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DUALITY OF REALITY AT PLANCK SCALE
VOLUME TWO

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To my dear wife, Velma, with all my love, gratitude, and devotion

Frank Boring Fitzgerald

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PREFACE TO VOLUME TWO

Volume Two continues with *DUALITY OF REALITY AT PLANCK SCALE* and contains a follow on dealing with *the* Singularity. It then presents my distant relative who dealt with Relativity by another name. It also contains text and diagrams of 2 public domain patents on fusion reactors which patents have expired. The first patent is the Flynn 1982 "warm" fusion reactor of 2 designs.

The second patent is the Gross 1975 "hot" fusion reactor.

This paper also contains some thoughts about the author's view of a hypothetical sonic bubble "cold fusion" reactor which design relies upon the Casimir Effect to offset Gravity's influence on the shape of the bubbles which must remain spherical during collapse into a shockwave state of producing fusion. It too contains text and a diagram of a possible "cold fusion" reactor.

INTRODUCTION TO VOLUME TWO

The below statement was signed by 190 persons and sent to Vice President Dick Cheney and other members of President Bush's National Energy Policy Development Group. The Group included Energy Secretary Spencer Abraham and other members of the President's Cabinet. The Statement was also sent to key members of Congress.

As of May 2006, the 1990 created "Board" [SEAB] is no more. While the President promises we can not sustain imports of energy we are in no position to create energy ourselves enough to sustain our uses of energy. Not unless we scientists get our acts together and R & D new sources of energy. Fusion is on the horizon and it is up to scientists to bring that view into our lives—soon, very soon.

STATEMENT ON FUSION AND ENERGY POLICY FEBRUARY 2001

Today, our nation is urgently searching for solutions to the power shortfall in the Pacific Coast region. While the immediate problem has many contributing causes, energy supply is essentially a long-term issue. We must not only react to recurring crises but also prepare for the future. In addition to acting to ameliorate the immediate problems, we urge you to address the nation's long-term energy needs through creation and funding of a focused R&D effort to expand our future commercial energy options.

We advocate an expanded, sustained energy R&D effort to provide the United States and the world with the energy it will need for the 21st century. The focus of this effort should be to provide new economic and environmentally acceptable energy technologies as soon as practical. The options that present themselves for mid-term application include advanced technologies for improving energy end-use efficiency, cleaner burning of fossil fuels, improvements in nuclear fission technologies, and less costly and more efficient renewable energy options. For the long term, we urge an accelerated effort to develop fusion energy.

Fusion power plants, when developed, offer a number of specific advantages, including an abundant fuel supply, no air pollution and much reduced risk from hazardous radioactive materials. At present, the United States has an excellent but underfunded scientific research program on fusion.

INTRODUCTION Continued

Other nations, notably Japan and the European Union, pursue both scientific research and also a focused development strategy aimed at eventual commercialization. We urge the United States to strengthen greatly its research into the fundamental science and advanced technology of fusion energy and to prepare a strategic plan for the realization of practical fusion energy as an important element in a long-term, environmentally responsible energy development strategy.

On August 9, 1999, the Fusion Energy Task Force of the Secretary of Energy's Advisory Board (SEAB) completed and delivered its Final Report: "Realizing the Promise of Fusion Energy". This report concludes: "...the threshold scientific question — namely, whether a fusion system producing sufficient net energy gain to be attractive as a commercial power source can be sustained and controlled — can and will be solved."
The report also noted that U.S. funding for fusion energy research is "subcritical" at this time. We very much appreciate your efforts to establish a responsible energy research and development policy for both the near and long term, to prevent recurrence of our present energy supply difficulties.

CHAPTER 13

THE SINGULARITY

One of the fundamental properties [happenings \ things] in place and going on thruout eons of time and thruout the continuum of the universe, allegedly, is ***the* singularity**. Galaxies may come and go but *the* singularity is forever. It contains an ability to cycle its *J* reactively stored contents it got from dipole virtual energies over every so many tens of billions of years. When full, it dumps the stored contents back into Real Reality of a next universe [in their big bang]. It is a *J* Reactive Reality wherein space, time, and place are irrelevant in terms of Real Reality. It exists virtually everywhere yet virtually nowhere. You can not feel it nor touch it. It was responsible allegedly for the big bang beginning of our universe [following the end of the last previous sequential universe] and our universe will eventually end which will then be followed by a big bang beginning of the next *"their"* universe in another cycle more than likely similar to ours.

Allegedly, all dipole virtual black holes everywhere [outside of stellar black holes] resonate into and out of *the* singularity when tension of resonance, with modulation, reaches an expansion \ compression of about 10^{42} Kg. This makes all of Real Reality related to *the* singularity via *J* Reactive Reality.

The singularity is *J* Reactive cosmological in character and is not physically in nor at a specific local Real place in our Real Reality. It does however *J* Reactively exist at each and every Planck Scale dipole end-nodes everywhere in the Quantum Matrix Reality. And all of our Real Reality universe contains a residual gravity which is at least step one non-reactive longitudinal AM [responsible for a minute part of the redshift] which step one makes each and every dipole end-nodal virtual black hole cycle as an entrance into *the* singularity at their event horizon points.

We can not actually see *the* singularity for it exists in the *J* Reactive Reality part of Quantum Matrix Reality at Level 4, as a subspace. But we can mind's eye conceptualize it, thus *see* it, and *see* into it. Each and every dipole virtual black hole resonates into and out of *the* singularity as if it were much less than a 10^{-35} m size and the entrance tension is equal to or greater then 10^{42} Kg. Yet, once inside, *the* singularity appears to our mind's eye as existing everywhere, a virtual size of the whole universe, as if existing via another group of dimensions.

As pointed out in previous chapters, allegedly, all dipole virtual black holes everywhere lead into *the* singularity, making *the* singularity, via *J* Reactive Reality, related to all of Real Reality. It is responsible for how and why fields, mass, and charge are bonded together as *things* and not break-up and disperse. [In studying bonding within *the* singularity, be ever mindful of the inverse square law for fields in Real Reality.] *The* singularity is also responsible for teleportation and entanglement when they are observed as superluminal.

The singularity is formed and held together via all of the step [one and greater] AMs of all the dipoles of the universe, forming a bonding in and of them all while the dipole resonances are inside *the* singularity each ½ cycle. So *the* singularity *landscape* undulates as a function of the intensity of entered dipole virtual energies at their event horizon point. Only the virtual black holes of all dipoles within stellar black holes would appear to remain a part of *the* singularity landscape all during those dipole cycles.

Ever wonder what keeps the charge on any electron as one unit, e? Or why does the at-rest stable mass of particles remain the same and equal to the other particles of the same type? Why does the quark charge come in 1/3 e or 2/3 e? Why not some other fractions? And why has the electric charge remained the same and likely to remain the same thruout space and time of our Real Reality?

Bondings between adjacent entrances within *the* singularity are herein said to form naturally from entered AMs which AM sideband components [generated by rectilinear properties of the dipole virtual black hole event horizons] are exchanged holding these *things* together inside and outside and which bonding appears to us in our Real Reality to be sole properties of the *things* themselves because we can not see nonlocality happenings in *the* singularity causing these properties but are only viewable in our local Real Reality.

The holding of things together in *J* Reactive Reality can be said to be a form of *J* Reactive storage in *the* singularity to remain that way until the next big bang which destroys the previous bondings in a gigantic explosion creating a new expanding universe to begin the cycle again in never ending cycles. This staying that way is caused by *the* singularity having an internal space-time equal to zero of our dimensions.

Do these natural bondings merely exist in our Real Reality as some scientists advocate? I can not conceive of *things* in our Real Reality holding themselves together in of themselves formed in a locality of Planck Scale dipoles. I see beyond mere dipoles to what they are doing and how they are doing.

If everything going on only happens in our local Real Reality, then how does one explain the nonlocality of superluminal entanglements and teleportation? In terms only of our Real Reality? Apparently not! Not simply in terms of locality alone! Can anyone explain superluminal entanglement transmissions or superluminal teleportation in locality terms alone? I have proposed such faster than light entanglement transmissions recorded the past several years take place within *the* singularity as a medium giving a nonlocality explanation but where the beginning and end of such transmissions are observed originating and ending within terms of locality.

Those superluminal entanglements scientists have witnessed so far, I say, were via the nonlocality medium of *the* singularity, which our man-made activities ought to have gotten the attention of ETs who I am sure utilize that superluminal medium for their artificial com-links.

We are likely to find ET on the Singularitynetwork not on the Microwavenetwork.

VIRTUAL BLACK HOLE EVENT HORIZONS ARE ENTRANCES TO THE NONLOCALITY "LANDSCAPE" OF THE SINGULARITY

One important essence of CHAPTERS 1-12 was discussion of Schwarz and Green virtual black holes which I allege form and un-form with each 1/2 cycle of Planck Scale dipole resonance [of dimensional fluctuation virtual energies whose spectrum of frequencies are at about 10^{-35} m producing a stabilized checks and balances system] at their end-nodes where compression \ expan-

sion reaches about 10^{42} Kg of tension.

A resonant virtual dipole of any given standing wave has a ½ cycle of about 10^{-43} sec making a universal frequency of about 10^{43} Hz. There are about 10^{43} standing waves intersecting at each and every dipole end-node making the appearance of a matrix, for lack of a better term.

Dimensional fluctuations [also know as zero point energy, zero point field, quantum vacuum, vacuum fluctuations, or, dark energy] are the alleged source of these dipole virtual energies at the very small and when white noise sidebands of the dimensional fluctuating are at a ½ wavelength of about 10^{-35} m they have the quantum energy needed to generate a dimensional stabilizing checks and balances via a resulting presence of a matrix of dipole resonance in intersecting standing waves with dipole end-nodal virtual black holes absorbing longitudinally those particular white noise sidebands, complying with quantum mechanics.

Transverse absorption would not take place because those dimensional fluctuation virtual energies would not be strong enough, and thus at odds with quantum mechanics, and could not participate in the formation of the stabilization system of checks and balances.

These dimensional fluctuation effects are found within the Quantum Matrix of intersecting dipole standing waves. That is why I say there is a residual gravity thruout the universe of at least step one longitudinal AM.

There are about 10^{43} standing waves intersecting at each and every dipole end-node making the appearance of a matrix, for lack of a better term.

I gave an explanation for the formation of virtual black holes at dipole end-nodes and offered the proposal, each is a virtual porthole [entrance] into *the* singularity.

The singularity contains each and every AMed dipole's end-nodes, so this part of the matrix, the end-node intersections are all contained *J* Reactively within *the* singularity which we can not actually see. This inside *the* singularity part of the matrix allows natural bondings [codes] between adjacent and nearby neighborhood entrances apparently via mutual exchange of sideband virtual energies.

I also alleged a dipole virtual black hole is similar to a stellar black hole as to some of their characteristics, taking into account the vast differences in size and shape.

Inside a stellar black hole, so it has been conceptualized in the literature, spacetime is zero [as we see it from outside].

I suggest herein, looking thru a dipole virtual black hole into the nonlocality of *the* singularity, length-time is zero allowing entrance bondings between adjacent dipoles and in their immediate neighborhood. And com-links take place in near zero time over vast distances of our Real Reality.

This zero length-time conceptual framework allows further conceptualization into the arena of teleportation, artificial entanglement of data transmission, or time entanglement com-links, via additional modulations such as Frequency \ Phase.

In Chapters 1-12, I formulated the concept of Quantum Matrix Reality as composed of two parts, that which is our Real Reality [locality enters the picture here, complying with Relativity and velocity limited to light speed], and, that which is *J* Reactive Reality to us [Nonlocality subspace of *the* singularity enters the *J* Reactive picture, producing explanations for superluminal events of: teleportations; data transmissions; entanglements, and changes in natural bondings; and, explaining observations of superluminal entanglements over distance]. The *J* Reactive Reality to us is what hypothetically we see happening to Matrix Reality from outside the event horizon of a virtual black hole as we are looking thru it, as a porthole, into *the* singularity, if we could actually do that.

If we were on the inside of *J* Reactive Reality [subspace], *things* we *see* would be very, very different. I herein propose, artificial entanglement com-links can take place in *J* Reactive Reality of *the* singularity via a proper set of artificial codes. For one thing, allegedly, virtual black holes dump us, via dipole resonance, thru the entrances into the inside of *the* singularity composed of the sum total of all entrances of each and every virtual black hole thruout the universe forming sort of an inside spherical ***landscape***.

For natural bondings to exist, the event horizon of each virtual black hole apparently contains an ability to code virtual energies of the modulated dipole resonance, because, the event horizon is both a rectifier and a *J* Reactive Reality entrance to *the* singularity.

For entanglement com-links to exist, the event horizon of each virtual black hole apparently contains an ability to code or allow the coding of dipole virtual energies, potential and kinetic [slightly different from bondings which hold *things* together in our Real Reality], of the modulated dipole resonance, because, the event horizon is a non-linear *J* Reactive Reality entrance to *the* singularity. However, there ought to be an additional form of modulation or two present which represent entanglement in like fashion non-reactive longitudinal AM represents at-rest gravity.

Each entrance into *the* singularity contains the natural makings of bonding with other adjacent entrances. *Rectilinear* properties of any dipole virtual black hole event horizon point allows mixing [heterodyning] of various dipole AMs and their sidebands to produce other sidebands which upon entering *the* singularity generate the natural bonding codes. Which may explain, in part, how and why integrity of fields, mass, and electric charge remain intact and do not fly apart.

Thus, each entrance into *the* singularity allegedly also contains the makings of com-linking with other entrances, if we could see codes in place for such com-links to occur. Again, the rectilinear properties of the event horizon allows mixing [heterodyning] of various modulations [AM plus FM \ PM], and their sidebands, to produce other sidebands which upon en-

tering *the* singularity generate the necessary com-link codes.

Specific AM sideband virtual energies reactively stay with the peak of a given dipole resonance entering into the *J* Reactive Reality of *the* singularity to emerge again with a continuation of AMed resonance cycle on that part of the given dipole which is in our Real Reality. So there is some coding already in place, naturally, for bondings, mentioned above, to take place. But is it enough for entanglement to take place? Apparently not. Any exchanging of sideband virtual energies on the inside of *the* singularity *J* Reactive Reality appears as an effect on the outside and that appearance as seen from the macrocosm has given rise to unrealistic concepts of bonding forces said to only be generated in our Real Reality by the *things* themselves in and of themselves.

To conceptually view natural bonding, therefore, involves our understanding of the process of dipole virtual energies resonantly entering and leaving *the* singularity via virtual black holes and precisely what part these virtual black holes, their event horizon points, modulations, sidebands, the selective mixing of those sidebands in the presence of the event horizon points, and *the* singularity, all participate in coupling effects between dipoles involved in a bonding process inside *the* singularity.

To view entanglement, on the other hand, involves our understanding of the process of resonant dipole virtual energies entering and leaving the virtual black holes and precisely what part these virtual black holes, their event horizons, and *the* singularity play in coupling effects [the coding allowing entanglement transmissions] between dipoles involved in a com-link.

If we view in the mind's eye, mechanics of bondings in relation to mechanics of the commonality of Level 1 of Quantum Matrix Reality plus AMs representing dipole effects at Levels 2, 3, and, *J* Reactive Reality of Level 4, we potentially could mathematically see there is an ability of entrances to bond with other entrances with little loss of time or signal using *the* singularity's unique features as a medium of coupling between entrances in the presence of *the* certain natural bonding codes. Add two more types of modulation, frequency \ phase and now we are allegedly capable of supplying com-link codes.

From CHAPTERS 1-12, allegedly, the whole universe in our Real Reality is composed of Planck Scale dipoles in a matrix of intersecting standing waves with virtual black holes at dipole end-nodes [10^{43} intersecting standing waves at each virtual black hole form the Reality Matrix]. And then there is *the* singularity which allegedly empties its *J* Reactive Reality contents with each big bang every so many eons in cycles.

Apparently, in nature, natural entanglement does not take place on a scale grand enough so as all of the universe is one gigantic some *thing* or other. Nor, even enough so one can ascertain there is any natural communications actually taking place across the universe. Yet, scientists are suggesting the universe is filled with some sort of dark matter, or, dark energy. Surely, *the* singularity would somehow be involved.

However, we may just have stumbled onto the method for [extra-terrestrial] ET's communications. Perhaps they program artificial entanglement com-links. Supposition tells us the entire universe is but one *the* singularity as seen from inside that *the* singularity. And I just bet ET makes use of ***that*** medium.

The SETI clan ought to take note of possible artificial entanglement com-links. I suspect, ET uses zero spacetime transmissions of artificial entanglement com-links thru *the* singularity as their medium and are not using EM radiation, and, perhaps, never have.

If we view in the mind's eye, mechanics of entanglement in relation to mechanics of the commonality of Level 1 of Quantum Matrix Reality and amplitude modulations representing Levels 2, 3, and, *J* Reactive Reality of Level 4, we might see there is a potential ability of entrances to communicate with other entrances with little loss of time or signal using *the* singularity's unique features as a medium of coupling between entrances in the presence of certain codes.

But first we have to know a great deal more than we do now for that theoretical overview to come to competent fruition.

I have labeled Level 4, with all of its complexities, ***subspace*** for lack of a better common usage word and to establish a convention for ultimate definitions.

ENTANGLEMENT AND TELEPORTATION
A PROPOSED EXPLANATION INVOLVING THE SINGULARITY

Allegedly, "entanglement" and "teleportation" are as a result of certain of the Planck Scale dipole virtual black hole connective mechanics being directly associated with *J* Reactive Level 4 of Quantum Matrix Reality. This can be explained via theoretical examination of effects taking place at about 10^{-35} m and 10^{-43} sec of: dimensional fluctuations stabilized [via virtual black holes in a negative feedback mode] into dipole resonance, plus modulations of the resonance, dipole virtual black holes, their rectilinear event horizons resulting in sideband generation and, *the* singularity's internal multi-dimensional "landscape". Entanglement and teleportation can be said to be forms of com-linking within *the* singularity between two or more entered dipole virtual black holes having proper "codes" [sidebands] for engagement.

This engagement is related to the com-link codes adding to the natural bonding codes which bonding codes hold "*things*" together. Apparently, entanglement and teleportation are not satisfactorily explained via classical nor modern physics and seem to violate them both in some regards. I propose herein a new set of theoretical physics concepts to give plausible explanation to results of certain entanglement and teleportation superluminal experiments conducted during the past three decades [4]. Mind you, they are only proposals not fact.

Particularly the matter of signal deterioration over distance does not seem to follow the inverse square law. Velocity of transmission does not seem to follow classical "rules". Some entanglements have been recorded traveling superluminal up to 16 times the velocity of light |c|.

I propose what are needed, are a new set of theoretical physics concepts to give plausible explanation to results of certain entanglement and teleportation experiments conducted during the past three decades [1]. Otherwise, science advancement comes to a grinding halt with scientists seeking instead to put entanglements and teleportation in the category of magic. My proposals are only proposals, not fact. As to magic; I leave that to those with a wand.

In this paper's previous CHAPTERS, 1-12, a version of which was published in ***Spacetime & Substance*** [2], I first gave my impression for what constituted Einstein's Reality Field [3] in my terms of Real Reality, Level 1, resonant Planck Scale dipoles.

Einstein's Reality Field is a steady-state continuous field, like unvarying DC, unquantizeable, because it contains no periodic variations [no frequency (v) for a quantum of hv], whereas when I add periodic variations, as in the AC [frequency for a quantum of hv] of dipole resonance in a quantum matrix of intersecting standing waves at Level 1, a new quantum Reality Field emerges which transforms [via Level 2 AM of Level 1] into a unified field theory of each and every field, at-rest or in motion. That meant quantum mechanics and Relativity are not competitors, merely different views of same dipole happenings.

In those previous 12 chapters, I covered various types of dipole amplitude modulation [AM] which AM appears to us to be representative of *things*. I said AM consisted of two families; the mass family of five longitudinal AM, and the charge family of five transverse AM plus two additional ones; 12 AMs altogether. I did not mentioned entanglement, teleportation, nor other types of modulation [frequency \ phase] which represents other *things* or happenings. I also went into *J* Reactive aspects of Reality in which I described Level 1 dipoles with end-nodal step one virtual black holes formed out of dimensional fluctuations and dipole primary AM of Levels 2 and 3 with steps 2 and above. Also event horizons of Level 4 as portholes [entrances] into *the* singularity.

This chapter proposes an explanation of entanglement and teleportation, which dilemmae have been, in one form or another, written about for over 75 years.

Only recently has entanglement and teleportation been given earnest attention, mainly as a result of curiosity of researchers studying teleportation [First the USA Army then the USA Air Force], and, data transmission [IBM and others].

Entanglement and teleportation studies are now to be found springing up all over the planet. [View the increasing number of entanglement papers references appearing on Internet search engines.]

QUOTE:
"**Certain objects can become linked by a mysterious process called 'entanglement'. Particles which become entangled are deeply connected regardless of distance between them… Physicists do not yet fully understand the nature of entanglement but there is growing evidence it is a fundamental property of the universe…"** [4]

UNQUOTE: Ins. ed. add.

So, what is entanglement? What is teleportation? Precise definitions have alluded scientists all these years because to truly define them requires putting forth explanations for their existence which existence seems to violate classical and modern physics in some regards [distance and velocity].

