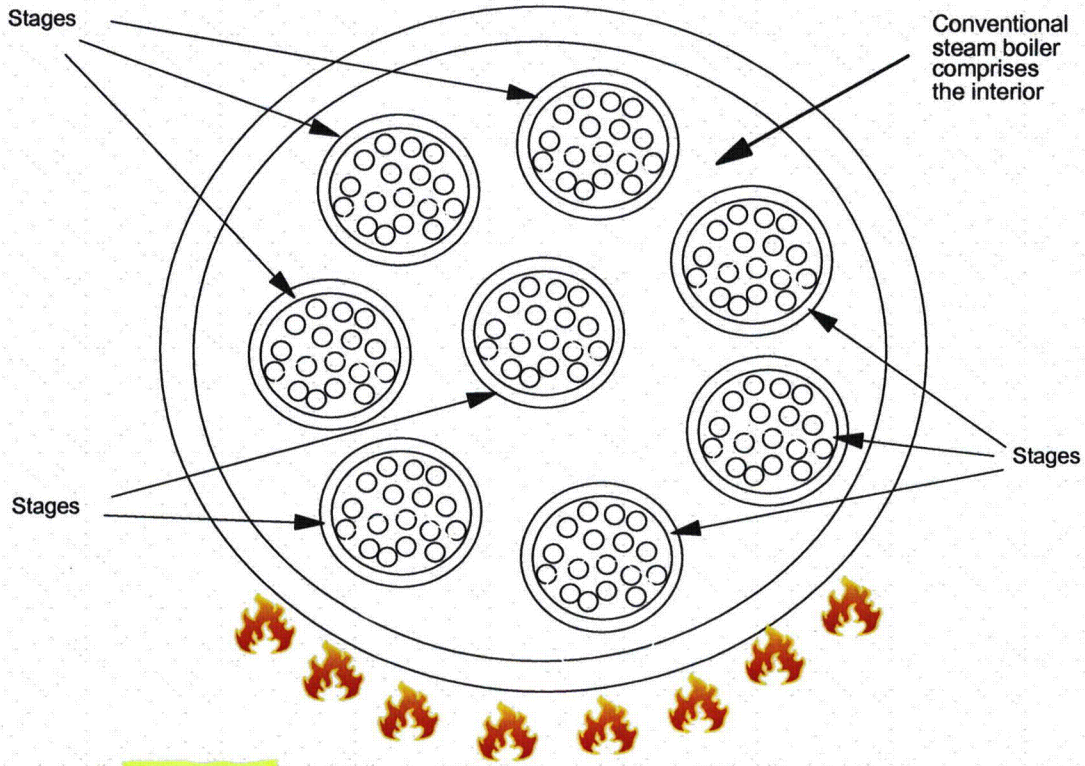


Figure 11. Multi-stage NRAM energy amplification boiler. Self-settles at about amplification = 18.

35.

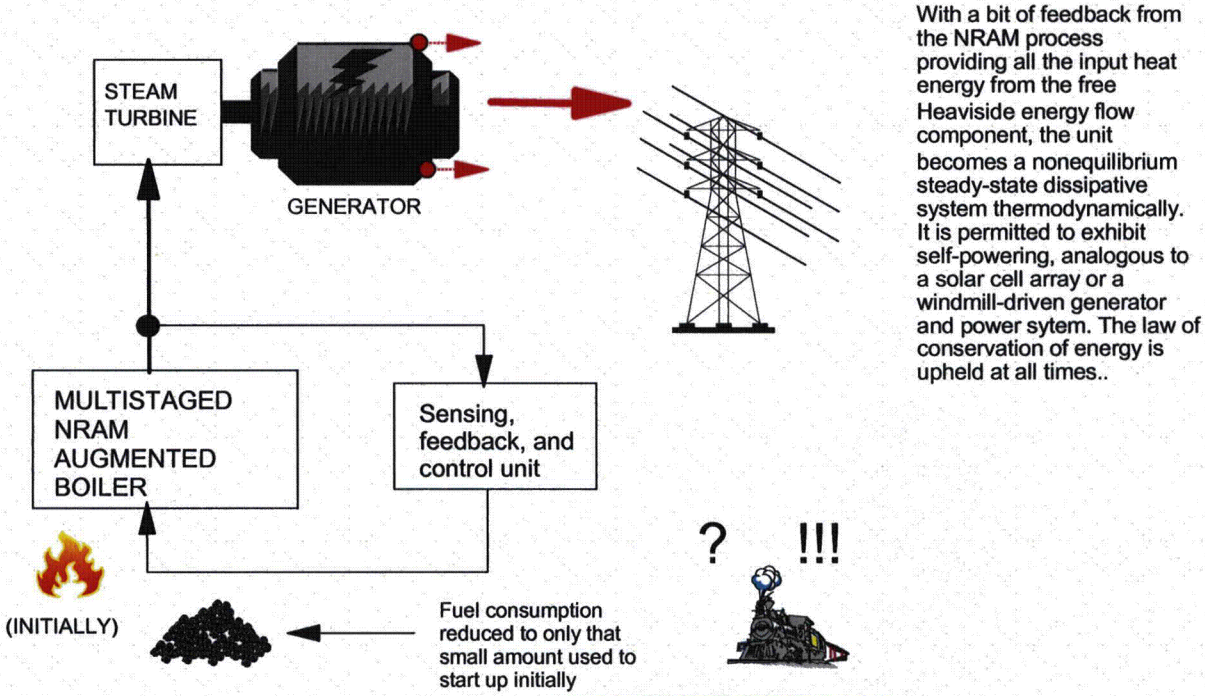


Figure 12. Self-powering NRAM electrical power system. Once heat feedback stabilizes, the fuel burning can cease altogether, and the system continues to operate and furnish full electric power.