Without actually defining them at this point, entanglement and teleportation can be said to be some sort of connections linking physical properties of and between two or more separated *things* having some sort of common denominator mechanics, forming a communications linking [com-links], I allege, which takes place within *the* singularity [*J* Reactive Reality] as a medium of connections. Specifying a distance and velocity of these mysterious com-links within *the* singularity seems to be irrelevant in our Real Reality. Some entanglement experiments observed show sub-light speed while others show many times light speed up to 16 times in one experiment. Some were separated by only a small distance while others a great distance by comparison. Not all entanglements and teleportations require use of classical channels. Distances and sophistication of experiments are on the increase.

As time goes on, more entanglements and teleportation are found to exist absent classical channels.

Sometime in the mid-1930's, Einstein called entanglement:

QUOTE: **"Spooky action at a distance."** UNQUOTE.

A quotation found in much of the entanglement literature, although original source of that quote lies buried in some obscure archive inaccessible on the Internet. Some scientists are now speculating, entanglement can com-link over small or great distances at near light speed or greater, with little or no attenuation.

The three principle, perhaps most important, entanglement com-link experiments were conducted by: Aspect, et al (1982); Tittel, et al (1998); and, Weihs, et al (1998). Those experiments and their results can be found together on-line in *Stanford Encyclopedia of Philosophy* [1].

The reason these are credited herein is to suggest, once and for all, entanglement com-links really do exist which certain papers had previously cast so much doubt upon such links actually taking place, or, over any distance with certainty as to make entanglements a Harry Potter type magic. There was doubt cast upon the time for transmissions to take place.

I allege, entanglement and teleportation are complex forms of natural bondings, mentioned above, which takes place inside *the* singularity but is related to the happenings in our Real Reality via certain forms of dipole modulation.

FREQUENCY \ PHASE MODULATION

Let me show *J* Reactive Reality from a viewpoint of involvement of a different set of modulations of the dipoles from those 12 AM I found, in CHAPTERS 1-12, associated with Reality Levels 1, 2, 3, and 4, to see if communication [entanglement and teleportation com-links] amongst dipole virtual black holes is possible.

Supposedly, amplitude modulations of Levels 2 and 3 are not, in and of themselves, capable of generating forms of artificial communications of dipole virtual energies over great Real Reality distances with little or no loss. Otherwise scientists would have long since discovered a natural form of supposed com-links.

As a point of argument, I assume for artificial communications [com-links] to take place, this requires other and addition forms of modulations, besides AM, in order for them to be impressed upon two or more dipoles via their virtual black holes and *the* singularity to produce the desired entanglement and teleportation com-link codes.

I therefore propose those other and additional dipole modulations are frequency \ phase [FM \ PM] modulation upon amplitude modulated dipoles of Levels 2 and 3.

One important feature of FM \ PM we can use is its ability to generate sideband virtual energies from the carrier virtual energy [also from any AM impressed on the carrier] as a function of intensity of FM \ PM modulation impressed upon that carrier [and AM sidebands]. Generation of sidebands in FM \ PM then reduces the carrier [along with its AM sidebands]. It must be noted, the sum total of FM \ PM sidebands virtual energies plus carrier virtual energies [plus AM sideband energies] remains the same as a function of FM \ PM modulation intensity. This generation of FM \ PM sidebands occurs with or without AM impressed upon the carrier. But I maintain, the com-links require the carrier and its AM sidebands all be impressed with the FM \ PM sidebands in order for com-link codes be generated.

CONCLUSION TO ENTANGLEMENT AND TELEPORTATION
A PROPOSED EXPLANATION INVOLVING THE SINGULARITY

I have made the distinction between bonding which takes place within *the* singularity holding *things* together naturally and entanglement and teleportation which also takes place within *the* singularity but is a form of communications linking various properties of two or more *things* over our Real Reality distance.

Before 1987, I thought a given particle, charge or field was held together by bonding forces associated only with that *thing* itself.

I have since become convinced there was much more to that tale of bonding forces. Now, I think it possible those forces are associated with effects generated by the virtual black hole event horizons and the inside of *the* singularity, the subspace of *J* Reactive Reality.
It is possible, AMs of dipole resonances while inside *the* singularity produce natural bondings among the same given particle, charge, or field AMed dipoles so as between those same dipoles

viewed in our Real Reality, those forces appear to us to be associated only with the particle, charge or field itself, because we can not by any practical method see thru the event horizons into *the* singularity to view happenings in that, as we presume it to be, a zero spacetime which probably it is not as could be "seen" from the inside.

Einstein's **"Spooky action at a distance"**, I make the claim, is composed of two parts as explained above; our Real Reality and the other part, *J* Reactive Reality of *the* singularity. I allege, it is *the* singularity responsible for entanglement and entanglement com-links and for the holding together of fields, mass, and charge absent a big bang which releases all that *J* Reactive storage.

We have such a very, very long way to go to understanding what the universe is made of and how it works. This has been but a small part of what makes entanglement and teleportation work and why. *The* singularity's internal properties plus the rectilinear properties of the dipole virtual black hole event horizons are the how and why.

AT-REST MASS, AT-REST ELECTRIC CHARGE THE SINGULARITY INVOLVEMENT

Classically, it is alleged, an at-rest mass entity has certain complex connectable mechanics amongst Planck Scale dipoles, found locally within the mass entity, having common denominator properties which dipoles are directly associated with, and are nonlocally bonded together within, *J* Reactive Level 4 of Quantum Matrix Reality of *the* singularity. This can be explained via conceptually studying effects of dipole resonance, amplitude modulations [AMs] of the resonance, dipole end-nodal virtual black holes, their event horizons, entrances into *the* singularity. *The* singularity has an internal landscape with ability to cause natural bonding [exchange of sideband virtual energies] between entrances, thus holding together an at-rest mass entity in our Real Reality. What is said about at-rest mass is also said of an at-rest electric charge entity taking into account the differences in the two families of AMs, complex *J* Reactive longitudinal for an at-rest mass entity versus complex *J* Reactive transverse for an electric charge entity.

This chapter is based upon conceptual frameworks of Chapters 1-12 [a version of which was published in *Spacetime & Substance*]. In Chapter 3, I gave my impression for what constitutes Einstein's Reality Field; Planck Scale dipoles in a matrix of standing waves at Level 1 of Quantum Matrix Reality. I mentioned along the way, various types of amplitude modulation [AM] of Planck Scale dipoles which AM effects appear to us to represent *things*. I said AM consisted of two families; mass family of five longitudinal AM, and charge family of five transverse AM; plus two additional ones. 12 AMs altogether.

This chapter proposes concepts and explanations for what is mass and what is electric charge.

A few brilliant scientists have advanced answers over the past several decades based upon their understanding of spacetime. However, are their concepts complete enough to answer ancillary questions emerging since nonlocal teleportation and entanglements were discovered? Especially those found to transmit superluminally?

Questions of what are at-rest mass and at-rest electric charge have been discussed for many centuries. Yet, not until Relativity, was mass given some truly earnest attention especially Einstein's equation $e = mc^2$ which brought about the nuclear age.

Some scientists can not adequately define mass or electric charge so they say, "Do not ask such questions!" Thus avoiding the reason they are scientists in the first place. Which requires of them they put forth such questions; to ask; or, to listen to questions from non-peers.

And which also requires they search for answers. Equally important—to adequately communicate their found or conceived answers to others; to get others thinking; to improve the state of the art of acquiring knowledge. My physics professor once said, "That is what science is all about—knowledge."

My intent herein is to show how to look with one's own mind's eye to see into *the* singularity where happenings in that *J* Reactive Reality allegedly effect our Real Reality.

So, what is mass? What is electric charge? Precise adequate definitions have alluded scientists all these centuries because to truly define what they are requires putting forth an explanation for both of their existence which existence seems to have eluded classical and modern physicists' abilities to define them competently and completely.

Without actually defining at-rest mass and at-rest electric charge at this point [which would require putting to print adequate complex mathematics beyond the scope of this presentation], they can be said to be forms of a holding together, a bonding of resonant and AM properties, of and between separated Planck Scale dipoles within these entities having some sort of specific AM common denominator dipole mechanics portrayed via mathematical complex phase planes which process distinguishes them from fields which are mathematically quite simplistic AMs by comparison.

Specifying a distance between and composition of these mysterious bondings, at first glance, seems to be irrelevant because, I say, bonding takes place within *the* singularity which we can not see except as a mind's eye concept. Yet, the complex AM causing the bonding exists as part of the dipole cycle on the outside of *the* singularity on the resonant dipoles which we can analyze and can prove via experimentation and mathematics.

However, what we have seen, for these many years, on the outside of *the* singularity is what most scientists have mistakenly attributed merely to naturally inherent properties of mass and electric charge themselves and that, has never adequately answered the question: What are they? Thus, perpetuating unscientific and incomplete reasoning for some scientists to say, "do not ask", or, "mass and electric charge are merely————just there", etc.

In this chapter, I shall be confined mostly to studying and analyzing natural bondings taking place within *the* singularity, which I say holds together at-rest mass and which also holds together at-rest electric charge, which both concepts rely on my spacetime conceptual frameworks

of Quantum Matrix Reality at Level 1, fields at Level 2, mass and charge at Level 3, and, Level 4, *J* Reactive Reality [a subspace as we might think of it] which, I claim, has carry-thru entrances into *the* singularity from each and every dipole virtual black hole thruout the universe. I attempt to analyze the modulations taking place in our Real Reality on the outside of *the* singularity and at the same time, mind's eye those modulations of the dipoles resonance which have entered the inside of *the* singularity to see what happens there via extension of analysis of *J* Reactive Reality back to analysis in our Real Reality.

AT-REST MASS

One can see from Chapter 8, intensity of an at-rest gravity field of dipoles making up the gravity field, was alleged to be a function of simplistic non-reactive longitudinal AM intensity. As a function of increased magnitude of this AM, the two opposite virtual black hole event horizon points of a given dipole take up new functional positions, always at about 10^{42} Kg tension, on the dipole towards the common dipole center.

What was said of at-rest gravity has application to at-rest mass via substitution of a specific complex *J* Reactive longitudinal AM for the simplistic non-reactive longitudinal AM of at-rest gravity. Results of this substitution are verifiable by addition of mathematical complex phase planes into the analytic mix of functionality of dipoles within the at-rest mass.

Due to the complexity of *J* Reactive longitudinal AM constituting at-rest mass, the decrease of dipole modulated resonance found in-between these two event horizon points constitutes a decrease in length of the dipole Real Reality and forms our viewed impression representative of an increase in gravity and an increase in density of at-rest mass, which is inversely proportional to the viewable dipole length, and gives us the impression the mass is held together by itself [outside of *the* singularity]. But that impression is not complete as mentioned above, and, is deceptive.

One dipole does not make an at-rest mass. A matrix of many dipoles make up an at-rest mass entity. And likewise for an at-rest electric charge, and any at-rest field.

Oh! There is that equation $e = mc^2$ some say defines mass. I say that equation merely relates mass and energy as equivalent. It does not answer the question, what is at-rest mass? Some scientists have said mass is a conglomerate of, a bundle of, constrained energy. I say that question is still on the table for debate I seek to get interested parties engaged in.

AT-REST ELECTRIC CHARGE

What is said above for at-rest mass is also said for at-rest electric charge except there is a substitution required of the AM. Instead of *J* Reactive longitudinal complex AM for at-rest mass, there is a substitution of *J* Reactive transverse complex AM representative of the at-rest electric charge. Thus, the two bondings produced in *the* singularity, while similar, are independent of one another as to their formations and functionality.

However, it appears origin of an at-rest electric charge does not exist in and of itself but rather

exists emanating from the particular mass it is associated with. This effect is created within *the* singularity in a proper exchange of entrance codes between the charge and the mass the charge is associated with; that is, transverse complex AM of the charge is created by the longitudinal complex AM of the mass the charge is associated with at the entrances to *the* singularity. Parity probably plays a part in these arrangements.

Einstein referred to an electron's electric charge as electrical mass [5] and he questioned why two electrons [in proximity] do not scatter their electrical masses.

QUOTE:
"…[should scatter] under the influence of their mutual repulsions, unless there are forces of another kind operating between them, the nature of which has hitherto remained obscure to us." ins. and ed. add.
UNQUOTE:

And cited in the footnote 1, he said,

QUOTE:
"The general theory of relativity renders it likely...electrical masses of an electron are held together by gravitational forces." ed. add.
UNQUOTE:

I say, what scientists have seen as mechanics on the outside of *the* singularity, as to mass and electric charge, are not the mechanics which hold them each together. Such mechanics are to be found inside *the* singularity where the holding together happens. So, to answer what are they we have to see there is a difference in happenings between inside and outside *the* singularity, and, analyze the situations accordingly.

To address Einstein's remarks and his question, I say, we have to look inside *the* singularity to see the electric charge [electrical mass using Einstein's language] of each individual electron of a pair in close proximity is a matter of bonding codes at work within *the* singularity of the originating entrances and not on the outside. Scattering of each charge destroying the other, which would be effective if bonding were entirely on the outside of *the* singularity, does not take place due to the bonding allegedly taking place **within** *the* singularity.

So, the electric charges of two electrons in very close proximity do not scatter due to individual charge continuous bonding taking place within *the* singularity. Of course, in Real Reality there is electric field bending of one field against the other to a *J* reactive 90º resulting in a paralleling of the two fields instead of opposing head on in a destructive mode. This is reflected in actions within *the* singularity.

CONCLUSION TO AT-REST MASS, AT-REST ELECTRIC CHARGE THE SINGULARITY INVOLVEMENT

Before the mid 1980s, I, as most scientists, thought, a given mass particle and a given electric

charge were each held together by forces associated only with that mass particle or only with that electric charge each in and of itself.

I have became convinced there is much more to that story of associative forces. Now, I think it possible these forces are generated as a result of effects associated with dipole virtual black hole event horizons and that part of the dipole matrix inside *the* singularity the dipole end-nodal virtual black holes are resonating into and out of.

It is possible, AMs of the dipole resonances while inside *the* singularity produce bondings between the at-rest mass particle dipoles and at-rest electric charge dipoles so as among those same dipoles viewed in our Real Reality, those forces appear to us to be associated only with the entities themselves, because we can not see thru the event horizons into *the* singularity to view happenings in there, as we presume it to be, a zero spacetime which probably it is not as seen from the inside.

I allege it is *the* singularity responsible for the holding together the entities of fields, mass and electric charge, at rest or in motion, absent a big bang.

We have such a very, very long way to go to understanding what the universe is made of and how it works. This has been this person's third offering.

ARTIFICIALLY ACCESSING THE SINGULARITY

From out of everywhere, *the* singularity allegedly has each and every one of Real Reality's modulated Planck Scale dipole's end-nodal virtual black holes *J* Reactively resonating into and out of it, which with properly coded entrances, have nonlocality exchangeable natural bonding mechanics and potential artificial com-links both existing on the internal landscape. These entrances and their functionality mechanics are associated with the various types of dipole modulations found in Real Reality. There are two families of amplitude modulations [AMs] naturally found in Real Reality; the mass family of five longitudinal modulations, and, the electric charge family of five transverse modulations, plus two more AMs [angle and torsional] making 12 AMs altogether representing all Real *things*.

Allegedly, two more different types of modulations are possible. Frequency modulation [FM] and phase modulation [PM] ought to make possible the necessary coded entrances for artificial com-links of entanglements, data transmissions, and teleportation, which can all take place superluminally within the zero spacetime of *the* singularity, as we *look* in from the outside.

In my paper, I have incorporated results of my study of books and papers going back 75 years which dealt with what has come to be called theories of hidden variables, some local, some nonlocal. In my paper, nonlocal hidden variables are referred to as associated with dipole resonances which lead into the second part of Quantum Matrix Reality, *J* Reactive Reality.

I propose hypothetical concepts which ought to eventually lead to ability to artificially access *the* singularity for such purposes as: artificial com-links of entanglements; data transmissions over

distances with great speed; and, for teleportation of artificially created *things*.

In a word, *the* singularity is subspace. Cosmologically, it is not viewable as physically Real at any specific local Real Reality place because it exists nonlocally in the *J* Reactive Reality, everywhere. However, it does *J* Reactively exist locally at each and every Planck Scale dipole end-nodal virtual black hole event horizon point as *the* un-viewable local hidden variable. So, *the* singularity pulsates at about 10^{43} Hz as dipoles resonate from our Real Reality into and out of *J* Reactive Reality via virtual black holes.

All of our Real Reality universe allegedly contains a residual gravity which is at least step one non-reactive longitudinal AM, responsible for a minute part of the redshift, which step one makes each and every dipole end-nodal virtual black hole act as an entrance into *the* singularity.

The singularity exists only in the *J* Reactive Reality part of Quantum Matrix Reality at Level 4, as *the* subspace. Each and every dipole end-nodal virtual black hole resonates into and out of *the* singularity as if *the* singularity were much less than a 10^{-35} m virtual dipole size and the entrance tension is equal to or greater then about 10^{42} Kg. Yet, once inside, if that were possible, *the* singularity is everywhere, a virtual *landscape*, a virtual size of the vast universe, but with apparently, a very **different set of *"dimensions".***

The singularity is formed and its landscape held together via all of the step [one and greater] AMs of all the dipoles of the universe, forming a bonding in and of them all while the dipole resonances are inside *the* singularity during part of or all of each ½ cycle.

The event horizons of all dipole virtual black holes are the entrance points into *the* singularity. It could be said, *the* singularity is another universe with a different set of dimensions, which we can not directly experience because that universe is hidden in *J* Reactive Reality, but one which we ought to be able to access via fabrication in our Real Reality of specific modulations and combinations thereof which can become proper codes upon entrance thru the event horizon points of dipole virtual black holes into *the* singularity where the happenings we intent ought to occur via these codes. [How precisely this artificial fabrication of specific combinations of modulations can occur remains unknown.] These codes are, in essence, the makings of the hidden variables. We can not see the codes and can not see the hidden variables.

Are these codes local or nonlocal? It can be said while they are produced at the virtual black hole event horizons, locally, they then are transmitted thru the entrances into *the* singularity landscape where they become non-local.

So, *the* singularity landscape entrances undulate as a nonlocal hidden variable being a function of the cyclic intensity of entered dipole virtual code energies. Only the virtual black holes of all dipoles within stellar black holes would appear to remain a part of *the* singularity landscape during all of the dipole cycle. If this concept were valid, the singularity has a limit as to its ability to store all these stellar black hole full time virtual black hole dipole cycles on the landscape resulting then in another big bang.

Things **are said, here in this simple presentation, to be at-rest in our Real Reality for reasons of confining subject materials to lesser complicated conditions. Translocation of these things poses some vastly more complex conditions which will be studied in another paper.**

Properties [codes] of landscape entrance undulations form the bases for bonding of *things* which bonding is related to AMs of each at-rest field, at-rest mass, and at-rest electric charge. And, for com-links of entanglements, data transmissions, and teleportations which these are related to (FMs) and (PMs) in addition to AMs.

We ought to be able to use artificially created codes of these landscape entrance undulations for artificial bondings and artificial com-links if only we knew <u>how to</u> generate those proper codes.

Allegedly, all dipole virtual black holes everywhere, outside of stellar black holes, resonate into and out of *the* singularity when tension of dipole resonance, with modulation, reaches an expansion \ compression of about 10^{42} Kg which tension forms an event horizon point as a beginning point of each dipole virtual black hole. This makes all of Real Reality related to *the* singularity via *J* Reactive Reality, the second half of Quantum Matrix Reality.

The codes of the landscape on the inside of *the* singularity are responsible for how and why each at-rest field, at-rest mass, and at-rest electric charge are each separately bonded holding each of them together as *things* and not break-up and scatter in our Real Reality. Codes generated via addition of FM \ PM, would also be responsible for teleportation and entanglement when they are factually observed as superluminal.

Bondings between adjacent entrances within *the* singularity are herein said to form naturally from entered AMs which AM sideband components [codes as unique combinations of sidebands generated by rectilinear properties of the dipole virtual black hole event horizon points] are exchanged resulting in a holding of these *things* together while inside, and also, outside via continuation of the dipole resonance into our Real Reality, and which bonding appears to us outside in our macrocosmic Real Reality to be sole properties of the *things* themselves.

This is because, we can not *see* nonlocality hidden variable happenings in *the* singularity causing these outside properties, which can only be viewable in our local Real Reality at the macrocosmic level. We can experience the macrocosmic summation of Planck Scale effects of *things*, which summation is a creation of *the* singularity, but we can not directly *see* the Planck Scale effects themselves in our Real Reality, in practical terms. They are much too small, on the order of 10^{-35} m.

Do natural bondings merely exist in our Real Reality as some scientists advocate absent attention to my writings? I can not conceive of *things* in our Real Reality holding themselves together in and of themselves, formed in a locality of Planck Scale dipoles which can not possibly allow Real Reality bonding, per se.

I say, it is sideband virtual energy exchanges amongst entrances as a property of *the* singularity of *J* Reactive Reality which does the bonding having received the necessary bonding codes from event horizon rectilinear properties during the entrance part of the dipole cycle.

I mentioned in Chapter 1, Einstein raised an issue:

QUOTE:
"There is no such thing as an empty space, i.e. a space without field. Spacetime does not claim existence on its own, but only as a structural quality of the field." [3]
UNQUOTE:

I see with my mind's eye beyond mere dipoles to what they are doing and how they are doing, when they are modulated.

Using that Einstein concept of **"There is no such thing as an empty space…"** as an analogy template in which at-rest fields, at-rest electric charge, and at-rest mass, could be said not to claim to be each locally held together on their own, but only as a structural quality [AMs] of the certain quantity of Planck Scale dipoles of the Matrix and hence the hidden variable nonlocality involvement of *the* singularity .

If everything going on only happens in our local Real Reality, then how does one explain the nonlocality of superluminal entanglements and teleportation? In terms only of our Real Reality? Apparently not! Not simply in terms of locality alone! Can anyone explain superluminal entanglement transmissions or superluminal teleportation in locality terms alone? I challenge any suggestion of locality as *the* one and only medium of generating superluminal entanglements and teleportation. Maybe tachyon involvement?

I have, in this chapter, proposed faster than light entanglement transmissions, recorded the past several years, take place, not via local hidden variables, but within *the* singularity as *the* medium giving a nonlocality explanation where the beginning and end of such transmissions are observed originating and ending within locality terms. The in-between events can not be directly observed allegedly due to taking place within *the* singularity. Some *thing* is observed leaving here and suddenly the *thing* appears over there. The phenomenon involved requires studying and proposing non-traditional non-classical explanations. That I have attempted herein. I certainly am not sticking with local hidden variables as the sole explanation of superluminal links but rather to explain those hidden variables in terms of *the* singularity's abilities.

For a different viewpoint of: *things* happening at a distance, instantaneously, see [6] at that paper's page XX.

ARTIFICIAL ACCESS

Now to the crux of this chapter. *The* singularity has several modes for utilization of its abilities and properties. I have addressed *the* singularity relationship to natural bondings and to superluminal entanglement transmissions. Now to artificially generate *things*, and a potential warp drive.

One's ability to access any of these modal potentialities of *the* singularity requires an indepth study of the complexities of modulations, sideband generation resulting from dipole virtual black hole event horizon rectilinear properties, and a mathematics to accompany those studies. Also, a study of nonlocal hidden variable theories, Bohmian mechanics [7], quantum potential, and Schrodinger complex equations.

The modulations I speak of are mentioned above. AM longitudinal and transverse; FM and PM; and, sidebands generated at the dipole virtual black hole event horizon points.

It is the FM \ PM which needs studying the most. Absent those FM \ PM modulations, the AM families simply generate natural bonding effects which do not include artificial com-links nor generation of artificial *things* at a distance.

It will take the FM \ PM families, in addition to the AM, for that I am sure of, to gain for us access to *the* singularity we need to accomplish our goals. But **how to** generate these necessary artificial FM \ PM families, even if we knew the precise mathematics involved, remains a mystery to this theoretician. However, it appears the **how to** is the only obstacle to success.

ZERO POINT STUDIES

NASA commissioned a study [8], which began to be worked on in 1996 by various physicists. The aim of the contract was to encourage research into an interstellar space drive technology. While many papers were generated, none seemed to satisfy the requirements of a practical space drive. Some of those papers are listed herein on pages 98-99. One paper listed there described a warp drive but it was stated in the paper it would require an energy output of the sun to work.

That energy needed for a warp drive need not be the amount of the total output of a sun but rather if such a drive were possible, it ought to rely upon the resources of the medium of *the* singularity artificially accessed. So say I.

CONCLUSION TO ARTIFICIALLY ACCESSING THE SINGULARITY

Before the mid 1980s, I, as most scientists, thought, a given mass particle and a given electric charge were each held together by forces associated only with that mass particle or only with that electric charge each in and of itself.

I have became convinced there is much more to that tail of associative forces. Now, I think it possible these forces are generated as a result of effects associated with dipole virtual black hole event horizons and that part of the dipole matrix inside *the* singularity the dipole end-nodal virtual black holes are resonating into and out of.
It is possible, AMs of the dipole resonances while inside *the* singularity produce natural bondings between at-rest mass particle dipoles and between at-rest electric charge dipoles via exchange of sideband virtual energies so as among those same dipoles viewed in our Real Reality, those forces appear to us to be associated only with the entities themselves, because we can not *see* thru the event horizons into *the* singularity to view the matrix in there, as we presume it to be, a zero spacetime which probably it is not as seen from the inside. If we could have done the viewing to

the inside before now, we probably would have a vastly different attitude towards nature.

I allege it is *the* singularity responsible for the holding together the entities of at-rest fields, at-rest mass and at-rest electric charge absent a big bang.

Until only recently in human history have scientists learned to mind's eye natural events taking place before their eyes to *see* the depth of Reality.
My mind's eye methodology of exploring the seen and the unseen could eventually lead to routine artificially accessing *the* singularity.

To get there, one first must conceptualize with the mind's eye to *see* inside where matrix happenings in the *J* Reactive Reality effect our Real Reality in non-classical ways.

Conceptual difficulties supporting causal views of nonlocality can be investigated only in a stochastic framework. Application of probabilistic theories of causation to the nonlocality issue is itself a controversial matter which can be settled via investigation of *the* singularity.

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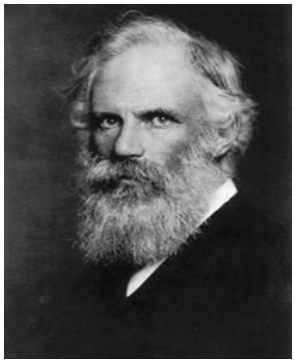
CHAPTER 14

GEORGE FRANCIS FITZGERALD
FIRST WITH THREE RELATIVISTIC CONCEPTS



George Francis FitzGerald

It is my honor and privilege to present my distant relative, Professor Doctor George Francis FitzGerald, first with 3 Relativistic concepts which preceded Relativity of Einstein.

The Michelson-Morley experiments of 1881-7 started the hunt for an explanation for their null results on the Earth's movement thru the ether of space. That hunt eventually led to Relativity. An explanation was first advanced by George Francis FitzGerald in 1889-92 which began the most remarkable advancement in science to that time—Relativity—altho it was not called Relativity until Einstein was credited with his Special Theory of Relativity in 1905. FitzGerald's Relativistic contraction concept, aimed at the MM null results, so divided the scientific community as to what his theorem actually meant, it remained for Lorentz to advance the same concept, who independently in 1895 arrived at the same explanation as FitzGerald had several years earlier. Decades later, most scientists rightly named the concept the FitzGerald-Lorentz Contraction. At first, confusion caused some scientists to scoff at FitzGerald calling his contraction theory merely deformation, meaning in volume and size. Some called his concept mere speculation. This continued discussion of deformation versus contraction cost FitzGerald at the time his first place in history when most scientists began calling his contraction theory the Lorentz-FitzGerald Contraction Theory, or, merely Lorentz Contraction.

The popular physics concept Relativity, began with Einstein's publication of his Special Theory of Relativity in 1905. But history tells us the multi-faceted Relativistic concepts had several names before Einstein and history also describes several events the various names were attached to.

In 1889-1892, George Francis FitzGerald was the first to propose an explanation of the failure of the Michelson-Morley experiments to detect the ether. He first proposed moving bodies deform in the direction of motion which cannot be measured because measuring rods deform in the same proportion. He was questioned about his deformation in a lecture [sometime between 1889 and 1892], at which point, he referred to his deformation as a contraction. Lorentz independently arrived at the same contraction conclusion in 1895 and developed the idea mathematically into a much more detailed description. But, at first, Lorentz also started with deformation but also

changed it to contraction. So, it became known as the Lorentz-FitzGerald Contraction Hypothesis which after Einstein it was a theory. That left FitzGerald as second rate, when in fact it was his idea to start with, and, Lorentz admitted FitzGerald was first. FitzGerald should have been named father of Relativity.

Over the years, many scientists rated Lorentz first. This most likely was because they did not see proof of FitzGerald being first, altho some believed he was involved but not first. The proof, for five decades, was buried in obscurity because of a lack of proper attention to preservation of papers, correspondences, and the very sad failures of archives to make available full texts of those documents upon demand, even now.

Some scientists even went so far as to drop FitzGerald calling the contraction the Lorentz Contraction. Some of those scientists did not believe FitzGerald was ever involved at all.

Now, many of us who have seen the proof give due credit to FitzGerald by rating him historically first, as in FitzGerald-Lorentz Contraction Theory.

This paper offers proof positive FitzGerald was first.

PERSONAL HISTORY

George Francis FitzGerald, Irish Physicist, was born August 3, 1851 in Dublin. After surgery, at age 49, his strength was not enough to survive. He died on February 21, 1901 in Dublin. [1]

Thruout his short life, FitzGerald was a kind, gentle, generous, uncomplaining person even to the point of apathy.

FitzGerald is an old Irish family surname. The surname consists of two parts: Fitz and Gerald. Fitz stands loosely for house of, or clan of, and Gerald is the name of the head of the house or clan. So, FitzGerald stands for House of Gerald. Those with a small “g” in USA are largely descendant from immigrants who came thru Boston where the “G” was dropped to “g”. Those who came thru Ellis Isle New York mostly did not drop the “G”.

George Francis FitzGerald was born into a highly educated extended family. His early education was obtained at home where he was tutored by M.A. Boole, sister of George Boole, Professor of Mathematics at University College Cork and known as Father of Computer Science. His uncle was George Johnstone Stoney the Irish physicist who introduced the term *electron* for the fundamental unit of electricity. [2]

At the age of 16, FitzGerald entered Trinity College Dublin to study mathematics and experimental science graduating in 1871 at the top of his class. He studied for 6 more years then won a TCD Fellowship in 1877. He was appointed a tutor in 1877 and became TCD Professor of Natural and Experimental Philosophy in 1881.

In 1883, FitzGerald concluded, an oscillating electric current would produce EM RF waves and

suggested a method how this could be done. [3]

So, FitzGerald for the first time was first with a definable Relativistic concept in 1883.

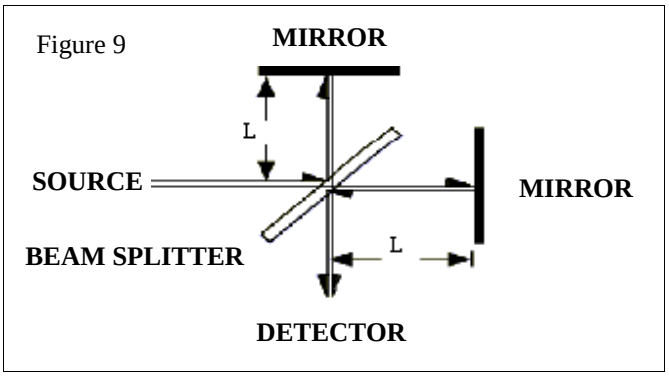
In 1893, he was elected fellow of the Royal Society. That same year, he married Harriette Mary Jellet, daughter of the TCD Provost, Professor of Physics. They had three sons and five daughters.

In 1899, he was awarded the Royal Medal of The Royal Society of London.

MICHELSON-MORLEY EXPERIMENTS OF 1881-7

The MM experiments, using an interferometer shown as Figure 9, produced null results contrary to classic physics by which the results should have been positive. According to classic theory, the time taken for each of the two round trips, L, should be different. The MM experiment however, demonstrated no difference in travel times.

Figure 9



In 1889, the American journal ***Science*** published in its May second issue a brief non-technical 1/2 page Letter to the Editor by FitzGerald, entitled **"The Ether and the Earth's Atmosphere"**. [Something else appeared in the May 17th issue—perhaps his paper.] [4]

FitzGerald dealt with *Science* in an attempt to capture attention of MM and because he had a falling out with the Royal Society of Dublin.

His letter to *Science* contained his suggestion of a Relativistic concept concerning a length change with velocity which could reconcile 1887 MM experiments with earlier, first-order, ether wind experiments.

QUOTE:
"...I have read with much interest Messrs Michelson and Morley's wonderfully delicate experiment attempting to decide the important question as to how far the ether is carried along by the Earth."

"Their result seems opposed to other experiments showing the ether in the air can be car-

ried along only to an inappreciable extent. I would suggest almost the only hypothesis which could reconcile this opposition are lengths of material bodies change, according as they are moving thru the ether or across it, by an amount depending on the square of the ratio of their velocities to that of light." ed. add.
UNQUOTE

So, FitzGerald for the third time was first with a definable Relativistic concept in May 1889.

FitzGerald's letter to *Science* was to remain virtually unknown for over a half century until Brush drew attention to it in 1967. FitzGerald to his death was not sure it had appeared in print. He could not bring himself to the point where he would have contacted *Science* to find out about the letter. Apparently, he did not know anyone who subscribed.

FitzGerald simply was a man not willing to put himself into the picture of current events at the time. Of consequence, he made no effort to contact the publication for details of a print. Today, most people would themselves have made the effort and for that reason see FitzGerald's lack of will as poor judgment. [I think it was a family trait as it was handed down to me and I have to fight my own lack of effort and complacency.]

Larmor, a friend and colleague of FitzGerald, who was responsible for editing FitzGerald's collected works in 1902 the year following his death, was not aware of the letter's existence altho he knew what it contained. [5]

FitzGerald sought to promote his contraction hypothesis primarily by way of lectures and private communications with colleagues between 1889 and 1892. He voiced the hypothesis in 1889 during a visit to the Liverpool home of Lodge, with Lodge's first references to it in print in his papers he published on optics in 1892 and 1893. In the first paper, Lodge viewed FitzGerald's hypothesis as results of a velocity thru the ether. [6]

DEFORMATION OF SIZE HYPOTHESIS LED TO LENGTH CONTRACTION THEORY

In a January 1889 letter to Heaviside, FitzGerald offered a suggestion. A Heaviside distortion might be applied to a theory of the forces between molecules of a rigid body. If these forces were rendered anisotropic by mere motion of the molecules, then the shape of a rigid body would be altered as a consequence of the motion. [7]

So, FitzGerald for the second time was first with a Relativistic concept in January of 1889.

A purely longitudinal contraction theory was not originally proposed by either FitzGerald, 1889, nor Lorentz, 1895, to apply to the MM null results but rather deformation of size. Nor was deformation as artificial or *ad hoc* as it was so often portrayed by some protagonistic scientists then very eager to criticize not fully explained concepts.

A plausible contraction support of the deformation theory was proposed independently by both Fitzgerald and Lorentz. But there were important differences between these arguments, each relied on an analogy with the effect of motion on electrostatic forces. Then there was FitzGerald's shift from deformation to relativistic contraction which he accomplished in the time frame 1889-1892, still before anyone else.

Apparently, there is no proof positive, as words written down by either FitzGerald or Lorentz, as to the exact dates upon which to claim what was written by whom. So, there is admittedly, the possibility of cross-over. But it is clear, FitzGerald had the edge over Lorentz via his letter to Heaviside, his 1889 letter to *Science* published May 2 and May 17, his visit to Lodge's Liverpool home in 1889, and, via Lorentz's admission, FitzGerald was first. The subject matter in those cases probably dealt with lengths of bodies versus velocity, meaning the length of a body versus its velocity relative to an observer.

In the annuls of science, we must be most precise in what we mean by such-and-such or some idiot will surely stretch our intent every which way but loose.

The misconstrued concept of 3-D deformation was one promoted by such scientists as Lodge, and by others much later attempting to cast doubt upon FitzGerald's concept in his letter to *Science* of **"...lengths of material bodies change...depending on the square of the ratio of their velocity to...light"**.

It should have been clear to all, FitzGerald did not intend his Relativistic concept to include breadth changing, nor height changing with velocity, only length, or he would have addressed them in the same paragraph.

In his lectures, he timely, modified his statement he had made to *Science* by confining lengths to just one, "...a length contracts in the direction of motion...". This new statement was said before a TCD audience competent as to their understanding of his meaning and he said the length statement quite enough times long before Lorentz went public with his own version of size deformation then length contraction.

Lorentz at one time **<u>was not</u>** aware of FitzGerald's 1889 letter to *Science* and in 1895 he proposed an almost identical deformation in a paper which then took the MM experiment very seriously. When it was pointed out to Lorentz in 1894, FitzGerald had already published a similar theory, he wrote to FitzGerald who replied:

QUOTE:
"I do not know if they [*Science*] ever published it." [apparently they did on May 17th.] "I am glad to know you agree with me for I have been rather laughed at for my view over here." ed. [8]
UNQUOTE:

One only has to look at FitzGerald's personality to see he was one not to follow thru with an in-

vestigation on his own of something which bothered him. He really did need some encouragement to over-come his inherent apathy. Most unfortunate, a family trait.

Lorentz took several opportunities after this to acknowledge FitzGerald had proposed the idea first. Only it was FitzGerald, who did not know if his article had actually been published, believed Lorentz had published first.

The MM 1881-7 experiments challenged classical physics by proving the speed of light is the same for all observers, regardless of their relative motion. FitzGerald and Lorentz attempted to preserve the classical concepts by demonstrating the manner in which length contraction of the measuring apparatus would reduce the apparent constancy of the speed of light to status of an experimental artifact.

Larmor wrote a paper in 1898 *Ether and Matter* in which he wrote down the (Lorentz) transformations (still not written down by Lorentz) and showed the FitzGerald-Lorentz Contraction was a consequence.

Lorentz wrote down the transformations, now named after him, in a paper of 1899, being the third person to have the written them down. He, like Larmor, showed the FitzGerald-Lorentz contraction was a consequence of Lorentz transformations.

A paper relating to Relativity was published in 1898, *La mesure du temps*, by Poincare. In that paper, Poincare says:

QUOTE:
"...we have no direct intuition about equality of two time intervals. The simultaneity of two events or the order of their succession, as well as equality of two time intervals, must be defined in such a way as statements of natural laws be as simple as possible." ed.
UNQUOTE:

In a second paper by Poincare, FitzGerald's claim is misinterpreted to be [as deformations of length ***and*** breadth]:

QUOTE:
"...size of bodies may be a function of their direction of motion thru the ether; and accordingly length and breadth of MM's stone supporting block [on which the interferometer is mounted] were differently affected…" ed. add.
UNQUOTE:

In a 1988 historical treatment of FitzGerald's hypothesis, Hunt pointed out, giving the benefit of any doubt to FitzGerald:

QUOTE:
"...there is no reason to think the idea which dawned on him in Lodge's study involved any-

thing other than a simple [longitudinal] contraction…". ed. add.
UNQUOTE: [9]

Such awareness would certainly have gone a long ways toward explaining FitzGerald's and Lodge's discussions of the deformation hypothesis.

Those discussions had been noted in 1966, by Bork, who wrote they do not state just what contraction is involved, in terms of mathematical details. Bork warned, Lodge's 1893 paper easily could be interpreted to indicate effects were taking place in both length ***and*** breadth of the moving body, which was exactly how FitzGerald's letter to *Science* was read by Capria and Pambianco in 1992. In his correspondence with Lorentz and Larmor, FitzGerald, it was said, never used the words "contraction" or "shortening", but referred to the length of the body changing depending on the orientation of the body relative to the direction of motion thru the ether, with a consequent alteration in the size of the body.

That misdirection of FitzGerald's intent is why scientists must be most precise in their correspondences, papers, and lectures. It helps an audience to understand via cycling the same idea over and over again each time expanding to re-enforce that which was said before.

Concerning the 1889 discussion with FitzGerald at his Liverpool home, Lodge recalled FitzGerald accepted his suggestion as to the effect of motion on MM's stone slab might be a shear distortion. Lodge apparently was projecting his own view, where the distortion ought to maintain volume.

By 1913, Lodge openly defended the shear-distortion. But Lodge's accounts, from 1892 to 1931, do not attribute shear distortion to FitzGerald other than as one possible kind of deformation amongst others. There appears to be no evidence FitzGerald complained his hypothesis was misconstrued by either Lodge or Lorentz. Yet, in the scientific community, renderings of misconstruction of FitzGerald's hypothesis become common place even up to the mid 1960s. Even now, once in a while, some scientist will cast doubt upon FitzGerald being first to expound a Relativistic concept.

Witness the many published dissertations on Relativity over the years and you will find, contrary to history, references to Lorentz but not FitzGerald as the name attached to the Relativistic concept of longitudinal contraction. In fact, a few critical renditions say it was written error to have mentioned FitzGerald as so much as involved with contraction.

History is on FitzGerald's side not junk scientists seeking to profit from their criticism.

LENGTH CONTRACTION THEORY *[*10]

In Relativistic terms, the length contraction concept amounts to a shortening of an object along longitudinal direction of its motion relative to a stationary observer, not relative to the so-called ether. Breadth and height dimensions are not contracted as seen by that observer. This concept agrees with Einstein's Special Theory of Relativity.

While it might be appropriate to write down in this article all of FitzGerald's equations dealing with his Relativistic concepts so as to propel the truth he was first, and for that matter all of the equations Lorentz wrote down, however, it would be more appropriate to simply write the one length equation to have come out of all that confusion about deformation versus contraction and who said what first. The one equation, now most often called the FitzGerald-Lorentz Contraction, is:

(38) $L = L_0 [1 - (v^2 \div c^2)]^{1/2}$

$(v^2 \div c^2)$ is that part of the equation which was mentioned in FitzGerald's May 1889 letter to the editor of *Science*.

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ADDITIONAL STUDY

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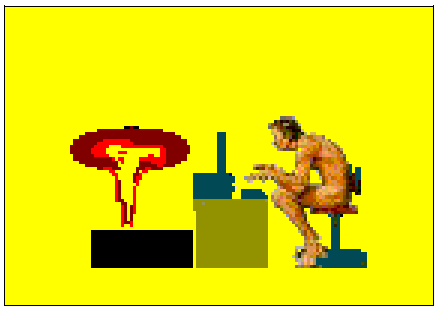
CHAPTER 15

SOME THOUGHTS ON FUSION



COLD FUSION

The phrase “cold fusion” is perhaps misleading. In some cases this phenomenon is neither “cold” nor “fusion”. Or, it might be a chilly car with the name, “Fusion”. “Cold” suggests the ambient temperature is at or near room temperature or between temperatures of freezing and boiling water. Fusion takes place inside of an environment which can exist at any temperature from absolute zero to the center of the sun as long as the fusion reaction itself is at the correct temperature. So the environment can be cold, warm, or hot. “Fusion” could be called transmutation of two joining isotopic hydrogen nucleus into another element’s nucleus plus companion particles so long as the Coulomb Barrier is breached.