1

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

BASIC OPERATION – [Figure 7]

The standard definition of an EM force field, and its energy and force, are based on the assumption of the interaction of force-free field in space with a *static* charged mass. The EM spatial field is naught but a condition of space (Feynman), and only by its interaction with charged matter are the EM force field and its energy produced in that interacting charged matter. And any EM field or potential decomposes into, and is, an ongoing set of longitudinal wave energy flows (Whittaker, 1903 and 1904). How much of the flowing energy comprising the interacting spatial field that is diverged around the intercepting charged mass, therefore depends on the reaction cross section of that charge.

It has been found (Letokhov, Bohren, Paul & Fischer) that inputting the spatial energy flow in the form of the wave-envelope having a frequency at which the intercepting charge is self-oscillating, produces a much larger reaction cross section and thus more Poynting energy flow is radiated from the self-oscillating charges in the absorbing medium than is input by the operator where his "input" has been specified in static-charge terms only.

Obviously, conservation of energy requires that more energy than that standard "static charge" input calculation must have been input to the collecting self-resonant charges.

Indeed, Poynting never considered anything except the energy flow component propagating through space along the conductors that gets diverged into the conductors. He also got the flow wrong by 90 degrees and was corrected by Heaviside.

Heaviside, however, discovered that there was an additional curled-form energy flow of much greater magnitude, present and ongoing through space outside and along a conductor, but usually not diverged into the conductor. So every EM circuit and system has always had much more available EM energy flow than the Poynting component input by the operator. That is because Lorentz arbitrarily discarded the Heaviside nondiverged energy flow component, and it has remained unaccounted till the present day.

The standard CEM/EE model also assumes a flat spacetime, which is not true when energy density changes in space. The self-oscillation of the intercepting charges do vary in speed to and fro as they move, and so they involve an oscillating curvature of spacetime. General relativity thus applies. Thus the self-oscillating charges involve an oscillating energy density in space, and so their reaction cross section to the incoming spatial EM field is altered rhythmically. Because of this spacetime curvature effect, the vector algebra of flat spacetime is inaccurate, and so the divergence of the curl need not be zero. This means that the self-resonant collecting charges couple to the frequency of the input EM spatial field envelope oscillations, and that physically increases the reaction cross section of the intercepting resonant charges. In that case, the charges absorb more energy from the same wave than they would do if static. In turn, these charges radiate a greater Poynting component of energy flow (the accounted energy flow) than is calculated as being input to them in static condition.

This area of physics is known as "negative resonance absorption of the medium" or NRAM for short. This term was originally chosen apparently to prevent having to clearly state it as "excess emission by the medium" (if static calculations are used).

The end result is that, in every EM circuit and system that is active and in which EM energy is flowing, there exists not only the presently taught Poynting energy flow component but also a very much larger but presently ignored Heaviside energy flow component. Since NRAM is a method of increasing the reaction cross section of a given charge, so that excess Poynting emission occurs, it follows that NRAM circuits and systems can be utilized to deliberately intercept, diverge, and utilize additional Poynting (diverged) energy from their long-neglected Heaviside energy flow components. And since the Heaviside component may be many orders of magnitude greater than the usual Poynting energy flow component, it means that a ubiquitous, free, usable, excess energy source of enormous magnitude and importance already exists in every EM circuit and system ever built and built today.

This invention is the first invention directly addressing this NRAM process, explaining its actual mechanism for increasing the collecting (absorption) reaction cross section, and then emitting much more EM energy than was furnished by the operator himself. The excess energy was of course input by the unaccounted Heaviside energy flow environment, since some of it has been made to diverge as an additional Poynting energy component.

Researchers in the NRAM field (Bohren, Letokhov, Paul and Fischer) have clearly shown that an optimum COP = 18 can be achieved. We may speak of that as a "gain" and compare the NRAM process to an energy-amplifying process. The energy amplification is of course an amplification of the energy input by the operator, and the necessary additional input energy for that gain is input freely by the external Heaviside energy flow environment. The NRAM process also is usually self-limiting to the gain of 18 value, since increasing the EM energy output changes the frequency of the wave away from its optimum value, thus lowering the gain and reducing the output energy.

In practical single-stage systems, the single stage gain may be limited to about 4 to 8, since one will usually use available heat as input energy and the heat input is not sharply optimized in a narrow IR band as are most NRAM experiments in optical physics. The gain can be increased closer to the maximum 18 by multi-staging, in series or in a conglomerated group stage interaction as shown in this invention.

With appreciable gains of from 3 to 18, it also follows that one has developed an asymmetrical Maxwellian system, of the type arbitrarily discarded by Lorentz when he symmetrized the equations just to make them simpler and easier to solve. Hence the operation of this asymmetrical NRAM power system is not describable or modelable by the standard symmetrized Maxwell-Heaviside-Lorentz equations and model used in electrical power engineering.

Consider Figure 9, which is a typical single stage NRAM application to the boiler of an existing electrical power plant. The boiler has been converted to an inner boiler ringed by an outer NRAM section. When the heat (from hydrocarbon combustion or nuclear fuel rod consumption) is input, now it is input to the NRAM outer shell. In turn, the NRAM particles go into self-oscillation (though imperfect because of the wider bandwidth of the IR input) and produce—say—4.0 amplification. This means that burning only 25% of the coal (as shown) or consuming only 25% of the nuclear fuel rods, will heat the internal water in the boiler to the same degree and amount as would be experienced in the full fuel consumption for a non-NRAM boiler. As a result, the amount of fuel burned or nuclear fuel rods consumed is dramatically

lowered (here, by 75%) whole producing the same amount of steam energy to the steam turbine driving the generator. Hence the generator produces its usual amount of electric power sent out along the attached external power transmission line to the distant loads.

Now consider Figure 10. Here multiple concentric NRAM rings are utilized for staging. This multistaged NRAM process will now produce greater amplification than 3.0, but is still rigorously limited to a gain of 18 or less.