However, “cold fusion” is one popular expression for several forms of isotopic hydrogen fusion reaction which, by other names and by other forms besides “cold”, are a proven fact whether or not some do not like cold fusion in any form. These “conflict of interest critics” are thought of as pathological disbelievers, who seek acclaim, or, are paid to proclaim it does not exist, or, who wave their magic wands, like Merlins, in attempts to make it go away.

In spite of [or because of] “critics”, some reliable scientists are stepping forth with results of their experiments and theories. Sometimes in spite of their institution’s CEO.

For example: On July 12, 2005, researchers at Purdue University announced they had new evidence supporting earlier findings by other scientists who had designed devices which used sound to produce ***sonofusion***. Some ***bubble fusion*** created in the Purdue sonic process were from perfectly spherical bubbles, and they collapsed with greater force than irregular shaped bubbles. Their research was confirmed by another group. Both were challenged by a group at UCLA and at last count the two groups were on the carpet, so to speak.

However, their research did yield evidence only spherical bubbles collapse with enough shockwave force to cause pairs of Deuterium nuclei to fuse together thru their Coulomb Barrier. This appears to confirm Flynn’s 1982 ***cavitation fusion*** US patent explanation of failure of odd shaped bubbles to function in any sonofusion reaction whereas spherical bubbles would cause

sonofusion. [See Chapter 16.]

Recently, Xing Zhong Li of Tsinghua University, Beijing, [1] produced a cold fusion theoretical concept entirely explained via his *Selective Resonant Tunneling Model*. And the list could go on.

It requires production of about 10^{12} atoms of helium per second from Deuterium, a stable isotope of hydrogen [1 proton plus 1 neutron], to equal about a 1 watt of heat. Deuterium is a component atom in a heavy water molecule, Di-Deuterium Oxide, D_2O.

United Nations Statistics Division - Classifications Registry classifies Deuterium oxide as SITC Rev. 3 code 525.91 produced via code 728.47 machinery and apparatus for isotopic separation, and parts thereof, n.e.s. Excimer tunable ultra-violet laser, tuned to the appropriate ultra-violet frequency, can be used for such isotopic separation to produce absolutely 100% pure D_2O needed for experiments. Contaminated, and less than 100% pure, D_2O has been cause for many table top experiments to go wrong. Use only absolutely 100% pure, D_2O in any experiment and use remote monitoring of the experiment going on in an "explosion-safe" lab. "Memory" problems can occur.

Iran has a D_2O production facility at Arak and is selling to other countries. Canada has two facilities for producing heavy water. D_2O is available commercially from three companies, one each in the USA, UK, and Germany.

All countries with nuclear fission power plants have stockpiles of 98% or less purity D_2O produced in their own nuclear power plants but do not want to export it, intending to use it in connection with additional fission nuclear power plants to be built later. Besides, none of those stockpiles are 100% pure which perfect purity is absolutely vital for reliable repeatable cold fusion experiments. Most stockpiled heavy water contains much too many impurities, some highly radioactive, to use for cold fusion experiments. So, those stockpiles are merely just being stored awaiting a decision as to what to do with them. They could all be turned to commercial use if cold fusion reactors come on line and the demand grows to the point where then existing "muddy hard heavy water" stockpiles would need to be processed to reclaim 100% pure D_2O. It would be a matter of weighing the relative costs involved, centrifuge triple distilled "mud" versus excimer laser D_2O separation from any source of water be it sea, river, well, rain, or lake water.

My preliminary calculations indicate 3.7853 liters of 100% pure D_2O, Deuterium oxide, heavy water, would produce about 100KW of heat for 46,400 hours in a cold fusion reactor using the d + d fusion process. Producing about 4.64 Giga Watt Hours of heat. Ideal for every home or office at greater than 30^o north or south latitude. The average efficient all-electric household consumes about 1.2MWH of electricity per month, when averaged over a year, making that 4.64GWH of reactor heat last over 3 centuries, if we could turn that reactor's heat into electricity.

If we could convert that reactor's 100KW of heat into a motion power source, we could produce a power plant for a 1 Mg automobile to drive at 120 KPH for over a Mega Km on 3.7853 liters of D_2O, considering about 30% overall efficiency. Automobiles could then be built with the heavy

water installed at the factory. [In those areas below freezing, the power plant and the heavy water of course would have to be kept above freezing (no anti-freeze please) by a pilot cold fusion heater.] That 100KW cold fusion reaction is enough for a million miles per gallon of heavy water. Some other estimates are suggesting as high as 48 million miles per gallon.

The 6 varieties of mechanics of cold or warm fusion have been worked on by scientists around the planet even before the cold fusion news conference in 1989 in Salt Lake City held by Martin Fleischmann of the University of Southampton and Stanley Pons of the University of Utah. Some of the duplication failures reported could be attributed to the heavy water used for the replication experiments was not 100% pure, or, if pure to start with it quickly became contaminated with usage, rendering test results uncertain at grave risk. So in each experiment, as part of the apparatus, the D_2O needs to be continuously cleansed of every impurity in order for test results to be reliable.

Fleischmann and Pons experiment of cold fusion produced mostly negative results in attempts at replication by most scientists who attempted repeating the experiment possibly for the above reasons. Considerable controversy occurred over the question of cold fusion existence? A committee was set in motion at the bidding of the US Department of Energy to answer that question. Their report was negative meaning there was little or nothing to cold fusion, but the final report did suggest limited further research ought to continue ["just in case"]. It appeared to some in the know, the committee was biased from the start, stacked with critics and skeptics. One committee member had a specific conflict of interest motive for frowning on cold fusion because his Institution was exploring, on large government grants, "hot" fusion.

Great pressure was put on the powers to be to review the findings of the increasing number of laboratories around the planet which had actually produced cold fusion contrary to what that biased committee had reported. The US Navy Research Laboratories at China Lake and San Diego [2] produced a two volume report which described production of cold fusion heat in fact actually does result, but the potential for multiple replication of the identical experiment being problematical at best was also reported on in the Report's Vol 1. Vol 2 contained mostly the tabulated lab measurements conducted by Professor Martin Fleischmann.

Because of recent pressure by some scientists who adhere to the concept cold fusion can be made to work, the US Department of Energy is now engaged in some very selective and very limited exploratory grants to elicit reports from which to decide if further research grants are warranted. However, if pathological disbelievers are part of the decision making process, there will be no further US Government grants. Not until Congress gets into the act.

Apparently, one of the most productive and successful for multiple replication cold fusion results have been obtained by Roger Stringham [3] et al, with their ultrasonic method [sonofusion] of Deuterium collision which produces excess heat on the order of several magnitudes over that of, say, the US Navy Laboratories' electrolytic process.

For example: Stringham's concept involves bubbles produced as a result of a presence of ultra-

sonic energy with production of extremely high bubble surface temperatures and pressures of the minute bubbles during the final phase of collapse. Other researchers have estimated temperatures inside collapsing bubbles during the final phase can reach 10^7 degrees K and pressures near 10^9 atmospheres.

For the same unit mass of fuel, a fusion reaction would produce 10 times more energy than fission. But the greatest advantage of fusion is environmentally far less radioactivity for far less time after placement in storage. [Years as against centuries.]

Deuterium is contained in seawater. A cubic kilometer of seawater contains enough Deuterium to supply all of the USA energy needs for the next thousand years.

One of my cold fusion reactor concepts involves generation of bubbles in between the same chrome plates which hold in place surface Deuterium ions via a strong surface work function. Those Deuterium ion holding chrome surfaces are surfaces of the electrodes of parallel resonant piezoelectric quartz crystals which generate the ultrasonic standing waves in the gap between the two crystals. Added stress on the surfaces of the [sonic generated] collapsing bubbles comes from standing waves of a pulsed high frequency electromagnetic field generated between the adjacent plates of the two crystals. If the distance between is adjusted to a very small gap, then the Casimir Effect should play a part in adding energy and spherical shape stability to the collapsing bubble surfaces. At which point we ought to see the zero point energy field effect engage in transferring some quantum vacuum energy to the process giving us the impression of a greater bubble fusion efficient process. Ultra-violet sonoluminescence light produced in the bubbles should add energy back into the process because this light can escape only at the edges of the reaction gap. Addition of high frequency RF to opposite plates across the gap should improve the ability of the Sonoluminescence light to add its energy back into the bubble process via a form of resonant tunneling.

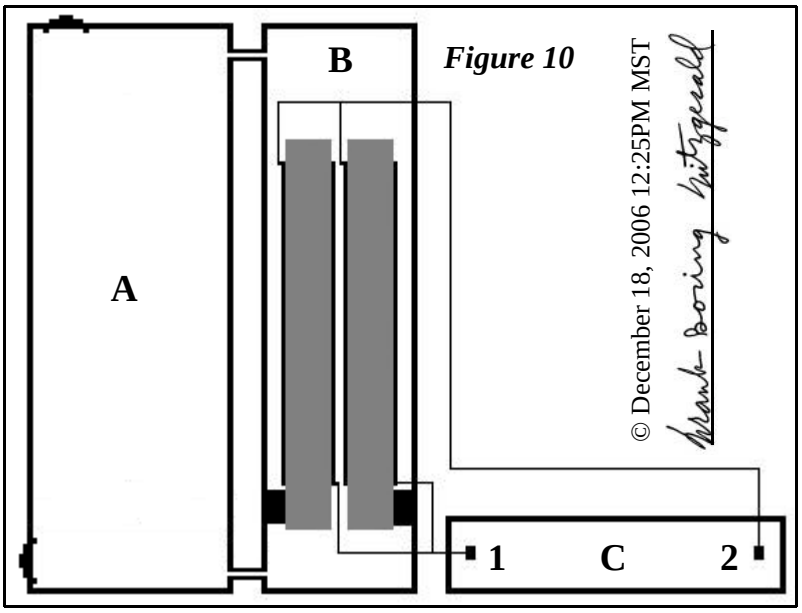


Figure 10

Figure 10 is my simplistic graphic example of a bubble fusion reactor. It could be called a cold fusion reactor because fusion takes place between a d of a collapsing bubble surface and a d held on the chrome surface by the surface work function and in pores of the chrome as well as between adjacent ds inside the bubble at its surface.

A. Pressure chamber contains storage for fresh 100% D_2O, storage for spent fluid, pressure regulator, check valve, circulation pump, heat exchanger, filtration system, and various sensor devices.

B. Cold fusion reactor [bubble fusion reactor]. Chamber contains 2 piezoelectric quartz crystals with plated electrodes. The quartz crystals are separated by a very narrow gap which gap is adjusted for maximum ratio of reactor RF power output to heat production.

C. RF Generator input starts the fusion process and then shuts down after unit is working at which point terminals 1 & 2 supply RF power output.

This device incorporates, among other things, the Flynn \ Stringham \ Taleyarkhan \ Xu \ Butt cold fusion \ bubble fusion \ cavitation fusion process generated via ultrasonic sound.

A 100KW RF power output reactor would have 20K parallel crystals with very narrow gaps between to increase the Casimir Effect which helps keep tiny bubbles attracted to the plates yet spherical during the 20-50 picoseconds of final bubble collapse.

The quartz crystal resonators are plated both sides with a very thin layer of gold upon which are plated two very thin layers of chrome. The chrome has pores in its crystal type structure sufficient to hold Deuterium ions via a strong work function at its surface. Much like an ion sticking its head out of a quantum well. The crystals are submerged in 100% pure D_2O under pressure suitable to formation of bubbles caused by ultrasonic standing waves in the gap between the two crystals.

The two crystals are placed into resonance via applying to the plates on opposite sides of each crystal an RF kept at the physical resonant frequency of the crystals, which under RF power, the crystals increase and decrease thickness at their resonant frequency, generating high intensity standing wave ultrasonic energy in the D_2O gap between the two crystals. This causes localized ionization of the D_2O and produces bubbles of the ionized Deuterium gas [and oxygen gas] which when collapsing produce an extremely high temperature and high pressure, sufficient to bombard the stationary Deuterium held on the surface of the chrome plates which Deuterium thereon has a large target cross-section due to a surface effects confinement. The ionized oxygen is expected to serve no purpose other than a buffer.

The result is Deuterium fusion which takes place at the frequency of the crystal RF. The RF generator in chamber **C** starts the surface process in chamber **B** with its power source later shut down because the varying Casimir Effect in the gap along with the varying piezoelectric effect are and pulsating fusion reaction are in positive feedback mode which generates RF which causes

the ultrasonics which causes the bubbles which causes pulsating fusion within the bubbles themselves and on the chrome electrodes with RF energy taken off as reactor power output from chamber **C** at terminals 1 and 2.

The gap liquid in chamber **B** is continuously exchanged with fresh D_2O from chamber **A** via therein a circulating pump, regulator, filter, and check valve. So, d + d fusion starts at the surface of the chrome plates then switches mostly to inside surface of the bubbles adjacent to the plates.

The very narrow gap between crystals allows the Casimir Effect to predominate over Earth's gravity so it is not necessary to supply a magnetic field to compensate for Earth's gravity as was required in the Flynn cavitation process. [4] The Casimir Effect polarizes the fusionable d mates held at and at and in the surface of the chrome stabilizing the d there as if in a quantum well and holding those d's ready as a target with large cross section.

The Casimir Effect also first polarizes the initial fusionable D mates on the inside of the bubbles during final collapse phase allowing additional pulsating RF field standing waves, and sonoluminescence energy, the opportunity, time-wise, to add energy to selective resonant tunneling leading to fusion.

In Flynn's 1982 patent [see CHAPTER 16] he pointed out an unstable bubble shape was due to Earth's gravity [tiny as it is] which resulted in a bubble not being able to produce high enough temperatures and pressures during final collapse phase for fusion to take place due to elliptical bubble shape [upsetting the selective resonant tunneling effect due to 100% pure, D_2O]. Flynn made it clear the bubble must be spherical during final phase of collapse or else fusion does not take place and the reactor shuts down. Those Flynn assumptions were confirmed in the 2005 Purdue findings.

This Casimir Effect stabilization of the bubble spherical shape allows various physical orientations of the reactor to suit installation requirements such as a moving vehicle, aircraft, and hand held devices.

The conceptual device I just described does have a "**memory**", that is, as described, it is self running at its maximum reaction, load or no load. So how is it controllable? How is it shut down? How safe can a fail safe system be? Enough? Or, watch out?

One answer to the "**memory**" problem is simply this. By changing the shape of the bubbles from spherical to elliptical, the reactor then shuts down so said Flynn in his USA Patent and confirmed recently by the Purdue group.
Bubbles all entirely spherical produces full fusion reactor power, elliptical bubbles shuts down the reactor. That suggests the control of the reaction as one being a control of the shape of the bubbles which is rather fast changeable, in theory. So the sensible answer is to control the intensity of the sonic and RF energies between the plates in the gap. This would have the effect of distorting the shape of bubbles and changing other factors.

CHAPTER 15 Continued

Fusion reaction control can be caused to immediately take place via changing the resonant frequency of the crystals and at the same time to change the intensity and phase angle of RF pulses with crystal sonic output a function of crystal vibrational energy frequency and phase angle. These two energies which cause the bubbles in the first place now are able to change the shape of the bubbles. This is where electronic control plays its part. In order to safely produce RF power output under any and all load conditions, the fusion reaction must match the load.

The RF frequency supplied to the crystals and the high RF pulses supplied to the bubbles both need to be automatically adjusted so bubble shapes are appropriate to reactor output load. No load, reactor activity is at idle supplying only the bare necessary energy to keep the reactor alive. The electronics are then on standby waiting to bring the reactor up to any load demand.

As load changes, the electronics adjusts the crystals' RF frequency via automatically adjusting to the proper frequency thru a correct change in "tuning" of the crystals plus adjusting the RF pulses. This has the effect of changing bubble shape and changing other factors.

Fail-safe equals adding a short circuit in each crystal's RF energy at the same time turning off the RF pulses supplied to the bubbles, by-passing the fine "tuning" procedures. This can be done automatically electronically or manually.

Run-away reactions can take place very quickly so vital precautions are necessary to be taken when an experiment is ready to run. For info on any lab setups as a minimum please see the webpage: [5]

In the Issue 67, May/June 2006, ***Infinite Energy Magazine*** [6] was published an article by Robert W. Bass on the *Cold Fusion Session of APS Meeting March 16, 2006, Baltimore Convention Center - 344 Baltimore, Maryland, 2:30 to 5:06 PM*, calling his article *An Afternoon to Remember:*

In that article, Bass said, "Roger Stringham of Firstgate Energies presented a video regarding impressively improved capabilities of his innovative 'sonofusion' device. A low mass durable 1.6 MHz unit produces 40 watts of excess heat with an acoustic input power of 17 watts. Excess $_2He^4$ commensurate with F&P's [Fleishmann and Pons] 1989 aneutronic d + d--> $_2He^4$ scenario has been found. The energy density of Roger's reactor is of the order of commercial energy suppliers."

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email Lxz-dmp@tsinghua.edu.cn
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[2] US Navy Research Laboratories at China Lake and San Diego, California, produced two re ports which each contained on their last page: **"Approved for public release; distribu tion is unlimited."**

Technical Report 1862, Feb 2002 - Thermal and Nuclear Aspects of the Pd/D_2O System Vol 1: *A Decade of Research at Navy Research Laboratories* 132 Pages www.spawar.navy.mil/sti/publications/pubs/tr/1862/tr1862-vol1.pdf [3.5MB]

Technical Report 1862, Feb 2002 - Thermal and Nuclear Aspects of the Pd/D_2O System Vol 2: *Simulation of the Electrochemical Cell (ICARUS) Calorimetry* 178 pages [mostly Fleischmann recorded data from CF experiments] www.spawar.navy.mil/sti/publications/pubs/tr/1862/tr1862-vol2.pdf [41.8MB = 4 ¼ hours dialup download - best to use a broadband connection = 9 minutes or less]

[3] Roger Stringham, First Gate Energies, PO Box 1230, Kilauea, HI 96754 firstgate@earthlink.net Phone: 1 808 828 2859

[4] Hugh G. Flynn US Patent 4,333,796 issued June 8, 1982. To view the patent, go to http:// www.uspto.gov/patft click on patent search and then enter 4333796 in box.

Time for the patent protection for this patent having expired, the patent is in the public domain. Professor Flynn died on May 23, 1997. The beauty of Flynn's patent is what he said in his description and explanation about the fusion process and how he proposed it be accomplished. His was the most complete patented design I have seen on a cold fusion reactor and that was patented in 1982, before Fleischman and Pons announcement in 1989.

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CHAPTER 16

The below on **CAVITATION FUSION** is an edited version of a United States Patent which, now in 2008, is in the Public Domain because its term has expired. It is published here for educational purposes and is not to be construed for any other purpose. As the author of this paper, I claim no copyright for any or all of the contents of this public document. Also, I do not indorse nor make any offering of this invention to anyone for any purpose. While this is not the first of many "warm" fusion concepts, meaning 1000 to 1500 K, it perhaps is *the* most important one to have been created. Little was known of this patent or of its inventor in ranks outside of the cavitation fusion clan for the past 25 years. The inventor deserves just credit for having the ability to adequately describe his process. Aspects of his 1982 patented concept are to be found being explored around the planet.

Dr. Hugh G. Flynn was professor emeritus of electrical engineering at the University of Rochester. Born on December 8, 1912 in Lancaster, Ohio, he died May 23, 1997, in Rochester, New York, at age 84. I would say he deserves the honor of being called ***"the father of ultrasonic bubble nuclear warm fusion"***.

****

United States Patent: 04333796

Inventor: Dr. Hugh G. Flynn
Filed May 19, 1978 as Application 90737
Issued June 8, 1982
Current U.S. Class: 376/100 ; 376/102; 376/149; 976/DIG.1
Current International Class: G21B 1/00 (20060101)
Field of Search: 176/1,2,3 181/115,120
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Primary Examiner: S. A. Cangialosi
Attorney, Agent or Firm: Shlesinger, Fitzsimmons & Shlesinger, Rochester, NY

METHOD OF GENERATING ENERGY BY ACOUSTICALLY INDUCED CAVITATION FUSION AND REACTOR THEREFORE

Abstract

Two different cavitation fusion reactors (Type I CFR and Type II CFR) are disclosed. Each comprises a chamber containing a liquid (host) metal such as lithium or an alloy thereof. Acoustical horns in the chamber walls operate to vary the ambient pressure in the liquid metal, creating therein small bubbles which are caused to grow to maximum sizes and then collapse violently in two steps. In the first stage the bubble contents remain at the temperature of the host liquid, but in the second stage the increasing speed of collapse causes an adiabatic compression of the bubble contents, and of the thin shell of liquid surrounding the bubble. Application of a positive pressure on the bubble accelerates this adiabatic stage, and causes the bubble to contract to smaller radius, thus increasing maximum temperatures and pressures reached within the bubble. At or near its minimum radius the bubble generates a very intense shock wave, creating high pressures and temperatures in the host liquid. These extremely high pressures and temperatures occur both within the bubbles and in the host liquid, and cause Hydrogen isotopes in the bubbles and liquid to undergo thermonuclear reactions. In one type of CFR the thermonuclear reaction is generated by cavitation within the liquid metal itself, and in the other type the reaction takes place primarily within the bubbles. The fusion reactions generate energy absorbed as heat by the liquid metal, and this heat is removed from the liquid by conduction through the acoustical horns to an external heat exchanger, without any pumping of the liquid metal.

DESCRIPTION

This invention relates to a method of producing thermonuclear energy by cavitation of a liquid metal, and more particularly to a reactor in which such energy may be generated.

BACKGROUND OF INVENTION

When certain liquids are subjected to reduction in pressure of an appropriate duration and magnitude, small pre-existing bubbles of gas and vapor in the liquids expand to some maximum size and then collapse with great violence. This phenomenon is called cavitation and, when properly controlled, causes very high energy densities to occur both within the bubbles and in the surrounding liquid. The invention disclosed hereinafter relates to a device called a cavitation fusion reactor (CFR), which uses cavitation of a liquid metal to bring about thermonuclear fusion of Hydrogen isotopes and other liquid (low Z) elements, both within a bubble created in the host liquid (metal), and in the surrounding host liquid. In its normal operation a reactor of this type produces one or more of the following:

1. release of energy which is removed as heat;

2. creation of elements, such as Tritium or helium-3, used as thermonuclear fuel, either in the CFR itself in a regenerative manner or in some other fusion device;

3. fission of heavy elements distributed in the liquid metal; and
4. radiation of neutrons.

In what follows, an asterisk (*), used on a symbol for a physical quantity, denotes a quantity in some system of units. Thus, R_n* denotes the equivalent or equilibrium radius of a bubble in centimeters. The symbol R* is the time-varying radius of the bubble in centimeters. The symbol, R, is the non-dimensional radius of a bubble and is defined by $R = R^*/R_n^*$. The absence of an asterisk denotes a non-dimensional quantity. The words "negative pressure" will mean a reduction of the ambient pressure in the liquid metal by an applied pressure, which may or may not make the total pressure less than zero. The small bubbles from cavitation starts will be called "seeds"; the liquid in which the cavitation takes place will be called the "host liquid"; and, a method of obtaining a specified distribution of seeds will be called "seeding" the host liquid. A very small seed containing N mols of gas may be lodged on a minute particle and not have a spherical shape. The term, "equivalent radius", R_n*, will be used to denote the radius of a spherical bubble containing the same number of mols of gas at the same ambient temperature and pressure in the host liquid. For a spherical bubble at rest in a liquid, the terms "equivalent radius" and "equilibrium radius" are identical. The cycle of expansion and contraction a bubble undergoes under the influence of an applied pressure field will be called a "cavitation event", and the region in the host liquid where these events occur will be called the "cavitation zone". Seeds may be a random distribution of very small bubbles with some average equivalent radius (say, of the order of 10^{-5} or 10^{-4} cm) or may be distribution of larger bubbles whose equivalent radii fall in a specified range. The words "bubble" and "cavity" used herein are synonyms.

Two main types of cavitation fusion reactors are described hereinafter: Type I CFR, which maximizes production of energy and other useful products through thermonuclear fusion in the host liquid; and, Type II CFR, which maximizes production of Tritium and other useful products through thermonuclear fusion within the bubbles in the host liquid.

Both types of cavitation fusion reactors may be operated in a mode which produces little or no radioactive products. In this mode the reaction is between lithium nuclei and ordinary Hydrogen ($_1H^1$ or h) nuclei. In alternative modes of operation the devices use Deuterium ($_1H^2$ or d), Tritium ($_1H^3$ or t), or a mixture of both D and T as the H-isotope fuel, and the liquid metal may be lithium, beryllium, aluminum, tin, indium, thallium or some other element or alloy. Deuterium is the heavy Hydrogen isotope (H-isotope) occurring in nature, while Tritium, the other heavy H-isotope, does not. Only Deuterium need be supplied from an external source in both the start-up phase and steady-state operation of the Type I CFR or a Type II CFR. Type I CFR uses a mixture of Deuterium and Tritium in order to yield a net gain of energy transformable into useful work. The required inventory of Tritium is produced within the reactor by the fusion of Deuterium nuclei and the interaction of neutrons with lithium or lithium alloyed with beryllium. In a similar manner, a Type II CFR may operate as a generator of Tritium requiring only Deuterium as the externally supplied fuel.

Once a CFR of either type is placed in operation, the reactor will "breed" its own Tritium; that is, the reactor will produce more Tritium than it burns, no matter whether or not the fusion reactions

start with Deuterium alone or with a mixture of Deuterium and Tritium.

THE HOST LIQUID

In the collapse of a cavitation bubble, the controlling parameter is the compressibility of the host liquid. Viscosity plays a minor role and in the final stage of collapse the interface moves so rapidly the effect of heat conduction is minimal and the entropy of the gas and vapor within the bubble becomes constant. The term "compressibility" is here used with a specific meaning: a compressible liquid is one with a finite speed of sound. The greater the speed of sound in a liquid, the less is its compressibility in this sense used here. If the speed of sound of a liquid were infinite, the liquid would be incompressible.

All real liquids have finite speeds of sound which increase with an increase of pressure in the liquid. When the speed of sound in a liquid is low, compressibility is most effective in moderating the violence of collapse of a bubble and in lowering the maximum temperatures and pressures attained. When a bubble collapses, the pressure in the liquid at and near the interface increases, and hence the local speed of sound increases there also. Because of this increase in the speed of sound at the interface, the violence of collapse may also be increased.

For this invention the host liquid must be one with a speed of sound as large as possible, and thus the host liquid must be a liquid metal. While all liquid metals have large speeds of sound, lithium and beryllium have the largest speeds of sound over a wide range of pressures.

One important characteristic of a liquid metal is its vapor pressure. Listed below are the vapor pressures of several liquid metals at their melting points:

Metal	MP (K)	Vapor Pressure (bars)	ΔK
Li	452	1.63×10^{13}	566
Be	1552	4.18×10^{5}	207
Al	933	2.42×10^{11}	877
In	430	1.42×10^{22}	1092
Sn	505	5.78×10^{26}	1260

The melting points (MP) are listed in degrees Kelvin and the range of temperatures above the melting point in which the vapor pressure remains less than 1 mm Hg (1.33×10^{-3} bars) is listed under the heading ΔK. The quantity ΔK is an important measure of the suitability of a metal as a host liquid. Of the metals listed beryllium has the smallest value of ΔK and a relatively high vapor pressure at its melting point.

Cavitation bubbles spend most of their lifetimes in an expanded state in which the vapor pressure of the liquid may be much greater than the pressure of the gas in it. Consequently a high vapor pressure at the start of collapse could have a disproportionate effect on the maximum temperatures and pressures attained at the end of collapse. Similarly, during collapse, a high vapor pressure could mean a large fraction of the mechanical energy used in compressing the bubble would be expended in heating and ionizing the vapor atoms rather than the Hydrogen isotopes. On the other hand, the presence of a small amount of vapor could have the effect of

decreasing the thermal conductivity of the gas-vapor mixture and thus hastening the onset of the adiabatic phase of compression. Both lithium and aluminum are examples of liquid metals with moderate vapor pressures over a wide range of temperatures above their melting points. Indium and tin are examples of liquid metals having very low vapor pressures over an even wider range of temperatures above their melting points. Beryllium is an example of a liquid metal with a relatively large vapor pressure and a small value of ΔK. A large value of ΔK permits the selection of an ambient or operating temperature, q*, in a reactor over a large range without causing an unfavorable rise in vapor pressure in collapsing bubbles.

Lithium and beryllium are unique among host metals. Their use in a CFR gives rise to material products which either may be used as fuel in subsequent cavitation events or are inert gases effective in slowing down neutrons.

Both of the natural isotopes of lithium interact with neutrons to produce helium-4 and Tritium. Lithium-6 has a large collision cross section for the capture of thermal neutrons and the reaction produces energy absorbed as heat. The more abundant isotope, lithium-7, which has a much smaller cross section for thermal neutrons, reacts with an energetic neutron to produce another neutron as well as helium-4 and Tritium.

The natural isotope of beryllium ($_4Be^9$) interacts with energetic neutrons to produce helium and Tritium. In one reaction chain, beryllium produces two neutrons and two helium-4 nucleii for every beryllium nucleus interacting with a neutron. In a second chain, the reaction produces helium-4 and Tritium and a net gain in energy as well, via an intermediate stage in which lithium-6 is produced.

In interactions with neutrons released by fusion reactions, both lithium and beryllium thus produce helium-4 and Tritium as end products. The helium-4 is an inert gas which helps moderate energetic neutrons and the Tritium can be used directly as fuel in the CFR or removed for use in other fusion reactors. Hence a host liquid of lithium or beryllium would provide a regenerative system re-seeding itself with Tritium.

The relatively high vapor pressure of beryllium above its melting point and its small value of ΔK mitigate against its use as a host liquid alone, but alloys of lithium and beryllium have several advantages neither lithium or beryllium alone possesses. Such alloys containing Hydrogen isotopes would be very effective in slowing down and capturing energetic neutrons released in fusion reactions. In such reactions, helium-4 and Tritium and energy would be produced.

The phase diagram for Li-Be alloys does not seem to have been determined. However, the chemical similarity between beryllium and aluminum makes it probable Li-Be alloys behave much as Li-Al alloys. Based on the phase diagram for Li-Al, it is anticipated addition of beryllium to liquid lithium would gradually increase the melting point and the sound speed of the alloy. The great advantage of such an alloy would be this increase in the speed of sound as compared to lithium alone. At the same time, vapor pressure of beryllium at such temperatures would be very low compared to lithium alone. Solid beryllium has a sound speed of 1.24×10^4 m

sec^{-1} while liquid lithium has a sound speed of 4.2×10^3 m sec^{-1} at 1000 K. Thus the sound speed of a liquid Li-Be alloy at that temperature should be much higher than Li alone.

The liquid metals used in a CFR, therefore, can be regarded as falling into three categories:
1. Alpha-metals in which H-isotopes dissolve readily and with which H-isotopes form stable compounds over at least part of the ambient or operating temperature of interest. The most important metal of this type is lithium, either in the natural isotopic mixture of lithium-6 ($_3Li^6$) and lithium-7 ($_3Li^7$) or as one of those isotopes alone, or as lithium-7 enriched with lithium-6.
2. Beta-metals in which H-isotopes dissolve readily but with which they do not form stable compounds over the operating temperature of interest. The most important metals of this type are beryllium and aluminum.
3. Gamma metals in which H-isotopes neither dissolve readily nor with which they form stable compounds in the operating temperature of interest. Tin, thallium and indium are examples of such metals.

In a Type I CFR the host metal is usually normal lithium, lithium-6, lithium-7, beryllium or an alloy of these light metals. In a Type II CFR, the host metal is, usually, tin, thallium, indium or aluminum.

DISTRIBUTION OF HYDROGEN ISOTOPES

The Hydrogen isotopes are distributed in the host liquid either as dissolved gas, as hydrides, or as small bubbles or "seeds". Seeds containing H-isotopes and vapor of the host metal may be a random distribution of bubbles of very small size (with an average equivalent radius of the order of 10^{-5} to 10^{-4} cm) or a carefully generated set of bubbles of much larger size. Helium may also be included as the third constituent of the content of a seed.

In an alpha metal such as lithium, at a given ambient temperature, q*, the mol fraction, Y_H, of H-isotopes dispersed in the liquid (either dissolved or as hydrides or stabilized as a gas) is a function of the "dissociation pressure" p_H*. Thus control of p_H* above a surface of the liquid controls amount of gas, Y_H, dispersed in the liquid. It is assumed the ambient temperature is higher than the melting point of any hydrides which may form. Because H-isotopes both dissolve in and combine chemically with alpha-metals, the gas in a bubble tends to be at its equilibrium pressure, p_H*, which usually is much less than the ambient pressure in the liquid. As a result the only bubbles in an alpha liquid persisting in time are very small ones stabilizing on minute inhomogeneities such as fragments of hydrides. In such a host liquid, the amount of gas in a growing or contracting bubble at any time has little relation to the amount of gas in the original seed from which it grew.

When an alpha-metal such as lithium is used as the host liquid, there is one simple procedure by which seeding of the liquid may be accomplished. An atmosphere of H-isotopes is maintained over a surface of the host liquid at the dissociation pressure, p_H*, corresponding to the mol fraction, Y_H, specified for the CFR at the specified ambient temperature, q*. The H-isotopes are absorbed, either in dissolved form or as hydrides. Small seeds of H-isotopes will nucleate on existing inhomogeneities in the liquid. As a result, there will be a stable distribution of very small

seeds with some equilibrium size (of the order of 10^{-5} to 10^{-4} cm in equivalent radius). A more rapid dispersion would be effected by allowing the liquid metal to be mixed mechanically with the H-isotopes under the same conditions.

The net gain of energy produced by a CFR is maximized when the fuel used is a mixture of Deuterium and Tritium distributed through a host liquid of lithium or of a Li-Be alloy. In one mode of operation, Deuterium is introduced into the host liquid at a surface and diffuses into the cavitation zone. The required inventory of Tritium is then produced in the cavitation zone by fusion of Deuterium nuclei alone. A specified mol fraction, Y_d, of Deuterium is maintained in the host liquid by the appropriate dissociation pressure, p_d*, over a surface and the specified mol fraction, Y_t, of Tritium maintained by the fusion and neutron reactions to produce Tritium. Thus only Deuterium, the naturally occurring isotope of Hydrogen, need be supplied to the CFR from an external source for fuel, both during the start-up phase and the steady-state operation of the CFR.

In another mode of operation, Tritium required in the start-up phase is introduced into the host liquid containing lithium-6, lithium-7, beryllium or helium-3 by irradiating the host liquid with neutrons from an external source. Deuterium is introduced into the host liquid at a surface (as above) and diffuses into the cavitation zone where Tritium is being generated by neutrons. A specified mol fraction, Y_d, of Deuterium is maintained in the host liquid by the appropriate pressure, p_d*, over a surface and the initial inventory of Tritium maintained by fusion and neutrons reactions which produces Tritium.

As will be noted later, the mol fraction of H-isotopes maintained in a CFR's host liquid has a critical effect on operation of a CFR using an alpha-metal such as lithium.

In gamma metals, it is possible to use much larger seeds of H-isotopes which can be introduced in a variety of fashions. While in alpha-metal such as lithium, the average seed will be a bubble having an equivalent radius of 10^{-5} to 10^{-4} cm, seeds of the order of 10^{-3} cm to 10 cm will be used in a gamma-metal liquid. The expected maximum radius, R_o*, of a bubble will be 500 to 10,000 times larger than the initial radius, R_n*, of a seed. Hence the order of magnitude of R_o* will change with the expansion ratio, R_o*/R_n*, as follows:

Expansion ratio = 500	1000	10,000
R_n* (cm)	R_o* (cm)	R_o* (cm)	R_o* (cm)
10^{-5}	5×10^{-3}	10^{-2}	10^{-1}
10^{-4}	5×10^{-2}	10^{-1}	1
10^{-3}	5×10^{-1}	1	10
10^{-2}	5×10^{0} 10	10^{2}	

The use of large bubbles as seeds is advantageous in a Type II CFR because the amount of H-isotopes contained in a seed increases as R_n^{*3} so a seed with $R_n^* = 10^{-2}$ cm has 10^9 more H-nucleii than a seed of 10^{-5} cm In a gamma liquid, the H-isotopes neither dissolve or react readily with the host liquid so the amount of gas in a seed is essentially that in the bubble at the start of the collapse phase. However, the use of large bubbles as seeds require the cavitation zone be in a

zero-gravity field.

When a distribution of such large seeds are introduced in a gamma-metal liquid in a zero gravity field, the distribution will be relatively stable in space and time. In the absence of gravity, bubbles will not rise to the surface nor disappear rapidly through diffusion.

When beta-metals are used as host liquids, the behavior of gas bubbles is much the same as in alpha metals except for the absence of hydrides in the host liquid. Alloys of Li-Be will fall in the alpha-metal category.

In addition to the methods described above for seeding CFR using alpha-metals as the host liquid, the following methods for seeding a host liquid may be employed:

1. Small seeds of H-isotopes in a beta-metal may be caused to grow into seeds of a specified size through the process of rectified diffusion brought about through an auxiliary acoustic field which may be independent of the hereinafter described primary field causing bubbles to grow to many times their initial size.

2. A metal which resists attack by the host liquid may be caused to absorb H-isotopes in appreciable quantities and then inserted into the wall of the reaction chamber or into the liquid at a surface other than a wall. The inner face of this insert will then be caused to release seeds into the host liquid by a variety of methods (e.g., by a change of pressure at the external surface of the insert). The H-isotopes injected into the host liquid would then be replenished in the solid insert by additional gas absorbed at its outer surface.

3. A metal which resists attack by the host liquid may be caused to absorb H-isotopes in appreciable quantities and then inserted into the host liquid as an electrode. A positive voltage applied to the electrode would then evolve seeds of H-isotopes of controllable size. The size of the seeds would be a function of the voltage applied.

4. Small particles of controlled size made up of compounds of a metal and H-isotopes are distributed through the host liquid and then caused to dissociate into the metal and seeds of H-isotopes by changing the ambient temperature of the host liquid. The size distribution of the seeds would be determined by the size distribution of the particles in a gamma-metal but not in an alpha metal.

5. Small particles of controlled size containing H-isotopes as dissolved or absorbed gases are distributed in the host liquid and then caused to evolve known amounts of these gases when the particles dissolve or the ambient pressure and pressure are changed.

Simple mechanical agitation of the host liquid (by a stream of H-isotopes through the liquid, for example) in the presence of H-isotopes would produce a random distribution of seeds whose average size in general would be small except in a gamma-metal in a zero-gravity field. In general, large bubbles would tend to dissolve away or rise out of the host liquid while bubbles of the order of 10^{-4} cm radius or less would move about in a random fashion because of Brownian motion if stabilized against diffusion.

OPERATING TEMPERATURE

The specification of an operating temperature, q_n*, depends on the type of cavitation fusion

reactor. Viewed as part of a thermodynamic system, the host liquid is simply a reservoir from which heat is transferred to a second, external reservoir. The fraction of energy in the second reservoir available for conversion to useful work increases when its temperature increases.

Because the fusion-generated heat is transferred to the external reservoir by conduction, this thermodynamic condition requires the host liquid be operated at as high a temperature as possible consistent with other constraints.

There are several constraints which effectively place an upper limit on the ambient (or operating) temperature. One is the corrosion of the reaction chamber by the liquid metal used as the host liquid. The attack by a liquid metal on such surfaces is accelerated by an increase in temperature and the host metal will become increasingly contaminated by material from the reactor surfaces. Another constraint is the vapor pressure, p_v*, of the host liquid, which is a rapidly increasing function of the temperature. The vapor pressure in a bubble may have a disproportionate effect on the dynamics of bubbles; a high vapor pressure may moderate the collapse of a bubble and a large mol fraction of vapor atoms in the bubble may impede the operation of both Type I and Type II reactors.

In either CFR, both the host liquid and the contents of a bubble will remain at the ambient temperature, q_n*, during all of the expansion phase and most of the contraction phase. In the final stage of collapse, the bubble and a thin shell of liquid around it are compressed adiabatically and the terminal, constant values of the entropy in the bubble and in the liquid shell are to a large extent determined by the ambient temperature.

In a Type I CFR, a major design objective is to achieve as high a maximum pressure as possible in the liquid at the bubble interface on collapse. This objective requires the terminal, constant value of the entropy, S_c*, of the gas and vapor in the bubble be minimized and hence a low ambient, or operating, temperature be chosen. In a Type I CFR, the objective of a high maximum pressure on collapse also necessitates the amount of H-isotopes and vapor in the bubble be minimized when the radius approaches its minimum value, R_m*. For given mol fractions, Y_d and Y_t, of Deuterium and Tritium in the host liquid, the equilibrium “dissociation pressure”, p_H*, of the H-isotopes is a function of the ambient temperature when the host metal is an alpha-metal. A choice of a low ambient temperature minimizes both pH* and p_v* and hence the amount of H-isotopes and vapor in the bubble on collapse.

In a Type I CFR, generation of thermonuclear fusion in a thin shell surrounding the collapsed bubble is not a critical function of the terminal, constant value of the entropy, S_L*, in the liquid shell. Hence placing some upper limit on the operating temperature does not in itself mitigate against the generation of very high temperatures in the liquid on collapse of a bubble. In a Type I reactor, the temperature in the liquid shell is multiplied by the very intense shock wave radiated by the bubble interface near its minimum radius and the condition for fusion is reached by a sequence of adiabatic compression of the liquid followed by a second compression by the shock wave.

However, there is a lower limit on the ambient (or operating) temperature when the host liquid is an alpha-metal. Then a lower limit on the temperature is established by the requirement it be greater than the melting point of any solid hydride which can form. In lithium where LiH melts at 975 K (or even less depending on the fraction of H-isotopes present) the host metal would have a vapor pressure of approximately 15 mm Hg at 1200 K. At an operating temperature of 1000 K to 1200 K, the vapor pressure would still be low and there still would be present in the liquid minute fragments of the hydrides which would serve as nucleation sites for seeds of H-isotopes.

Furthermore, in a Type I CFR using lithium, the range of 1000 K to 1200 K is high enough to cause a terminal value of S_c* at which fusion of Deuterium alone can occur in the start-up phase.

In general, a high vapor pressure within a bubble is undesirable for the reasons stated above. Lithium is an exception to this general design criterion. At low concentrations, lithium atoms in a mixture of H-isotopes will markedly reduce the thermal conductivity of the gas-vapor mixture and hence assist in bringing about adiabatic compression of the bubble's contents at an earlier stage of motion. Lithium nuclei in a mixture of H-isotopes may serve as a fuel in thermonuclear reactions with those isotopes. While in most liquids, it is desirable to keep the vapor pressure and hence the ambient temperature low, the restriction is not critical for lithium at temperatures at or below 1200 K.