Consider now Figure 11. Here a very special kind of multistaging is used, where we show a typical nine stages. The heat output of each of them is influenced by the output heat of all the rest, which affect and increase its input. This is a nonlinear staging, and so gains closer to the optimum 18 are realized. For a gain of 10, e.g., the consumption of hydrocarbon fuel or nuclear fuel rods may be decreased by 90%, while still furnishing the same amount and intensity of steam to the generators, and thus the same amount of electrical energy to the external transmission line and to the distant loads.

With such gains (well above 3.0), the system can be close-looped so that some of the excess energy being extracted from the Heaviside component flow in the environment can be used to replace the operator's heat input (for which he is burning the hydrocarbon fuel or consuming the nuclear fuel rods). With this application, once the system is up and running and in stable operation, and the operator's normal input being replaced by the input from the Heaviside energy flow component, the operator's input can be zeroed. In short, at that point the basic power plant can cease further consumption of hydrocarbon fuel or nuclear fuel rods, while continuing to power the external transmission grid and the distant loads in normal fashion. This "close-looped" or self-powering function is permitted to any nonequilibrium dissipative thermodynamic system that freely receives all the necessary input energy from its active, energetic external environment. In this case, some of the overall energy output by the NRAM process is diverted and fed back to the operator's input—or, for a boiler, to provide the outside heating to the boiler, and thereby replacing the normal nuclear fuel rod heating or hydrocarbon fuel heating input.

Such asymmetric systems were originally in the Maxwell-Heaviside equations, but were arbitrarily discarded since Lorentz arbitrarily symmetrized the equations and thereby arbitrarily discarded all asymmetric Maxwellian systems. So the system fits overall EM theory where such simplifying assumptions are not made, but it does not fit the current highly symmetrized electrical power engineering. Nonetheless, nature did not and does not discard such asymmetric Maxwell-Heaviside systems, even though our present electrical engineers and electrical power engineering science do continue to arbitrarily discard such systems. They are no more mysterious than a wind-powered electrical generator, where all the necessary input energy is freely received from the external environment. Or similarly, such systems are comparable to the solar-cell-array powered system, where again all the input energy is freely furnished by the sun.

SUMMARY, RAMIFICATIONS, AND SCOPE

There has been provided, in accordance with the invention, an energy-amplifying staged electrical power system capable of dramatically reducing or eliminating the burning of hydrocarbon fuels, consumption of nuclear fuel rods, etc. at normal electrical power plants already in existence by modifications primarily to the boiler and its input and control. The energy amplification by the NRAM process (which uses the mechanism of this invention, unknown to

present NRAM scientists and researchers) is already proven in modern physics since 1967 (e.g., Letohkov, Bohren), but the source of the excess energy input has not previously been understood. Specifically, the energy amplification occurs by use of extra Poynting diverged EM energy flow freely received from the always present but previously ignored Heaviside giant curled energy flow component, in a curved spacetime. Practical COP increases of the boiler process—and lowering of the fuel consumption to provide the same amount of heat energy—of from COP = 4.0 to COP = 18 can be achieved or expected. With staging, in many cases self-powering (i.e., COP = ∞) is achievable.

The process can be applied to a non-fuel electrical power process by having a much smaller power plant first produce a heat output, and then simply apply the amplifying process with that heat as the input to it. By adding feedback controls, the system then can be made self-powering, once in operation, and the "self-starting" can be by a much smaller "power plant" as the initiator. In this way the process can be used to greatly amplify the utility and usage of wind mill initiated electrical power systems, hydroelectric initiated electrical power systems, etc.

The process is adaptable to the great majority of commercial power plants throughout the world, and to many other processes including electrical automobiles and trucks, a new kind of jet engine that burns no hydrocarbons, etc. The process when applied will also dramatically reduce the energy-related pollution of the biosphere by energy-related chemical wastes and byproducts, and will reduce the biospheric interference and damage of windmill-powered electrical power systems, hydroelectric power plants, etc. It will allow augmentation and increased COP of solar cell array electrical power systems, while assuring their continued operation when solar radiation is lacking or deficient. It will allow eventual gradual replacement of the presently highly vulnerable centralized national electrical power system to a highly decentralized national electrical power system. It will rather quickly and dramatically reduce the grave dependence of any nation on oil, natural gas, nuclear fuel, winds, solar radiation, etc. It can be adapted also to battery-powered equipment and systems, and it can be adapted to electric cars and trucks, electric locomotives, etc.

The reader will see that, by ushering in the age of *asymmetrical* power systems freely receiving most or all of their input energy from the giant Heaviside energy flow component ubiquitously present in (and previously ignored) all EM circuits and systems, the energy problems of the world can be solved cleanly, quickly, and in straightforward manner.

The invention has the following typical advantages:

- The system has a high output power to weight ratio, which can be increased at will by addition of higher gain stages or more stages or both.
- The system can be made highly portable for mobile applications.
- The size and output of the system are scalable.
- The system is rugged and reliable for use in hostile environments where conventional generators would fail or be extremely difficult to sustain. It can easily be environmentally shielded.
- The system has very wide operating temperature ranges for use where conventional batteries and fuel cells cannot usually function. As an example, it can power a

resistance heater to keep its insulated batteries warm. It can also power electrostatic or magnetic cooling devices to keep the unit cool in higher temperature environments.

- The system has an extremely long life cycle and high reliability, allowing it to be placed where frequent maintenance is not possible.
- The system uses no fuel or fuel transport, packaging, storage, and disposal systems. The overhead and financial savings are significant.
- Use of these systems in a combined centralized and decentralized electrical power system provides survival of electric power and graceful degradation, rather than catastrophic collapse, of electrical power in the presence of damage and destruction.
- The system produces no harmful emission, harmful or radioactive byproducts, hazardous wastes, or biospheric pollutants. As its usage is phased in world wide, a significant reduction of environmental pollutants and hazardous wastes will result, as will a cleaner biosphere.
- The system can produce AC or DC power directly by simple electrical additions, and provide shaft power simultaneously.
- Coupled with driven electric motors, the system can provide attractive power system alternatives for automobiles, tractors, trucks, aircraft, boats, ships, submarines, trains, and other vehicles, again without exhaust emissions, pollutants or harmful waste products.