In a Type II CFR, a major design objective is to achieve the highest possible temperature within a collapsed bubble. The final temperature reached in the adiabatic compression of a bubble is an exponential function of the terminal, constant value of the entropy. This statement is exact for an ideal gas and an approximate one for non-ideal gases. This requirement means the entropy, S_c*, of the contents should be as large as possible during the adiabatic compression of a bubble in a Type II CFR. If the host metal is tin, the vapor pressure is 1.33×10^{-3} mm Hg at 1400 K. Hence the operating temperature in a Type II CFR may be as high as 1400 K or 1500 K in order to achieve a large value of S_c* in the final stage of collapse without having an undesirably high vapor pressure.

In a Type II CFR, a large value of O_n* combined with a low value of p_v* means less mechanical energy is used in dissociating and then ionizing the gas and a larger share is then used in heating the ionized gas to high temperatures. The fewer heavy vapor atoms present, the more rapidly will the process of ionizing the H-isotopes be completed.

OPERATING PRESSURE

The static, operating (or ambient) pressure, p_{ln}*, of a CFR is the pressure which exists in the host liquid independently of a time-varying pressure, p_A*(t). The total pressure in the cavitation zone of the host liquid is the sum of p_{ln}* and p_A*(t). There are several ways this parameter may be used to control the operation of a CFR.

The static pressure affords an alternative way to apply a positive pressure of specified magnitude to a bubble which has expanded to a maximum radius, R_o*, and starts to contract. In some modes of operation, it may be preferable to transfer mechanical energy to the collapsing bubble via the

static, ambient pressure than by means of an acoustic pressure. For example, when the applied pressure field consists solely of a negative pulse, causing a seed to expand into a much larger bubble, the required positive pressure at the start of collapse may be supplied by the ambient pressure. However, it is important to point out the speed of collapse depends almost solely on W_m*, the total mechanical work done on the bubble by the total pressure. The ambient pressure, p_{ln}*, may be 1 bar or 100 bars, but the speed of collapse for a given compression ratio, R_o*/R*, is controlled by Wm* and not by p_{ln}*.

One effect of p_{ln}* is to change the amount of H-isotopes contained in a bubble with a specified equivalent radius, R_n*. Thus, for R_n* = 10^{-3} cm, a bubble would contain 50 times more gas when p_{ln}* = 100 bars than when p_{ln}* = 1 bar. In a Type II CRF, this multiplication of H-nuclei available in a large seed is an important factor in energy gain and neutron production.

There are several factors which place an upper limit on the ambient pressure in a CFR. Diffusivity and solubility of H-isotopes in metals such as W, Mo, Ti and Zr (which may be used as walls of the reaction chamber) increase rapidly with pressure. Hence the normal specification of p_{ln}* will be due to hydrostatic pressure plus the dissociation pressure, p_H*, of the H-isotopes present in order to assist in containment of Tritium within the reaction chamber.

Large negative and positive pressures p_A*(t) must be established in the cavitation zone of any CFR. These pressure fields may be generated in a variety of ways and devices. However, as noted above, the most important quantity associated with the interaction of a bubble with such a field is the amount of mechanical energy transferred to the bubble during its expansion from a seed and its subsequent collapse. The detailed specification of the acoustic field and the manner it is generated are less important than its ability to transfer a given amount of energy to the bubble.

There is, however, one important time constraint on the cycle of negative and positive pressure created in the CFR. At the start of such a cycle, the pressure falls to some negative minimum and then rises back to zero. This time interval the pressure p_A*(t) is negative must be long enough in duration for the seed to grow to its maximum size before a positive pressure is applied. A typical example is a seed whose initial radius, R_n*, is 2 x 10^{-5} cm As a result of an applied negative pressure of -50 bars, the seed grows into a bubble whose maximum radius, R_o*, is 2.7 x 10^{-1} cm during a time interval of 1.8 x 10^{-4} sec. Under an applied positive pressure of +50 bars, the bubble collapses to a minimum size in 1.7 x 10^{-4} sec. If the acoustic pressure field in this example were time-harmonic (or sinusoidal), the period would need to be at least 3.6 x 10^{-4} sec. and the frequency not greater than 2.8 x 10^3 Hz. Otherwise, the expansion ratio of the bubble would be much less and the collapse much less violent. That is, if the frequency were higher, the bubble would not reach the maximum radius of 2.7 x 10^{-1} before it started to contract under the positive pressure.

The volume of the host liquid occupied by the cavitation zone, the number of cavitation events taking place during one pressure cycle and the repetition rate of such events have important roles in determining the power output of a CFR. The economic utility of a CFR increases when:
1. In one pressure cycle, thermonuclear fusion is brought about in many bubbles.

2. The pressure cycle is short enough so the expansion-collapse cycle of bubbles occurs many times in a second.

The cavitation zone must be large enough so there is no interaction between bubbles as they expand and collapse during a pressure cycle. If the maximum radii of the bubbles were 0.1 cm on an average, then a sphere with a radius of 2 cm would be a cavitation zone where 10 bubbles could grow and collapse without undue interaction when the applied pressure amplitudes are large (say, of the order of 100 bars).

If the repetition rate of the acoustic field is 2000 Hz and the number of bubbles creating thermonuclear fusion is 10 in any cycle, then there would be 2×10^4 cavitation events in the cavitation zone specified above in each second. If each event yields 10 Joules, the power generated in the reactor is 200 kilowatts. This simple calculation shows the premium placed on the use of small bubbles. The number of bubbles created in a cavitation zone at any given times obviously may be increased with a decrease in the average maximum radius, R_o*, of the bubbles, and a decrease in R_o* permits an increase in the repetition rate.

This conclusion favors the use of a Type I CFR. The operation of a Type II CFR with large seeds must compensate for this decrease in the possible number of cavitation events per second. This compensation can be done through an increase in the fuel nuclei contained in each bubble. However, when a Type II CFR is operated as a device for producing Tritium rather than energy, this condition is not so important.

The cavitation zone in a reactor is determined by the geometry of the acoustic field. A pressure field in which the required pressure amplitudes occur only in a very small volume decreases the power output of a CFR by decreasing the number of cavitation events per pressure cycle.

The applied pressure field may be generated in several ways. Two important classes are:
1. Resonant systems
2. Non-resonant systems.

Resonant systems designed around elements such as resonant cylinders, resonant spheres and Helmholtz resonators are typically simple devices useful in some modes of operation of a Type II CFR where a high repetition rate is not required. The drawback on their use is the operation of such resonant systems normally requires the host liquid be homogeneous. Once a bubble has grown from a seed, the condition for resonance has been destroyed until all bubbles have expanded to their maximum radii, collapsed and effectively vanished.

When a resonant device is used to produce a required negative pressure (say, -50 bars), the required positive pressure to be applied during collapse can be supplied by using a static, ambient pressure, p_{ln}*, of appropriate magnitude. The cycle of expansion and collapse would be repeated when the condition for resonance is reestablished.

Non-resonant systems are used to establish pressure fields either harmonic in time (sinusoidal) or

are pulse like. Thus:
(a) Time harmonic fields are established by transducers (external to the chamber) continuously maintaining a required time sequence and positive pressure amplitudes in the cavitation zone.
(b) Pulse-like fields are alternating pulses of negative and positive pressures generated, for example, by shock excitation of a surface in contact with the host liquid, either directly or via "horns".

Both kinds of non-resonant systems may be focused by means of acoustic lenses or by reflection from a curved surface at which there is a large change in the specific acoustic impedance. When a negative pulse of appropriate amplitude is generated in the host liquid, the corresponding positive pulse may be generated by reflection of the negative pulse from a surface whose specific acoustic impedance is very low compared with the host liquid (i.e., from the free surface of the host liquid). The amplitude of the positive pulse is controlled by specification of the ambient pressure, which increases the total pressure on the collapsing bubble to the required value.

When a bubble has reached a maximum radius very much larger than its initial, equivalent radius, the collapse consists of two phases or stages. In the first phase the contents of the bubble remain at the ambient or operating temperature of the host liquid. In the second phase the increasing speed of collapse brings about a transition to an adiabatic compression of the bubble contents and of a thin shell of liquid surrounding the bubble. The positive pressure applied to a collapsing bubble causes this transition to occur at a larger radius than would occur in its absence, and also causes the bubble to contract to a smaller minimum radius. The smaller the minimum radius the greater are the maximum temperatures and pressures reached in the bubble and in the liquid.

At, or near, the minimum radius, a very intense shock wave is radiated by the bubble. The crucial difference between the design of a Type I CFR and a Type II CFR is the relative importance in each of the adiabatic compression of a bubble's contents and the very high pressures and temperatures created in the host liquid by the intense shock wave. A controlling factor during a cavitation event is the amount of work done on a bubble by the applied pressure field. There are many ways the parameters of the applied pressure field (duration, period, amplitude) may be chosen, but they are effectively equivalent if the work done on a bubble is the same.

STABILITY OF THE BUBBLE INTERFACE

The generation of high pressures and temperatures produced by a collapsing bubble in the host liquid depends strongly on whether or not the interface of the bubble remains spherical during most of the collapse. When the bubble is expanding, the interface is stable in shape, but when the acceleration is inward the interface is dynamically unstable against any small perturbation of the spherical interface caused by asymmetrical forces. However, in the very final stage of collapse, the acceleration is again outward and the interface is again stable.

The gravitational field of the earth is an asymmetrical force tending to create perturbations in a bubble's interface and this external force may cause the spherical interface of bubbles to deform during collapse. A zero-gravity field in which such distortions of the initial spherical shape do

not occur is found in an orbiting space vehicle. On the surface of the earth a similar cancellation of the earth's gravitational field is produced in a properly designed static, inhomogeneous magnetic field. Both the contents of the bubble and the host metals are either diamagnetic or paramagnetic and, as a consequence, a magnetic field may be so designed so in the cavitation zone of the host liquid the vertical force per unit area (magnetic pressure) exerted by the magnetic field on the surface of the bubble cancels the force per unit area (gravitational pressure) exerted on the bubble by the gravitational field.

A static magnetic field, B*, readily penetrates a liquid metal and in this invention an inhomogeneous magnetic field, similar to those generated in conventional magnets, is used to create an approximately zero-gravity field in the cavitation zone of a CFR.

A horizontal magnetic field, B*, is established in the host liquid so its strength falls off rapidly along a vertical axis from its specified maximum, B_o*. Below the maximum, the gradient of the field is positive (with positive distance upward) and above the maximum the gradient is negative.

At any point in the host liquid, the force due to gravity may be cancelled in the cavitation zone by an upward force due to a magnetic field, calculated to show, for a given example, B_o* must be 44 kilogauss in the absence of a bubble and 30 kilogauss in the presence of an H-isotope bubble. Hence, in this example, a value of B_o* of the order of 30-44 kilogauss would effectively cancel the effect of gravity in the cavitation zone.

The crucial statement is, by proper design of an inhomogeneous magnetic field, there will be a region in the host liquid where any value of B_o*, equal to or less which value specified for cancellation of gravity, will also help inhibit the growth of an instability of the bubble interface. Properly designed (as described hereinafter) an inhomogeneous magnetic field counteracts the effect of gravity and creates a "zero-gravity" field in the cavitation zone of the host liquid. Normally, large seeds placed in a liquid rapidly float to the surface and disappear from the cavitation zone. However, the zero gravity field used in a CFR will cause such seeds to remain in the cavitation zone where they are introduced or generated. Thus such seeds remain at their site of formation and in a Type II CFR do not vanish through diffusion of the H-isotopes into the liquid metal. Similarly, in a Type I CFR a zero-gravity field causes seeds of Tritium generated by fusion to remain within the cavitation zone.

CHAMBER REACTIONS

All energy released in a CFR, whether electromagnetic or carried by charged particles or neutrons, is absorbed in the host liquid or in a liquid metal "blanket" surrounding the reaction chamber where fusion takes place. The nuclear reactions which yield this useful energy at temperatures attainable through operation of a CFR are:

$$_1H^2 + {}_1H^2 = {}_2He^3 + {}_0n^1 + 3.27 \text{ Mev}$$
$$_1H^2 + {}_1H^2 = {}_1H^3 + {}_1H^1 + 4.03 \text{ Mev}$$
$$_1H^3 + {}_1H^3 = {}_2He^4 + 2{}_0n^1 + 11.3 \text{ Mev}$$
$$_1H^1 + {}_3Li^7 = 2{}_2He^4 + 17.35 \text{ Mev}$$
$$_1H^1 + {}_3Li^6 = {}_2He^3 + {}_2He^4 + 4.02 \text{ Mev}$$

The energy released in each reaction is given in Mev (million electron volts).

Neutrons released by cavitation fusion give up their energy to the host liquid, to a moderator surrounding the host liquid, or to the liquid metal blanket until the neutrons have slowed down to speeds at which they interact with lithium or beryllium nuclei and in so doing create Tritium and energy through the following reactions:

$$_3Li^6 + _0n^1 = _1H^3 + _2He^4 + 4.8 \text{ Mev}$$
$$_3Li^7 + _0n^1 = _1H^3 + _2He^4 + _0n^1 - 2.47 \text{ Mev}$$
$$_4Be^9 + _0n^1 = _4Be^8 + 2_0n^1 = 2_2He^4 + 2_0n^1 - 2.70 \text{ Mev}$$
$$_4Be^9 + _0n^1 = _3Li^6 + _2He^4 + e^- - 0.71 \text{ Mev}$$

When the host liquid is lithium or beryllium, or a mixture of the two metals, and Hydrogen isotopes are dispersed in the host liquid, the fusion reactions have as end products only helium and Hydrogen isotopes and of these the only radioactive by-product is Tritium, which may be contained within the reactor and used as fuel. In the fusion reaction involving $_1H^1$ and $_3Li^7$, the only reaction product is helium-4 and there are no radioactive by-products. These elements—Hydrogen, helium, lithium and beryllium—are the most effective moderators of fast neutrons produced in fusion reactions. Both lithium-6 and helium-3 (produced in several fusion reactions) have large capture cross sections for neutrons which have thus been slowed to thermal or threshold energies.

A primary object of this invention, therefore, is to provide a novel method of utilizing the phenomenon of cavitation of a liquid metal to produce a thermonuclear reaction.

Another object of this invention is to provide a novel method of effecting thermonuclear fusion of Hydrogen isotopes in a liquid host metal by inducing a cavitation effect in the metal.

A further object of this invention is to provide a novel cavitation fusion reactor for carrying out the reaction taught by this invention, and for utilizing the by-products resulting from such reaction.

Still another object of this invention is to provide a reactor of the type described capable of functioning in a regenerative manner to generate Tritium which can be used as fuel for the reactor.

A further object of this invention is to provide a novel cavitation fusion reactor which uses metal acoustical horns both for transmitting energy to the liquid metal in the reactor chamber and to conduct fusion heat from the chamber to a heat exchanger disposed externally of the chamber.

Other objects of the invention will be apparent hereinafter from the specification and from the appended claims, particularly when considered in conjunction with the accompanying drawings.

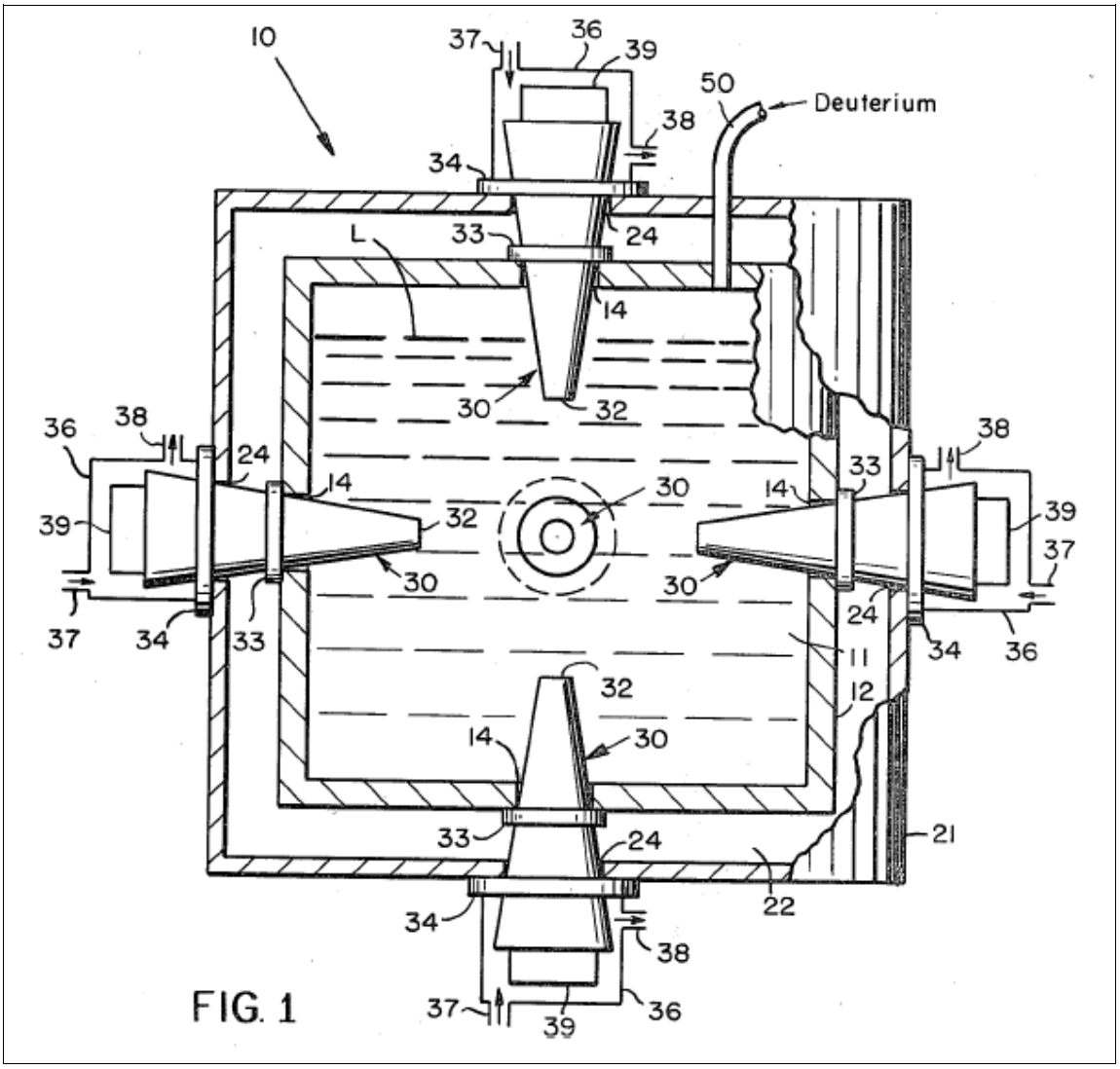

FIG. 1 is a schematic fragmentary sectional view taken through the center of a Type I CFR, which is made according to one embodiment of this invention.

In the Drawings:

TYPE I CFR

Referring now to the drawings by numerals of reference, and first to **FIG. 1**. 10 denotes generally a Type I CFR comprising an inner chamber 11 adapted to contain a host liquid, such as, for example, lithium or an alloy of lithium and beryllium. Chamber 11 is formed by a housing 12 made from a refractory metal such as tungsten, titanium, molybdenum, rhenium or alloys thereof. In the embodiment illustrated, housing 12 is shown to be generally cylindrical in configuration, but it is to be understood its shape can be altered (e.g. to be made spherical) without departing from this invention. Moreover, although specific refractory materials have been suggested, it is to be also understood refractory metals in Groups IV B, VB and VIIB of the periodic table may be

used provided the metal used can be easily penetrated by a static magnetic field for reasons noted hereinafter.

Housing 12 is surrounded by a neutron and Tritium shield 21, similar in configuration to, but larger than, the housing 12. (See Hansborough, L. D., Tritium Inventories and Leakage: A Review of Some Theoretical Considerations, pg. 92 in AEC Symposium Series No. 31, The Technology of Controlled Thermonuclear Fusion Experiments And The Engineering Aspects of Fusion Reactors; and, Stickney, R. E., Diffusion and Permeation of Hydrogen Isotopes in Fusion Reactors: A Survey, pg. 241 in The Chemistry of Fusion Technology (D. M. Gruen, ed.) Plenum Press, 1972). The annular space 22 between housing 12 and shield 21 is adapted to be filled with helium.

Six solid acoustic horns 30, generally truncated-conical in configuration, are used in the embodiment illustrated in order to supply acoustic energy to chamber 11 and to remove fusion heat from the host liquid. Two of the horns project into opposite ends of the chamber 11 coaxially thereof, and the other four project into the chamber medially of its ends, and at 90° intervals about its axis.

Each horn 30 is made of tungsten, or another suitable refractory metal possessing both high tensile strength and a large value of thermal diffusivity, and is mounted intermediate its ends in registering openings 14 and 24 in the adjacent walls of housing 12 and shield 21, respectively, so the tip or discharge ends 32 of the horns project equidistantly into chamber 11. Two spaced, external flanges 33 and 34, located on each horn at its velocity nodes so no motion will be imparted to the flanges, are secured to the outer surfaces of the associated walls of housing 12 and shield 21 around the openings 14 and 24, respectively, so these openings are effectively sealed to prevent any leakage between chamber 11 and the surrounding space 22 between housing 12 and shield 21.

Rearwardly of its flange 34 each horn 30 has its outer end enclosed in a heat exchanger housing 36, having an inlet 37 connected to a supply of heat exchange fluid, and an outlet 38 connected to a device which is to receive the heat energy drawn from the reaction which takes place in chamber 11. Also mounted on the outer end of each horn 30 within the associated exchanges housing 36 is a conventional transducer 39, operable in a known manner to supply mechanical energy to the associated horn 30. As shown more clearly in **FIG. 1**, the outer end of each horn 30 and its associated transducer 39 are enclosed within a heat transfer housing 36, so any heat generated in the horn as the result of a fusion reaction in chamber 11 will be transmitted through the horn and transducer 39 to the fluid which circulates in the associated heat exchange housing 36.

Also as illustrated in **FIG. 1**, the six horns (only five of which are illustrated) are positioned to form three pairs of coaxially disposed horns, with each pair having its axis lying in one of three different planes intersecting one another at right angles. Assuming the outer surface of each horn 30 is So and the inner surfaces Si, the conical taper of the horn causes a broad beam of intensity Io to change into a narrower beam of intensity Ii = Io (So/Si). The particle velocity of the narrow

beam radiated into the chamber 11 increases as the square root of the ratio So/Si. Therefore a decrease in the radius of the horn by a factor of 4 increases the intensity by a factor 16 and the particle velocity by a factor of 2. The pressure in the beam radiated from the inner end of each horn increases in the same ratio as the particle velocity—i.e., by a factor of 2. Consequently with the arrangement as illustrated in **FIG. 1**, when each horn increases the pressure by a factor of 2, the six horns increase the total pressure in the cavitation zone (the volume in chamber 11 where the beams from the horns intersect) by a factor of 12. Thus a pressure of 10 bars at So of each horn becomes a pressure of 120 in the cavitation zone.

Instead of using six transducers 39 as described above, it would be possible to use an array of three transducers, so arranged there is a reflecting acoustical mirror opposite each inner surface of a horn 30. Such as arrangement will concentrate acoustical energy in the cavitational zone as before, but the design decreases the number of holes which must be made in the walls of the housing 12 defining the chamber 11. Refractory metals such as tungsten make effective mirrors because their characteristic acoustic impedances are 30 times greater than which of lithium at 1000 K and the pressure reflection coefficient of such a mirror would be of 0.94.

Although solid horns 30 have been specified in **FIG. 1** as a means of transferring acoustical energy in the reaction chamber 11, and to extract heat from the chamber, this dual function could also be performed, as desired, by a modified acoustical horn of the type denoted at 40 in **FIG. 2**.

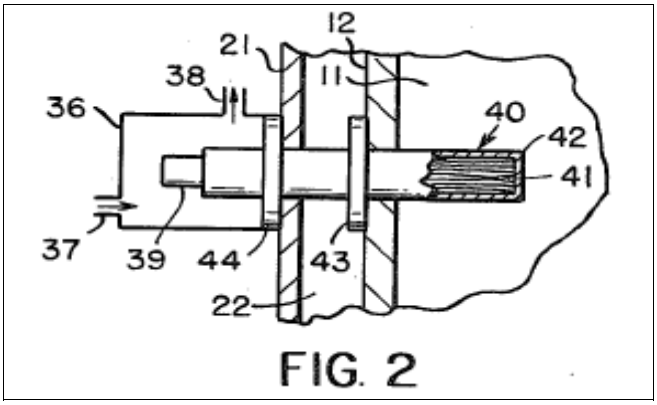

FIG. 2 is a fragmentary sectional view of part of a modified form of the CFR shown in FIG. 1, and illustrating an alternative form of acoustical horn.

Each such horn 40 may comprise a bundle 41 of metal fibers made of a refractory metal such as tungsten, and enclosed or encased within a shield or housing 42 made of the same material (tungsten, for instance). As in the case of the previous embodiment, housing 42 has thereon a pair of external flanges 43 and 44, which seat against the outsides of the walls of housings 12 and 21 to secure the housing 42 in the registering openings in these walls so the forward end of each housing 42 projects into chamber 11. The outer end of each housing 42 projects into a heat exchange housing 36 through which fluid flows, as in the case of the first embodiment, to remove heat transferred by the horn 40 from chamber 11 to the exterior of the shield 21. Also as in the

first embodiment a transducer 39 is secured to the outer end of horn 40 for supplying energy thereto.

The advantage of the embodiment shown in **FIG. 2** is removal of heat from the fiber bundle is facilitated by the large increase in surface area in contact with the heat transfer fluid. If desired, the external end of the fiber bundle 41 may be attached to a solid horn disposed outside of the chamber 11.

In use of CFR of the type denoted at 10 has its chamber 11 approximately filled with a host liquid, such as lithium or an alloy thereof, to a level denoted at L in **FIG. 1**, so the tip of the horn 30 projects downwardly from the upper wall of housing 12 immersed in the host liquid. Preferably this host liquid is purified of all gases, such as oxygen and nitrogen, before H-isotopes are introduced. The reaction chamber 11 is likewise degassed, further helping to reduce corrosion of its walls.

Thereafter H-isotopes are distributed into the host liquid by feeding Deuterium through a tubular conduit 50 into the top of chamber 11 above the surface L of the liquid host. Conduit 50 is connected at one end to a supply of Deuterium, and at its opposite ends extends through registering openings in the shield 21 and the upper wall of housing 12.

One mode of operation of a Type I CFR requires the introduction only of Hydrogen (1 H1 of h) into the lithium, and the fusion reaction is between this isotope and lithium. However, in the example described in connection with the CFR as illustrated in **FIGS. 1 or 2**, the mol fraction Y_h of Hydrogen is taken to be zero initially, and the mol fraction of Deuterium Y_d, and the mol fraction of Tritium Y_t, in the steady state are taken to be equal, and their sum $Y_d + Y_t$ is approximately 0.1. The rate at which reaction (D, T,) occurs in the liquid host is proportional to the product Y_d and Y_t, and thus this product should be as large as possible without making the liquid metal more compressible. The Tritium inventory is built up in the host liquid by generating Tritium from Deuterium alone in the CFR during the start-up phase.

The concentration of Deuterium is maintained by the appropriate “dissociation pressure” (p_d*) over the surface of the host liquid. This pressure is a function of the mol fraction of H-isotopes dissolved into lithium and of the operating temperature. For a combined mol fraction of 0.1 of H-isotopes and the range of operating of temperatures specified hereinafter, this pressure would be on the order of 50 mm Hg or less. The initial concentration of Tritium is renewed by the fusion reactions and by its production in neutron capture by lithium. Also, distribution of seeds in the host liquid will be very small bubbles which nucleate on minute inhomogeneities such as fragments of the various hydrides which can form in the host liquid.

The operating or ambient temperature must be greater than the melting point of the hydrides which can form and less than about 1200 K, so in practice the range of temperature is approximately 1000 K to 1200 K. In order to assist nucleation of seeds, the ambient temperature must be lowered to the melting point of the hydrides and then raised back to the operating temperature. An external heat source will initially bring the reaction chamber 11 to the operating

temperature and thereafter the temperature is maintained by the heat caused from fusion. Operating or ambient pressure in chamber 11 is the sum of the hydrostatic pressure plus the gas pressure maintained above the surface of the host liquid and the vapor pressure of the liquid itself. Typically it is on the order of 1.0 bar or less.

For proper operation, a magnetic field inhomogeneous in the vertical direction (as illustrated in **FIG. 1**) and uniform in a horizontal direction is created in the host liquid by an external source.

For an H-isotope bubble in liquid lithium, a magnetic field B* with a maximum B_0* of the order of 30-44 kilogauss will approximately cancel the effect of gravity in the cavitation zone. The maximum is positioned above the cavitation zone and for values specified here, approximate cancellation occurs over a range of 4 cm, if the vertical gradient of the magnetic energy density is designed to be constant over that interval and B* becomes negligible outside that range. It is important to state a value of B_o* less than specified which will still be effective in helping inhibit the growth of an instability of the interface. This zero gravity field can also be created by the forced acceleration of the host liquid as a whole in such a manner the acceleration cancels effect of gravity during collapse of bubbles. A device such as an electromagnetic "shaker" causes the reaction chamber 11 to vibrate along a vertical axis. By choosing proper magnitude and frequency of vibration, the shaker imparts to the reaction chamber 11 a downward acceleration during part of the vibration cycle so the host liquid is essentially in "free fall" during the interval. The expansion-compression cycle of cavitation bubbles is timed so collapse of bubbles occurs during zero gravity interval created by the vertical vibration.

It should be noted, magnetic fields are widely used in industry to separate particles from paramagnetic fluids. Magnetogravimetric separation, for example, involves transformation of magnetic forces into hydrostatic pressures wherein "levitation" of immersed particles can occur. This technique therefore may also be applied, if desired, to provide the necessary zero gravity parameter required to perform applicant's process as disclosed herein. [See, e.g., Zimmels, Y., Y. Tuval and I. J. Lin, IEEE Transactions of Magnetics, MAG-13, 1047 (1977) Principles of High Gradient Magnetogravimetric Separation; Rowlands, G., IEEE Transactions of Magnetics, MAG-13, 992 (1977) Magnetostatic Energy of Parametric Particles in Magnetic Separators.]

At an operating temperature of 1000 K, thermal diffusivity of tungsten is 1.2 times greater than liquid lithium. Hence use of solid metal horns 30 or fiber bundles 41 of tungsten provide an effective way to remove fusion heat from the liquid lithium and transfer it out of reaction chamber 11. These horns or fiber bundles simultaneously transfer mechanical energy from external acoustic transducers 39 to the liquid lithium and transfer heat from the lithium to an external heat reservoir. In this manner, the liquid lithium remains in the reaction chamber 11 and all difficulties associated with pumping a hot, corrosive liquid metal are avoided. Heat is removed from the external portion of the horns or fiber bundles by direct contact with a heat exchange fluid circulating in housing 36. This use of a coolant in direct contact with the horn also serves to keep the outer face of a horn and any transducer attached to it at a constant temperature.

Additional heat transfer may also be provided by circulating the helium from space 22 between

housing 12 and shield 21 through a heat exchanger.

The solid metal horns may be driven at their outer surfaces in one of a variety of ways:
a. An array of piezoelectric or piezomagnetic ceramic shapes or crystals with a high Curie point.
b. An electrodynamic driver element which is not in actual contact with the outer horn surface. This device may be one similar to those described by Seeman and Staats [Seeman, H. J., and H. Staats, Acustica 6, 326-334 (1956)] for steady-state operation or a device such as which described by Eisenmenger [Eisenmenger, E., Acustica, a 186-202 (1962)], for generation of intense pressure pulses.
c. The outer face of the horn may be the termination of an acoustic transmission line driven by a remote source of acoustic energy.

Permeation of Tritium through the wall of housing 12 of reaction chamber 11 is inhibited by electrically isolating shield 21 from horns 30 or 40 and then placing a negative voltage on the reaction chamber and grounding a metal shell in or on the shield. H-isotopes, such as t, exist as ions when dissolved in metals and an electric field of the specified direction at the surface of the reaction chamber will drive the Tritium back into the interior of the chamber. If Tritium does escape from the reaction chamber, it will mix with the helium and then be removed from the inert gas by a variety of ways when it is circulated as a heat exchange medium.

A specified Deuterium pressure p_d* is maintained over the level L or surface of the liquid lithium in chamber 11 by connection of conduit 50 to an external reservoir of Deuterium.

Tritium generated in the cavitation zone will be concentrated in that zone by flow of acoustical energy into region of the host liquid. A fundamental requirement has been placed on the acoustic field in this example of a Type I CFR which is one pressure cycle consists of a negative pressure of specified amplitude followed by a positive pressure whose amplitude typically is twice which of the negative pressure. Thus on an average, the pressure will be a maximum in the cavitation zone and decrease with distance toward wall of the chamber 11. There will thus exist a negative pressure gradient in the liquid lithium. This pressure gradient will cause the H-isotopes to diffuse toward center of the cavitation zone relative to the liquid metal. In this manner the specified acoustic pressure field will itself be used to help contain the Tritium generated in the cavitation zone, and thus meet a primary design requirement.

In a steady state field, there may also be acoustic streaming causing a flow of the liquid lithium from inner surface of the horn to the cavitation zone. Such flows set up rotational patterns of convection which may also help contain Tritium in the cavitation zone. In a given mode of operation, streaming or the negative pressure gradient may be more effective in this containment. Streaming can be eliminated by using short bursts of a few cycles of negative-positive pressures while at the same time an average negative pressure gradient is maintained.

TYPE II CFR

The Type II CFR maximizes the production of Tritium and other useful products through thermonuclear fusion inside collapsing bubbles. The bubbles contain H-isotopes and vapor of the

host metal and, in one mode of operation, lithium vapor as well. In a Type II CFR fusion is brought about by the high temperatures and pressures caused by adiabatic compression of the bubbles' contents in the terminal phase of collapse. The host liquid is tin, although any one of the several gamma-type metals such as indium, thallium or gallium may be used. Characteristics of tin making its selection useful are its low vapor pressure over a wide range of operating temperatures, the very low or zero solubility of H-isotopes of Hydrogen in the liquid, and the instability of its hydrides in the range of operating temperatures. Although H-isotopes dissolve in it, aluminum may also be used in a Type II CFR as the host liquid.

The use of tin as the host metal requires its container be surrounded by a layer or "blanket" of lithium or a lithium-beryllium alloy in order to generate Tritium for use as a fuel. The blanket of Li or Li-Be will be referred to hereafter as the Li-blanket for brevity. The Li-blanket is separated from the host liquid by a neutron moderator to be described below as part of the reaction chamber. Tin has small collision and capture cross sections for neutrons and the function of the moderator is to reduce the energy of fast fusion neutrons to the range where they have a high probability of interacting with Li and Be and producing Tritium. The Li-blanket is at an operating temperature at which removal of Tritium is simply effected by acoustic means. A low amplitude acoustic field (as constructed with the high amplitude acoustic field in the cavitation zone) applied to the Li-blanket will cause any small aggregation of Tritium atoms to grow into bubbles which will rise to a surface of the blanket or aggregate in specified regions as described below.

The host liquid, tin, will contain little or no dissolved H-isotopes. Seeds containing such isotopes will be relatively large, with equivalent radii of 10^{-3} to 10^{-2} cm Although a variety of methods may be used to introduce seeds into the host liquid, a specific method will be described below. When such seeds are introduced into the host liquid below a zero-gravity field caused by an inhomogeneous magnetic field, the seeds rise until they enter the zero-gravity region in the cavitation zone. The seeds remain essentially unchanged in the cavitation zone until they are caused to expand and collapse by the applied acoustic pressure field. A bubble may then either reform as a seed in the cavitation zone and repeat the expansion-collapse cycle or be ejected from the cavitation zone by hydrodynamic forces or be released by pulsing of the magnetic field.

The operating temperature is in the range of 1400 to 1500 K, although lower temperature may be specified. At 1400 K, the vapor pressure of tin is 1.44×10^{-4} mm Hg or approximately 0.1 N m^{-2}. At that temperature, the vapor pressure of lithium is 129.4 mm Hg.

The Li-blanket will contain only low concentrations of Tritium which will be removed by acoustic degassing at interior regions. Hence the operating, or ambient, pressure will have little effect on permeation of Tritium through structural walls containing either liquid tin or liquid Li or Li-be. While the precautions for containment of Tritium described in connection with the Type I CFR will be retained, the choice of the operating pressure, p_{ln}, may be either low (of the order of 1 bar or less) or high (of the order of several hundred bars), depending on the mode of operating of the Type II CFR which is specified.

In both the Type I and Type II CFR's, the applied or acoustic, pressure is a sequence of a

negative pressure of 50-100 bars followed by a positive pressure of 100-200 bars.

As in a Type I CFR, a magnetic field uniform in a horizontal direction but inhomogeneous in the vertical direction is created in the host liquid (and in the Li-Be blanket as well) by an external source. The host metal, tin, is diamagnetic in the liquid state and has a susceptibility, $cL = 3.02 \times 10^{-6}$. H-isotopes are also diamagnetic with a susceptibility, $cc = -2.48 \times 10^{-5}$. Here we have two possible specifications for the magnetic field:

1. In order to cancel the gravitation force in the liquid in the cavitation zone in absence of a bubble, the maximum of the magnetic field, B_o*, should be 466 kilogauss and be located below the cavitation zone.

2. In order to cancel the gravitational force in the host liquid in the presence of a bubble, the difference $cL - cc = +2.17 \times 10^{-5}$, fixes the maximum, B_o*, at 174 kilogauss and locates it above the cavitation zone.

The magnetic field required for gravity cancellation in tin is approximately 6 to 10 times larger than required in lithium. When aluminum is used as the host liquid, the range of B_o* is 76-127 kilogauss.

The very large magnetic field required for gravity cancellation in a Type II CFR on the earth's surface makes the alternative specification for operation of a Type II CFR in a space vehicle in zero gravity flight an advantageous one.

Large bubbles such as those employed in a Type II CFR normally float to the surface of the host liquid or dissolve. By choice of tin as the host liquid, the solubility of H-isotopes in the host liquid is negligible and bubble will dissolve very slowly, if at all. By creation of a zero-gravity field in the cavitation zone, a bubble placed in the cavitation zone will remain unless ejected by force in the acoustic pressure field or hydrodynamic forces during collapse.

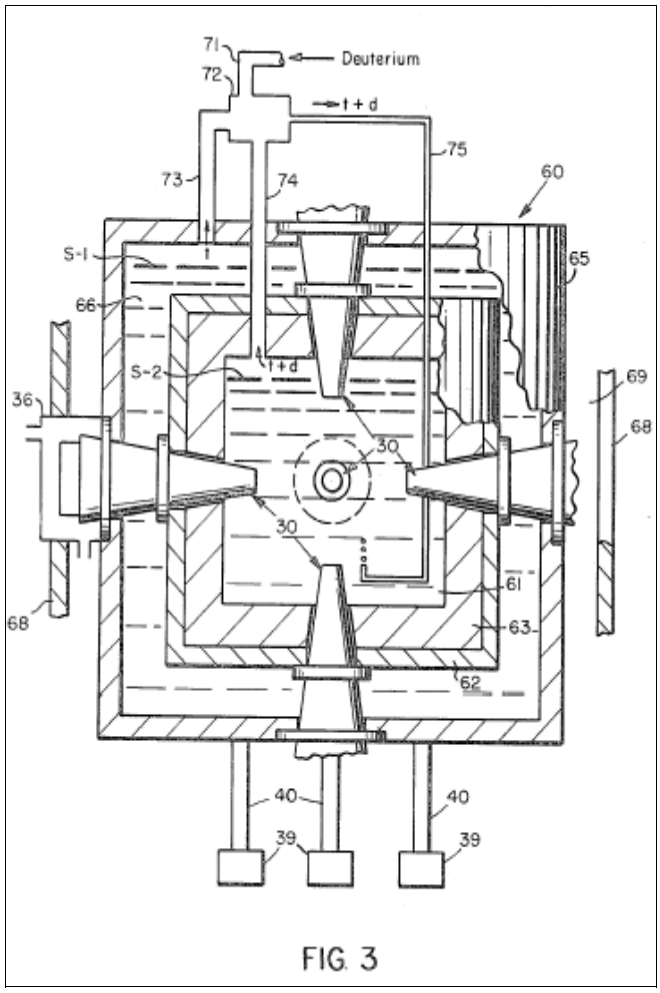

FIG. 3

FIG. 3 is a schematic, fragmentary sectional view taken through the center of a Type II CFR, made according to another embodiment of this invention.

Referring now to **FIG. 3**, 60 denotes generally a Type II CFR having a fusion chamber 61 formed inside of a cylindrical, inner housing 62, which, for example, is made of tungsten, and lined with a solid

layer 63 of beryllium. Housing 62 is surrounded in radially spaced relation by a second cylindrical housing 65, which may also be made of tungsten. The space between housings 62 and 65 contains a liquid metal 66, such as a lithium-beryllium alloy, which forms the above-noted Li-blanket between the housings. Outer housing 65 is, in turn, enclosed within a neutron-Tritium shield 68, similar to the shield referred to in the first embodiment. Also, as in the first embodiment, annular space 69 between shield 68 and the outer housing 65 is filled with a gas such as helium, or the like. The Be-blanket 63 functions as a moderator, slowing neutrons down to energies at which they react with the Li-blanket to produce Tritium. Outer surface of reaction chamber housing 62 and outer cylinder 65 are made of tungsten because these surfaces are in contact with the Li-blanket. Beryllium moderator layer 63 has fairly good corrosion resistance to liquid tin even at elevated temperatures, and any beryllium which dissolves will only enhance properties of the host liquid, for example, the host liquid will become less compressible.

The concentration of dissolved H-isotopes in the Li-blanket and in the liquid tin will be relatively small, and the problem of containment of Tritium in this Type II CFR is correspondingly less than in the case of the CFR shown in **FIG. 1**.

For supplying acoustic energy to the host liquid, an array (for example, six) of acoustical horns 30, which may be similar to the solid tungsten variety employed in the first embodiment, are mounted intermediate their ends in central, registering openings in housings 62 and 65 so their tapered or pointed ends project centrally into chamber 61 in spaced relation to each other. As in the case of the first embodiment, each of these horns has associated therewith a heat transfer housing 36 for removing heat from chamber 61 when the CFR 60 is operated as a generator of energy.

For providing low-power acoustic energy to the Li-blanket 66, another plurality of acoustical horns 40, which may be similar to the tungsten fiber-type horns illustrated in **FIG. 2**, are mounted on housing 65 for operation by their associated transducers 39. While in the embodiment illustrated in **FIG. 3** only three such low-power transducers 39 and their associated tungsten fiber bundles 40 are illustrated, it is to be understood additional such horns could be employed as desired.