Although the description above contains many specificities, these should not be construed as limiting the scope of the invention but as merely providing illustrations of some of the presently envisioned preferred embodiments of this invention.

For example, the invention can be readily applied to steam ships.

As another example, the invention can be readily applied to submarines.

As another example, the invention can use a small amount of external power to produce some resistance heating, and then employ and amplify that resistance heating in a self-powering operation, disconnecting the input external power once the system is in full operation.

In ground combat forces, particularly those for fast moving situations, the burden of fuel logistics support can be materially decreased, if much of the mobile equipment incorporates the invention.

The adaptations and alterations of the embodiment are limited only by the ingenuity of the engineer and the particular needs of a given application. It is to be understood that all terms used herein are descriptive rather than limiting. Although the invention has been specifically described with regard to the specific embodiments set forth herein, many alternative embodiments, modifications and variations will be apparent to those skilled in the art in light of the disclosure set forth herein. Accordingly, it is intended to include all such alternatives, embodiments, modifications, and variations that fall within the spirit and scope of the invention as set forth in the claims herein below.

NOTE REGARDING CLAIMS

The claims for the final Patent Application will be formally and legally prepared by a skilled patent attorney so as to accurately describe the claims for this invention. In this

Provisional Patent Application write-up we have included the features that will produce the *major elements* of the claims as we best understand them without recourse to attorney. In addition, as is customary practice, in the final Patent Application submission we will request that the Patent Examiner point out any resulting claims we may have inadvertently missed, and that he point out any relevant changes that should be made to clarify the submitted claims, and that he point out any unintended duplication of claims should such inadvertently occur.]

How can a particle absorb more than the light incident on it?

Craig F. Bohren
Department of Meteorology, Pennsylvania State University, University Park, Pennsylvania 16802

(Received 11 February 1982; accepted for publication 26 April 1982)

A particle can indeed absorb more than the light incident on it. Metallic particles at ultraviolet frequencies are one class of such particles and insulating particles at infrared frequencies are another. In the former strong absorption is associated with excitation of surface plasmons; in the latter it is associated with excitation of surface phonons. In both instances the target area a particle presents to incident light can be much greater than its geometrical cross-sectional area. This is strikingly evident from the field lines of the Poynting vector in the vicinity of a small sphere illuminated by a plane wave.

I. INTRODUCTION

Several years ago a friend of mine was on the last leg of a long journey to a conference nearly halfway across the world from his home. Exhausted, disoriented, lost in thought, his reverie was suddenly and unexpectedly interrupted by a fellow conferee in the adjacent seat, who turned to him and asked anxiously: "How can a particle absorb more than the light incident on it?"

To those who first encountered in neutron physics the concept of the area that a target presents to a projectile (i.e., its cross section), it comes as no surprise that targets can sometimes extend beyond their strict geometrical boundaries, even greatly so. Indeed, the very unit for neutron cross sections, the barn, encourages one to think big. But photons are supposed to behave more soberly than neutrons; every physics student knows that photons travel through free space mostly in straight lines, although they do sometimes exhibit a bit of waywardness in the vicinity of edges. Notions about what photons can and cannot do are formed in traditional optics courses, which emphasize visible light interacting with large bodies, usually transparent. With time these notions become deep-seated prejudices and are often difficult to dislodge. Yet it is incontrovertible that there are many circumstances, by no means exotic, under which small particles (smaller than the wavelength) can absorb more than the light incident on them. My first task in this paper is to examine some of these circumstances. Then I shall give a pictorial representation of absorption of light by a particle in a way which, to the best of my knowledge, has not been done before.

II. PLASMONS AND PHONONS IN SMALL CRYSTALS

A. Bulk plasmons

Let us take as a simple model of a metal a gas of free electrons moving against a fixed background of immobile positive ions. The number density $\mathcal{N}$ of positive ions is therefore constant in space and time; in equilibrium the density of electrons is also $\mathcal{N}$. But if the electrons are somehow disturbed slightly from equilibrium the nonuniform charge distribution will set up an electric field which will tend to restore charge neutrality. The electrons, having acquired momentum from the field, will overshoot the equilibrium configuration: there will be an oscillation. This collective oscillation of the electron gas is called a plasma oscillation; its frequency, the plasma frequency ω_p is given by

$$\omega_p^2 = \mathcal{N}e^2/m\epsilon_0, \tag{1}$$

where e and m are the electronic charge and mass, and ϵ_0 is the permittivity of free space.

A plasma oscillation is longitudinal and originates from long-range correlations of the electrons caused by Coulomb forces. Such plasma oscillations in gaseous discharges were investigated theoretically and experimentally by Tonks and Langmuir.[1] Further refinements to the classical theory were added by Bohm and Gross[2]; this in turn led to a series of papers on the quantum theory of plasma oscillations by Bohm and Pines.[3]

The frequency of longitudinal oscillation in a medium emerges from examination of the equations of the electromagnetic field; we need only the first of them [assuming harmonic time dependence $\exp(-i\omega t)$]:

$$\epsilon(\omega)\nabla\cdot\mathbf{E}(\omega) = 0,$$

where $\mathbf{E}$ is the electric field and the dielectric function[4] $\epsilon(\omega) = \epsilon'(\omega) + i\epsilon''(\omega)$ is the permittivity of the medium relative to that of free space.

There are two cases to be considered. At frequencies where ϵ does not vanish the divergence of the electric field must; in this instance the field is transverse. But at frequencies where $\epsilon = 0$ the divergence of $\mathbf{E}$ need not vanish; such a field is longitudinal. The frequencies at which the medium can support longitudinal oscillations are therefore the roots of

$$\epsilon(\omega) = 0.$$

The dielectric function of a simple free-electron metal is given by the Drude formula

$$\epsilon(\omega) = 1 - \omega_p^2/(\omega^2 + i\gamma\omega), \tag{2}$$

where ω_p is as in (1) and γ is a damping coefficient. The frequency $\omega \simeq \omega_p - i\gamma/2$ (assuming $\omega_p \gg \gamma$) at which ϵ in (2) is zero is therefore complex; this just means that the plasma oscillation is damped.

In quantum-mechanical language excitation of a plasma oscillation is referred to as creation (or excitation) of a *plasmon*, the quantum of plasma oscillation, with energy $\hbar\omega_p$ and lifetime $\tau = 2/\gamma$. For a plasmon to be a well-defined entity it must be sufficiently long lived ($\omega_p\tau \gg 1$).

Up to this point I have tacitly assumed that the plasma is unbounded; that is to say, I have had in mind *bulk plasmons*. Because of the long-range nature of the organizing forces in a plasma oscillation, however, it is reasonable to

43.

expect that for a sufficiently small system the electrons will sense the presence of the boundaries and modify their collective behavior accordingly. Indeed, following hard on the heels of the acceptance of bulk plasmons in metals came the realization that *surface plasmons* were possible in thin films.[5] Whereas the energy of a bulk plasmon is $\hbar\omega_p$, that of a surface plasmon in a thin film (in air) is $\hbar\omega_p/\sqrt{2}$. The next member in this family of plasmons is the surface plasmon in a sphere. The easiest route to its energy is classical; this route is followed below.

B. Surface plasmons

Suppose that a spherical particle of radius a is illuminated by a plane monochromatic wave with irradiance[6] I_i. The rates at which energy is absorbed by the particle and scattered in all directions are products of the irradiance and the cross sections—so named because they have the dimensions of area—for absorption and scattering:

$$W_{abs} = I_i C_{abs}, \quad W_{sca} = I_i C_{sca}.$$

It is customary, but by no means necessary, to normalize these cross-sectional areas:

$$Q_{abs} = C_{abs}/\pi a^2, \quad Q_{sca} = C_{sca}/\pi a^2. \tag{3}$$

The resulting dimensionless quantities are referred to as *efficiencies* (or efficiency factors) for absorption and scattering. This term is poorly chosen: the efficiencies in (3) are not bounded by unity, as the word efficiency implies. Normalized cross section would be a better term.

If the particle is sufficiently small compared with the wavelength then the approximate expressions for the absorption and scattering efficiencies are[7]

$$\left.\begin{aligned} Q_{abs} &\simeq 4x\,\mathrm{Im}\left(\frac{\epsilon-1}{\epsilon+2}\right) \\ Q_{sca} &\simeq \frac{8}{3}x^4\left|\frac{\epsilon-1}{\epsilon+2}\right|^2 \end{aligned}\right\} \begin{array}{l} x \ll 1 \\ |\sqrt{\epsilon}|x \ll 1, \end{array} \tag{4}$$

where the *size parameter* x is the particle's circumference divided by the wavelength ($2\pi a/\lambda$).

The conventional wisdom has it that because the size parameter is small, then small particles are "inefficient" absorbers and scatterers of light: an inappropriate noun spawns an even more inappropriate adjective. Let us leave aside the fact that because the term "efficiency" is really quite meaningless it is also meaningless to describe small particles as inefficient. In (4) there are expressions involving ϵ, often overlooked because they are small—sometimes. But it is difficult to stare at these expressions for long without an itch to set their denominators equal to zero and to ask: Are there any materials with the property that $\epsilon = -2$ at some frequency? For if there are, then such materials when fashioned into very small spheres will be strong absorbers and scatterers of light of this frequency. The answer to this question is that there are many such materials: free-electron metals, for example. The frequency at which the Drude dielectric function (2) is -2 is complex; but if $\gamma \ll \omega_p$, then the real part is approximately $\omega_p/\sqrt{3}$, which is sometimes denoted as the *Fröhlich frequency* ω_F.

We may interpret this as follows. In an unbounded metal the frequency of collective oscillation of the electrons is ω_p, the plasma frequency. But when the electrons are confined to a small sphere the frequency of collective oscillation shifts to a lower value because of the presence of the boundaries. In the language of elementary excitations there is a bulk plasmon with energy $\hbar\omega_p$ in an unbounded metal and a surface plasmon with energy $\hbar\omega_F$ in a small metallic sphere.

Absorption at the Fröhlich frequency is not infinite, but it can be quite large depending on the value of ϵ'', the imaginary, or absorptive, part of the dielectric function. This dependence, however, is contrary to what one might expect: absorption is *inversely* proportional to ϵ'' at the frequency where ϵ' is approximately -2. That is, it follows from (4) that

$$Q_{abs}(\omega_F) = 12x/\epsilon''(\omega_F). \tag{5}$$

Note that, although x is small, Q_{abs} may be large because ϵ'' may also be small.

Up to this point I have tacitly assumed that the particles are in air. If they are not, as in many laboratory investigations, then the effect of a surrounding nonvacuous medium is to shift the Fröhlich frequency to lower values. This shift can be appreciable, so it is well to be cognizant of it.

It is reasonable to expect that if the frequency of collective oscillation of electrons changes in going from an infinite to a finite medium, then this frequency will depend on the shape of the medium as well. This is indeed true, but to discuss shape effects would lead us too far afield.

C. Surface phonons

Consider now collective oscillations of lattice ions in, say, an ionic solid like NaCl, which when quantized are called phonons. If the frequency of collective oscillation of electrons depends on the size and shape of their container then so does that of collective lattice oscillations. That is, if there are surface plasmons then there may be *surface phonons* as well. An excellent review of phonons in small crystals has been given by Ruppin and Englman.[8]

The starting point for a discussion of surface phonons is the Lorentz dielectric function for a system of identical oscillators

$$\epsilon(\omega) = \epsilon_\infty + \frac{\omega_p^2}{\omega_t^2 - \omega^2 - i\gamma\omega}. \tag{6}$$

Because the mass of an ion is so much greater than that of an electron the frequency ω_p in (6) is much lower—in the infrared—than plasma frequencies for metals, which are usually in the ultraviolet. The *transverse optical mode frequency* ω_t is the frequency at which ϵ'' is a maximum (approximately). Another frequency of importance is the *longitudinal optical mode frequency* ω_l, given by

$$\omega_l^2/\omega_t^2 = \epsilon_0/\epsilon_\infty,$$

where ϵ_0 and ϵ_∞ are low-frequency and high-frequency limits of (6); ω_l is the frequency at which ϵ is zero (approximately), hence the designation longitudinal.

For materials described to good approximation by (6)—alkali halides at infrared frequencies, for example—the Fröhlich frequency lies between ω_t and ω_l:

$$\omega_F^2 = \omega_t^2\left(\frac{\epsilon_0+2}{\epsilon_\infty+2}\right).$$

On the basis of the results of the previous paragraphs there are two classes of small particles which, at some frequencies, are expected to appear larger to an incoming beam than their geometrical cross sections: metallic parti-

44.

cles at ultraviolet frequencies and insulating particles at infrared frequencies. It is easy enough to compute absorption efficiencies for small spheres and note that, yes indeed, they can be greater than unity. But it seems more physically satisfying and visually appealing—as well as pedagogically more effective—to examine how the Poynting vector behaves in the vicinity of a small sphere, both at and away from the Fröhlich frequency; this is done in Sec. III.

III. FIELD LINES OF THE POYNTING VECTOR

A. Derivation of the basic equation

The magnitude and direction of energy flow in an electromagnetic field is specified by the Poynting vector. In the region outside a sphere illuminated by a plane harmonic wave the electric (magnetic) field is the sum of the incident field $\mathbf{E}_i$ ($\mathbf{H}_i$) and the scattered field $\mathbf{E}_s$ ($\mathbf{H}_s$). The total Poynting vector $\mathbf{S}$ (time-averaged) in this region may therefore be written as

$$\mathbf{S} = \mathbf{S}_i + \mathbf{S}_s + \mathbf{S}_{ext},$$

where

$$\mathbf{S}_i = \tfrac{1}{2}\,\mathrm{Re}(\mathbf{E}_i \times \mathbf{H}_i^*),$$

$$\mathbf{S}_s = \tfrac{1}{2}\,\mathrm{Re}(\mathbf{E}_s \times \mathbf{H}_s^*),$$

$$\mathbf{S}_{ext} = \tfrac{1}{2}\,\mathrm{Re}(\mathbf{E}_i \times \mathbf{H}_s^* + \mathbf{E}_s \times \mathbf{H}_i^*).$$

We may interpret $\mathbf{S}_{ext}$ as the term which arises because of interaction between the incident and scattered fields; the subscript ext indicates that the integral of $\mathbf{S}_{ext}$ over a surface surrounding the particle is, for unit incident irradiance, the extinction cross section—the sum of the absorption and scattering cross sections. $\mathbf{S}_s$ is associated solely with the scattered field. Of greater interest here, however, is the flow of electromagnetic energy exclusive of that scattered. Thus the Poynting vector under consideration (normalized by I_i, the magnitude of $\mathbf{S}_i$) is

$$\mathbf{A} = (\mathbf{S}_i + \mathbf{S}_{ext})/I_i.$$

Were it not for the particle, of course, $\mathbf{A}$ would just be a unit vector parallel to the direction of propagation of the incident wave, and the field lines would be parallel lines. At sufficiently large distances from the sphere the field lines are nearly parallel, but close to the sphere they are distorted. It is the nature of this distortion, and its relation to the properties of the sphere at the frequency of the incident wave, that I wish to investigate.

If the incident electric field is polarized along the x axis and propagating in the $+z$ direction, then the electric and magnetic fields [omitting the time-harmonic factor $\exp(-i\omega t)$] are

$$\mathbf{E}_i = E_0 e^{ikz}\hat{\mathbf{e}}_x, \quad \mathbf{H}_i = (k/\omega\mu)E_0 e^{ikz}\hat{\mathbf{e}}_y,$$

where $k = 2\pi/\lambda$ and μ is the permeability of the medium surrounding the particle (assumed to be free space). The field scattered by a sphere of arbitrary radius is an infinite series in vector spherical harmonics[9,10]

$$\mathbf{E}_s = \sum E_n(ia_n\mathbf{N}_{e1n}^{(3)} - b_n\mathbf{M}_{o1n}^{(3)}),$$

$$\mathbf{H}_s = \frac{k}{\omega\mu}\sum E_n(ib_n\mathbf{N}_{o1n}^{(3)} + a_n\mathbf{M}_{e1n}^{(3)}), \tag{7}$$

$$E_n = i^n E_0(2n+1)/n(n+1),$$

where the *scattering coefficients* a_n and b_n are complicated functions of the radius and optical properties of the sphere.[11] Vector spherical harmonics are generated by solutions ψ of the scalar wave equation in spherical polar coordinates r, θ, ϕ:

$$\mathbf{M} = \nabla\times(\mathbf{r}\psi), \quad \mathbf{N} = \nabla\times\mathbf{M}/k,$$

where $\mathbf{r}$ is the radius vector. The generating functions for the vector harmonics in (7) are[12]

$$\psi_{e1n} = \cos\phi\, P_n^1(\cos\theta)h_n^{(1)}(kr),$$

$$\psi_{o1n} = \sin\phi\, P_n^1(\cos\theta)h_n^{(1)}(kr),$$

where P_n^1 is an associated Legendre function of the first kind and $h_n^{(1)}$ is a spherical Hankel function.

If the sphere is sufficiently small compared with the wavelength of the incident light then a_1 is the dominant coefficient, and in this instance

$$\mathbf{E}_s \simeq -\tfrac{1}{2}a_1 E_0\mathbf{N}_{e11}^{(3)}, \quad \mathbf{H}_s \simeq \frac{3i}{2k\omega\mu}a_1 E_0\mathbf{M}_{e11}^{(3)},$$

$$a_1 \simeq \frac{-i2x^3}{3}\frac{\epsilon-1}{\epsilon+2}.$$

The ϕ component of $\mathbf{A}$ is zero in the xz plane ($\phi = 0$). In this plane, therefore, the field lines are solutions to the differential equation

$$dr/d\theta = rA_r/A_\theta. \tag{8}$$

All the ingredients are at hand for writing (8) in explicit form, a laborious task the details of which are best omitted; the result is

$$\begin{aligned} d\rho/d\theta = -\rho\cos\theta/\sin\theta\,\{\,&\rho^3 + [(x^2\rho^2\cos\theta \\ &+ x^2\rho^2 - 1)(K_r\cos\xi + K_i\sin\xi) \\ &+ (x\rho\cos\theta + x\rho)(K_r\sin\xi - K_i\cos\xi)]\,\}/\{\,\rho^3 \\ &+ [(x^2\rho^2\cos\theta + 2)(K_r\cos\xi + K_i\sin\xi) \\ &+ (x\rho\cos\theta - 2x\rho)(K_r\sin\xi - K_i\cos\xi)]\,\}, \end{aligned} \tag{9}$$

where $K = K_r + iK_i = (\epsilon-1)/(\epsilon+2)$, $\xi = x\rho(\cos\theta - 1)$, and $\rho = r/a$. Subject to restrictions on the size of the particle, (9) is completely general: it gives the field lines of the Poynting vector right up to the boundary of the sphere.

Equation (9) was solved numerically with a fourth-order Runge–Kutta scheme. It was usually more convenient to recast (9) as a differential equation in the rectangular Cartesian coordinates; sometimes, however, the advantage was tipped in favor of the polar coordinates. The results given in the following section were obtained with a mixture of the two approaches.

B. Field lines

To good approximation, particularly in the far ultraviolet, the dielectric function of aluminum is given by the Drude formula (2). At a photon energy of about 8.8 eV—the surface plasmon energy—the real part of the dielectric function of aluminum[13] is -2; the corresponding imaginary part is about 0.2. It follows from (4) or (5), therefore, that the absorption efficiency of a small aluminum sphere (in air) with size parameter 0.3 is about 18: such a sphere presents to incident photons a target area 18 times greater than its geometrical cross-sectional area. This conclusion follows from a simple back-of-the-envelope calculation. More palpable evidence of the sphere's great size in this instance is provided by Fig. 1, which shows the field lines of the Poynting vector in the surrounding region. Note the strong convergence of field lines near the sphere; light that, from the point of view of ray optics, would have passed the

45.

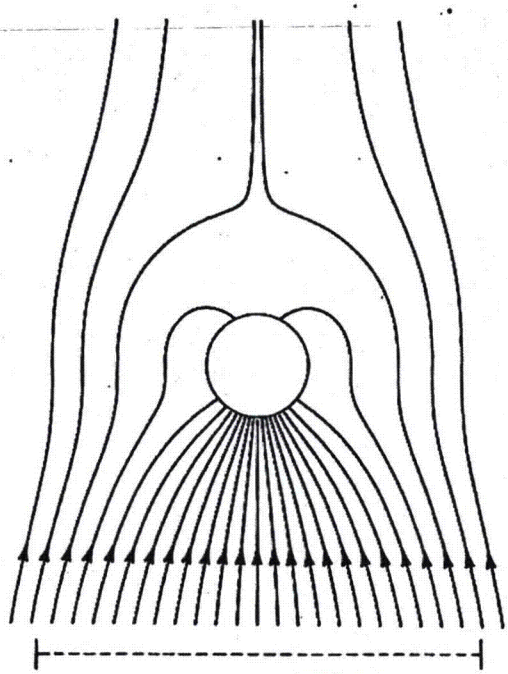


Fig. 1. Field lines of the total Poynting vector (excluding that scattered) around a small aluminum sphere illuminated by light of energy 8.8 eV. The dashed vertical line indicates the effective size of the sphere for absorption of incident light.

sphere without impediment, is deflected toward it.

An absorption cross section 18 times greater than the geometrical cross section implies that the absorption radius—to coin a term—is about 4.2 times greater than the geometrical radius. This follows from the analytical expression (5), but it should also emerge from purely geometrical reasoning. And indeed it does: note in Fig. 1 that those field lines extending to about 3.9 times the particle radius converge onto the particle.

At other frequencies, on either side of 8.8 eV, a small aluminum sphere presents a much smaller target to incident photons. At 5 eV, for example, the absorption efficiency of a sphere with $x = 0.3$ is about 0.1; as far as absorption is concerned, the sphere is much smaller than its geometrical cross-sectional area. The field lines of the Poynting vector, shown in Fig. 2, are what are to be expected for such a small target; a few lines intersect the sphere, but most are deflected around it.

Silicon carbide is an insulating solid the infrared dielectric function of which is well approximated by the Lorentz formula (6).[14] The Fröhlich frequency ($1/\lambda_F$) for SiC is about 932 cm^{-1} and its dielectric function at this frequency is quite close to that of aluminum at 8.8 eV. So Fig. 1 also shows the field lines of the Poynting vector around a small SiC sphere illuminated by light at the Fröhlich frequency. On either side of this frequency, however, the sphere is much less absorbing; at 900 cm^{-1}, for example, where the dielectric function of SiC is about $-4.8 + 0.3i$, the absorption efficiency (for $x = 0.3$) is about 0.13; in this instance the field lines are quite similar to those shown in Fig. 2 for aluminum at 5 eV.

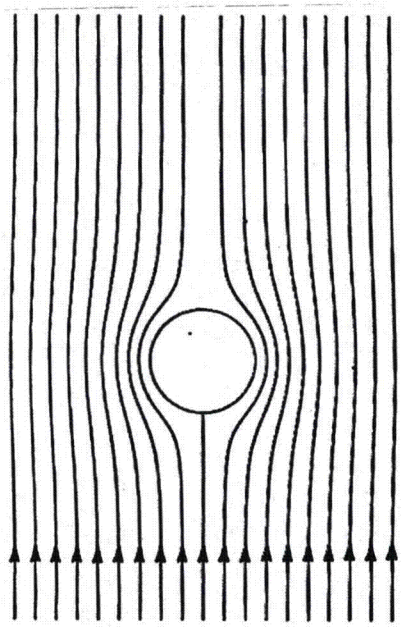


Fig. 2. Field lines of the total Poynting vector (excluding that scattered) around a small aluminum sphere illuminated by light of energy 5 eV.

IV. CONCLUDING REMARKS

No textbook on electromagnetic theory would be complete without a figure showing the field lines around a sphere in an electrostatic field. The reason, of course, is that this is a very effective way of presenting an idea—the sphere distorts the otherwise uniform field—in such a way that it can be grasped at a glance. But a small sphere illuminated by a plane wave also disturbs the flow of electromagnetic energy in its neighborhood. To the best of my knowledge, a graphic illustration of this has never been given. Yet the field lines of the Poynting vector (exclusive of the scattered Poynting vector) around the sphere help to elucidate how a particle can absorb more than the light incident on it.

ACKNOWLEDGMENTS

Scientific work hardly seems worth the effort unless at least one other person responds to it. I am grateful in this instance for the enthusiastic endorsement of my colleagues Sean Twomey, Alistair Fraser, Donald Huffman, John Olivero, and Timothy Nevitt, without which I would not have undertaken this work in good spirits. I also thank Peter Shaw for discussing some of the ideas in this paper with me.

[1] L. Tonks and I. Langmuir, Phys. Rev. 33, 195 (1929).

[2] D. Bohm and E. P. Gross, Phys. Rev. 75, 1851 (1949); D. Bohm and E. P. Gross, Phys. Rev. 75, 1864 (1949).

[3] D. Bohm and D. Pines, Phys. Rev. 82, 625 (1951); D. Pines and D. Bohm, Phys. Rev. 85, 338 (1952); D. Bohm and D. Pines, Phys. Rev. 92, 609 (1953).

[4] Dielectric constant is more commonly used, but dielectric function avoids tautologies such as "we measured the dielectric constant and found it to be constant." The term dielectric function also explicitly recognizes that it depends on frequency and is not constant.

[5] R. H. Ritchie, Phys. Rev. 106, 874 (1957); E. A. Stern and R. A. Ferrell.

46.

Phys. Rev. 120, 130 (1960).
[6]The term irradiance for the magnitude of the Poynting vector is gradually replacing the perhaps more familiar term intensity.
[7]H. C. van de Hulst, *Light Scattering by Small Particles* (Wiley, New York, 1957), p. 70.
[8]R. Ruppin and R. Englman, Rep. Prog. Phys. 33, 149 (1970).
[9]J. A. Stratton, *Electromagnetic Theory* (McGraw-Hill, New York, 1941), pp. 563–573.
[10]The scattering coefficients (a_n, b_n) are denoted by $(-b'_n, -a'_n)$ in Ref. 9. The former notation is common in more modern papers and books on light scattering theory, Ref. 7, for example.
[11]Reference 9, p. 565. Also Ref. 7, p. 123.
[12]Reference 7, Chap. 7.
[13]H. -J. Hagemann, W. Gudat, and C. Kunz, J. Opt. Soc. Am. 65, 742 (1975).
[14]W. G. Spitzer, D. Kleinman, and D. Walsh, Phys. Rev. 113, 127 (1959).

Comment on "How can a particle absorb more than the light incident on it?"

H. Paul and R. Fischer
Zentralinstitut für Optik und Spektroskopie, Akademie der Wissenschaften der DDR, DDR-1199 Berlin, Rudower Chaussee 6, German Democratic Republic

(Received 28 October 1982; accepted for publication 16 November 1982)

Independently of the work by C. F. Bohren,[1] we investigated the same problem,[2] however, on the atomic scale. Specifically, we considered the following physical picture: In the presence of an intense (plane-wave-type) coherent resonant monochromatic electromagnetic field, an atom, being initially nonexcited, acquires an electric dipole moment—in the sense of the quantum-mechanical expectation value. This dipole moment, oscillating at the frequency of the incident field, according to classical electrodynamics emits a wave which interferes with the incoming wave.

We found that the energy flux lines in the superposition field are bent, in a rather large neighborhood of the atom, in such a way as to direct energy into the atom. In fact, the corresponding curves in the x, z plane are very similar to those presented by Bohren.

In contrast to his paper, we had to deal with a transient phenomenon—the absorption process being finished when the atom has taken up the energy of a single photon. Physically, the essential difference between our results and that of Bohren is that we found the effective absorption cross section of an atom to decrease with growing intensity of the incident field as the inverse of the field amplitude, while the corresponding quantity for a macroscopic particle (with dimensions still small compared with the wavelength) proved to be independent of the field in Ref. 1.

From our study, it becomes evident that the wave picture quite naturally accounts for the well-known large effective absorption cross sections, compared to the geometrical ones, of atomic systems, while the particle picture certainly fails to do so.

[1]C. F. Bohren, Am. J. Phys. 51, 323 (1983).
[2]H. Paul and R. Fischer, Usp. Fiz. Nauk. (to be published).

47.