Fuel is supplied to chamber 61 in the form of a mixture of Deuterium and Tritium. The Deuterium is supplied from an external source by means of a pipe 71, which is connected to one inlet of a combination pump and mixer 72. In the steady state operation of CFR 60 necessary Tritium inventory is maintained by “breeding” of Tritium in Li-blanket 66. The initial “charge” of Tritium is created in the lithium either by fusion reaction between Deuterium nuclei alone in the CFR, or by neutrons from an external source. Fusion reactions between Deuterium nuclei generates both Tritium in the reaction chamber 61 and in blanket 66 by reaction of fusion neutrons. This initial distribution of Tritium is then renewed by reactions of Li and Be with neutrons from fusion reactions in collapsing bubbles. Tritium generated in blanket 66 aggregates into seeds, made to grow into large bubbles by application thereto of a low-amplitude acoustic field through the horns 40. This field causes the seeds to grow by a process called rectified diffusion, which forces Tritium into the bubbles.

In operation, a zero-gravity field is created, as above, by a horizontal magnetic field, B*, in a small, central region parallel to horizontal axis of the magnetic field. This zero-gravity field exists in liquid Li-blanket as well as in the liquid tin in reaction chamber 61. Tritium bubbles which form in blanket 66 above the zero-gravity field float to the surface S-1, and those which form in or below the zero-gravity field are trapped in it. By pulsing the magnetic field at intervals, the trapped Tritium is released and floats to the surface S-1 where it is removed by pumping. It may be used as fuel at another fusion reactor or as shown in **FIG. 3**, it may be mixed with Deuterium by drawing it through pipe 73 to pump 72. At the pump it is mixed with Deuterium and is then used to seed the liquid tin in chamber 61 as noted hereinafter.

The Li-blanket is at approximately the same temperature as the host liquid, and the process of extracting Tritium from the blanket is helped by this high temperature. When the magnetic field is pulsed, bubbles of Deuterium and Tritium trapped in the cavitation zone also will be released and will float to the surface S-2 of the host liquid chamber 61, where the gases above the liquid are removed by pumping through pipe 74 to pump 72. From the pump a mixture of Tritium and Deuterium is fed into the cavitation zone by a small tungsten capillary tube 75 which opens into the liquid tin below the cavitation zone. The pressure on the gases in tube 75 is maintained at a value needed to force small bubbles of a desired size into the liquid tin at a specified rate.

It is to be understood in the embodiment shown in **FIG. 3** neutron-Tritium shield 68 and the enclosed protective helium atmosphere in space 69 are design features illustrated only schematically in the drawing. Likewise, it is to be understood any methods of supplying acoustic power as described in connection with embodiment in **FIGS. 1 and** 2 can be employed to supply acoustic power to the cavitation zone in Type II CFR. Freedom to operate a Type II CFR at an elevated ambient pressure, p_{ln}*, makes it possible to use single negative pressure pulses in causing cavitation in the cavitation zone. Required positive pressure pulse is then produced by reflection of the negative pulse from a low acoustic impedance surface such as the free surface of the host liquid.

One of the advantages of this design of a Type II CFR is the installation does not require the pumping of either liquid lithium or liquid tin. Moreover, the energy released by fusion in this Type II CFR may be enhanced by introducing fissile material such as thorium or uranium in sub-critical amounts into the Li-blanket. Thermalized neutrons which reach the blanket would then interact with such heavy element to produce fission as well as Li (and Be) to create Tritium.

In the mode of operation in which fusion occurs between lithium and ordinary Hydrogen, bubbles of $_1H^1$ and lithium vapor are introduced in the host liquid (for example, as particles of LiH) and stabilize as seeds in the zero-gravity cavitation zone. In this mode of operation, no neutrons are created and Tritium is not required for operation of the CFR, and consequently the Be-moderator and the Li-blanket are omitted from this design of a Type II CFR.

CALCULATED GAIN IN ENERGY AND TRITIUM IN CAVITATION FUSION REACTORS

Two examples of operation of cavitation fusion reactors (both Type I CFR and Type II CFR) are

described hereinafter. In each a seed of equivalent radius, R_n*, in a specified host liquid grows into a bubble of maximum radius R_o*, and then collapses to a minimum radius, R_m*. In expansion, a negative pressure does W_o* Joules of work on a bubble and, in collapse, a positive pressure does W_c* Joules of work on the bubble. Hence, in the cycle of expansion and collapse, W_m* = W_o* + W_c* Joules of mechanical energy is transferred to the bubble by the applied acoustic pressure field. Object of these calculations is to show there is a net gain in energy and Tritium produced by thermonuclear fusion in such a cavitation event.

During most of the cycle of expansion and collapse, the liquid and contents of a bubble remain at operating, or ambient, temperature, q_n*. However, as interface of a bubble accelerates inward during collapse, there occurs a transition from isothermal to adiabatic compression of the bubble's contents and of the liquid shell surrounding the bubble. Once the compression of the liquid and the bubble contents have become adiabatic, collapse continues until the inward motion is arrested by high pressures and temperatures at a minimum radius, R_m*. At or near the minimum radius, an intense shock wave is radiated into the liquid.

These motions and the resulting pressures and temperatures in the liquid and in the bubble are calculated using a mathematical formalism applicant has developed for cavitation dynamics (J. ACOUST. Soc. Am. 57, 1379-1396 (1975) and 58, 1160-1170 (1975) "Cavitation Dynamics I, A Mathematical Formulation" and "Cavitation Dynamics II, Free Pulsations And Models For Cavitation Bubbles"). The set of differential, integral and algebraic equations developed there permit reliable calculations to be made of the behavior of cavitation bubbles under a wide variety of conditions.

GAIN OF A TYPE I CFR

In a Type I CFR, thermonuclear fusion occurs mainly between H-isotopes dissolved in the host liquid. During collapse of a bubble both its contents and a thin shell of liquid surrounding it are compressed adiabatically. When the bubble reaches its minimum radius, the interface remains essentially at rest for an interval of the order of 10 picoseconds (10^{-11} sec.). In this interval the bubble radiates an intense shock wave which compresses the liquid shell a second time. Temperatures and pressures in the liquid behind the shock are high enough to cause thermonuclear fusion of the H-isotopes dissolved in the liquid metal. This liquid shell in which fusion takes place is called the "fusion shell". In the fusion shell behind the expanding shock, thermonuclear fusion adds enough energy to the liquid to maintain the strength of the shock as it encloses an increasing volume of liquid. Because the strength of the shock remains constant, the temperature and pressure are the same throughout this volume and thermonuclear fusion occurs at a constant rate throughout this expanding sphere.

When the interface starts to move appreciably, it generates a rarefraction wave which eventually destroys the shock. In this second interval (also of the order of 10 picoseconds), in which the rarefraction wave is overtaking the shock, the fusion shell still propagates outward with a uniform rate of energy production per unit volume but with a decreasing thickness. However, the decrease is small, in 10 picoseconds.

In the example of operation of a Type I CFR described hereinafter, the fuel is a mixture of Tritium and Deuterium, and the host liquid is lithium. The operating temperature is 1200 K, the ambient pressure is taken to be one bar, and a pressure, $p_v^* + p_h^*$, of 0.127 bar is maintained over the surface of the liquid lithium vapor and H-isotopes. The dissolved mol fraction, Y_t, of Tritium is 0.05 and the dissolved mol fraction Y_d, of Deuterium is 0.05 in the steady state.

The calculation assumes in the cavitation zone of the reactor there is a seed of t and D with an equivalent radius, $R_n^* = 2 \times 10^{-5}$ cm The specification of the seed of this size is an arbitrary, but convenient, choice because the exact amount of H-isotopes initially in the very small seeds used in a Type I CFR is irrelevant to the subsequent motion of the bubble. Whatever the content of the seed, pressure of vapor and gas in the expanding bubble quickly reaches equilibrium value, $p_v^* + p_h^*$, determined by the ambient temperature and is maintained at this value during expansion and most of the collapse of the bubble.

When a negative pressure is applied to the cavitation zone, the seed expands to a maximum radius, $R_o^* = 2.68 \times 10^{-1}$ cm The work done by the acoustic field in expanding the bubble is 7.52×10^{-3} joules. While the bubble is at this maximum size, a positive pressure of +100 bars is applied to the cavitation zone and the work done by the acoustic field in compressing the bubble is 8.11×10^{-1} joule. Thus total mechanical work, W_m^*, transferred to the bubble is 8.19×10^{-1} joule.

Condensation of vapor and diffusion of H-isotopes is assumed to cease during collapse when the amount of gas and vapor in the bubble is that of a bubble of equivalent radius, $R_n^* = 2 \times 10^{-4}$ cm This transition occurs when radius of the bubble is 100 times greater than the radius of the initial seed.

Transition from isothermal to adiabatic compression is found to occur when radius of the bubble is approximately 3×10^{-4} cm That is, the transition occurs roughly in vicinity of the new equivalent radius (a result which holds for most collapsing bubbles).

A bubble collapses to a minimum radius of $R_M^* = 1.19 \times 10^{-6}$ cm At this minimum radius, the temperature in the bubble rises to a maximum of $T_m^* = 4.22 \times 10^7$ K and the pressure in the bubble to a maximum of $pm^* = 1.67 \times 10^{12}$ bars. The temperature in the liquid at the interface is 2.64×10^7 K and the density of the liquid at the interface is 1.69×10^3 gm cm^{-3}.

A shock wave with a constant strength equal to this maximum, p_m^*, then propagates into the liquid from the bubble. As the shock wave moves outward, the interface remains relatively at rest for a time interval of 25 picoseconds (25×10^{-12} sec.). However, in this calculation this interval is taken to be only 10 picoseconds.

In those 10 picoseconds, thermonuclear fusion of Tritium and Deuterium in the fusion shell enclosed by the shock releases an amount of energy equal to 3.24 joules. Hence the gain in energy released as heat over the mechanical energy supplied to the bubble is 3.96, or, approximately, the energy gain is 4.

When the applied positive pressure is increased to +200 bars at the start of collapse (and all other parameters held fixed), the same bubble collapses to a minimum of 1.06×10^{-6} cm (which is, $R_m^* = 1.06 \times 10^{-6}$ cm). The total mechanical work done on the bubble by the acoustic field is now $W_m^* = 1.75$ joules. The maximum temperature reached in the bubble is 6.27×10^7 K and the maximum pressure is 3.50×10^{12} bars. Temperature in the liquid at the interface is 3.5×10^7 K and density of the liquid at the interface is 2.59×10^3 gm cm^{-3}. As the intense shock wave propagates outward in the liquid with a strength $p_m^* = 3.50 \times 10^{12}$ bars, fusion reactions between Tritium and Deuterium in the lithium produce an amount of energy equal to 43.85 joules in the time interval of 10 picoseconds. Hence the gain in energy released as heat over mechanical energy supplied to the bubble is 25.06. Hence, approximately, the energy gain is 25, even though the mechanical energy absorbed has only doubled.

The rate of energy production in fusion reactions depends on the square of the density of the medium as well as being a complicated function of temperature, and it is the large increase in density within the fusion shell of the host liquid which makes these net gains in energy produced possible. In both calculations of the energy gain from a Type I CFR, the time interval during which thermonuclear fusion takes place in the fusion zone was in all probability underestimated by a factor of at least two.

Studies of Tritium "breeding" in blankets of Li or Li-Be show for each neutron produced in the (T, D,) reaction there will be on an average up to two Tritium nuclei produced by reactions of the fusion neutrons with Li or Be nuclei. Hence a reasonable multiplication factor for Tritium in the host liquid for a Type I CFR is 1.5 Tritium nuclei per fusion nuclei. This factor means Tritium produced in the host liquid more than replaces Tritium used as fuel in the reaction chamber and which only Deuterium need be added to keep the process in operation. Tritium remains in solution in the liquid lithium until it is consumed by thermonuclear reactions in the fusion shell of a collapsed bubble.

In the example above where the applied negative pressure is +200 bars, the neutrons released create 2.06×10^{13} Tritium nuclei or 3.4×10^{-10} mols of Tritium. This amount of Tritium produced by a single cavitation event is contained in a bubble with an equivalent radius of $R^* = 10^{-2}$ cm (as compared with the initial seed with $R_n^* = 2 \times 10^{-5}$ cm). As noted, this Tritium will be dispersed in the liquid lithium until another cavitation event consumes it as fuel.

When the calculation is repeated for a seed which expands to a maximum radius of 2.68×10^{-1} cm as before but in liquid lithium containing a mol fraction, Y_d, of Deuterium alone, it is found energy produced by fusion is less than mechanical work done on the bubble in the expansion-collapse cycle. Thus, when a positive pressure of +200 bars is applied at the start of collapse, the ratio of energy generated to mechanical energy absorbed is only 0.48. However, each such cavitation event causes the thermonuclear fusion of 2.64×10^{11} Deuterium nuclei. There are two channels for the (D, D,) reaction:

$$D + D = T + H$$
$$D + D = {}_0n^1 + {}_2He^3$$

which have almost equal probability of occurring. Thus fusion of four D-nuclei produce one

Tritium nucleus and a neutron, in addition to a proton and a helium-3 nucleus. Hence a multiplication factor of 1.5 yields 2.5 Tritium nuclei for every four D-nuclei which undergo fusion. In this example, a single cavitation event produces 616×10^{11} Tritium nuclei or 1.09×10^{-12} mols of Tritium. This amount of Tritium is contained in a bubble whose equivalent radius is 5×10^{-3} cm

The conclusion is an inventory of Tritium sufficient for steady state operation of a Type I CFR can be built up rapidly by operation of the reactor with Deuterium alone as fuel in the start-up phase. It is assumed above, the cavitation event takes place in a zero gravity field. In these examples of operation of a Type I CFR, amount of energy generated by thermonuclear fusion within a bubble is always negligible compared with that released in the fusion zone surrounding the collapsed cavity.

In summary, operation of a Type I CFR is such:
1. When a useful gain of energy results from a cavitation event in a Type I CFR, the work, W_o*, done by negative pressure, in expanding a bubble to its maximum radius, R_o*, is much less than the mechanical work, W_c*, done by the positive pressure during collapse. Typically, the ratio of work done on a bubble during collapse to work done during expansion is of the order of 100.
2. In a Type I CFR, the mechanical work, W_o*, done in expanding a bubble from its initial radius, R_n*, controls the maximum radius, R_o*, which it reaches. The work, W_o*, is chosen so R_o* is of the order of 10^{-1} cm or less and the expansion ratio, R_o*/R_n*, is of the order of 10^3 or 10^4.
3. In a Type I CFR, for a specified value of R_o*, the mechanical work, W_c*, done on a bubble in collapse controls maximum pressures and temperatures reached in the host liquid and in the bubble and hence controls in fusion energy, E*, released in the cavitation event.

A Type I CFR is an amplifier whose output of fusion energy, E*, for a single cavitation event of specified R_o* is a non-linear function of the mechanical input work, W_c*, which increases more rapidly than the third power of W_c*.

GAIN OF TYPE II CFR

In a Type II CFR, relatively large seeds of H-isotopes are used. Typically, their initial radii are 50 to 100 times larger than those used in a Type I CFR, and their volumes are consequently 10^5 to 10^6 greater. Larger seeds are required because fusion reactions in a Type II CFR takes place mainly between H-isotopes within bubbles and not in the liquid. Hence amount of H-isotopes in a seed places an upper limit on amount of energy which may be released in fusion reactions caused by a collapsing bubble in a Type II CFR.

In a Type II CFR there is a transition from isothermal to adiabatic compression of a bubble contents during collapse and it is this adiabatic compression which raises temperature and pressure within the bubble to values where thermonuclear fusion takes place. The temperature rise in the liquid could cause only a negligible number of fusion reactions of H-isotopes in the liquid (whose mol fraction in any event is very small).

CHAPTER 16 Continued

The host liquid in a Type II CFR is normally a gamma-metal such as tin, indium, gallium or thallium, which neither dissolve or react with Hydrogen in the temperature range of interest. In the example of the operation of a Type II CFR described here, however, the host liquid is aluminum because its equation-of-state data have been established experimentally well into the megabar region of pressure. Aluminum closely resembles a gamma-metal except Hydrogen does dissolve in it freely. In this calculation, it was assumed aluminum acts like a gamma-metal in all respects.

Calculations are made for gain in Tritium produced in the Li-blanket over the Tritium consumed as fuel in fusion reactions for:
1. An operation in which a mixture of Deuterium and Tritium is used as fuel,
2. An operation in which Deuterium is used as fuel alone.

The calculations which were made show:
a. There is a net gain in the production of Tritium when a mixture of Deuterium and Tritium is used as fuel in the steady state operation of a Type II CFR.
b. Start-up operation of a Type II CFR can be accomplished by use of Deuterium alone as fuel.

In this example, the host liquid is aluminum, the operating temperature is 1500 K, the ambient pressure is 1 bar and the vapor pressure of the liquid metal is 4.96×10^{-5} bars.

There is a zero-gravity field in the cavitation zone of the reactor. Hence seeds containing a mixture of H-isotopes introduced into the cavitation zone will remain there. Because the host metal is a gamma metal, the seed will not dissolve and, in the absence of an acoustic field, a distribution of seeds remains relatively stationary both in space and time. Another consequence is the gas content of a bubble remains constant throughout the expansion and collapse phases.

The calculation assumes a seed with an equivalent radius of $R_n^* = 10^{-3}$ cm and containing equal mol fractions of Deuterium and Tritium is placed in the cavitation zone of the reactor. A negative pressure of -100 bars causes the seed to expand to a maximum of $R_o^* = 1.82$ cm A positive pressure of +100 bars is then applied and the total mechanical work, W_m^*, done on the bubble is 2.59×10^2 joules.

The bubble collapses to a minimum radius of $R_m^* = 1.92 \times 10^{-6}$ cm and then remains relatively motionless for 10 picoseconds. In that time interval, temperature remains at its maximum, $T_m^* = 1.64 \times 10^8$ K and the pressure at its maximum, $p_m^* = 6.32 \times 10^{13}$ bars. The number of (D, T,) reactions taking place in the bubble in this time interval is 3.93×10^{10}. Each reaction releases 3.20×10^{-12} joules and hence the total energy released is 1.26×10^{-1} joule. The net energy gain is then only 4.86×10^{-4}.

However, each (T, D,) reaction produces a neutron and a helium-4 nucleus and each fusion neutron on an average produces 1.5 Tritium nuclei in the Li-blanket. Thus the collapse of a bubble produces 7.08×10^{10} Tritium nuclei or 1.18×10^{-13} mols of Tritium. The amount of Tritium originally in the seed was $N_t = 3.05 \times 10^{-14}$ mols so the net gain in Tritium is 3.9.

CHAPTER 16 Continued

When the calculation for a Type II CFR is repeated using Deuterium alone as fuel, the yield of Tritium is 1.63×10^{-15} mols. Here again the necessary inventory of Tritium can be built up using Deuterium alone.

There are other very great advantages in using liquid metals as the host liquid in a CFR. Electromagnetic radiation from excited atoms in a collapsing bubble will be trapped within the bubble by the metallic interface and in a liquid metal all energy carried by charged particles will be quickly absorbed in the metal and appear as heat. The thermal conductivities of liquid metals are all large and hence liquid metals are highly efficient agents for transfer to heat out of the reactor. All liquid metals have large values of coefficient of surface tension, a property which helps the bubble interface to retain its spherical shape during collapse.

In the foregoing disclosure, both specification of a Type I CFR and discussion of stability of interface of a collapsing bubble have assumed at its maximum radius a bubble is spherical in shape. The interface of a spherical bubble is stable during expansion, but is unstable during collapse, in the sense a small perturbation of the interface may grow. Several methods have been described for inhibiting the growth of such instabilities through creation of a zero-gravity field within the cavitation zone of a CFR. Another method of operating a CFR so as to prevent destruction of a collapsing bubble's interface from growth of surface instabilities will now be described in the context of a Type I CFR; but it is to be understood it will apply equally as well to a Type II CFR.

Interface of a cylindrical (or quasi-cylindrical) bubble has neutral stability in the sense which any small perturbation of the surface will neither grow nor decay. In arrangements to be described, bubbles are constrained to assume a quasi-cylindrical shape and hence have neutral stability against the growth of a surface perturbation. Points at which a vertical axis through the center of a bubble intersects the interface will be called the "poles" of the bubble, and the intersection of the bubble interface with a horizontal plane will be called the "equatorial circumference".

Alternative arrangements for creating quasi-cylindrical bubbles in a CFR include:
1. Rotation of the host liquid in a cavitation zone around a vertical axis. The rotation of the liquid metal may be induced by "motor" action of an imposed, time-varying magnetic field. A bubble on the axis of rotation will assume a quasi-cylindrical shape because the rotation generates an inward force in the liquid at the interface which is a maximum at the equatorial circumference and a minimum at the poles.
2. Superposition of static, horizontal, uniform magnetic fields on the cavitation zone. Such magnetic fields generate a distribution of forces which has the same net effect as created by rotation of the host liquid. Directions of the magnetic fields are distributed symmetrically about a vertical axis through the cavitation zone. Each magnetic field interacts with a collapsing bubble so as to induce eddy currents in the liquid metal at the interface. These currents in turn interact with the magnetic field so as to oppose the inward motion. When a number of such equally spaced magnetic fields of equal magnitude are superposed, the net "drag" force opposing the inward motion will be a maximum at the poles and a minimum at the equatorial circumference.

The difference between the maximum and the minimum forces increases with the number of superposed fields. Hence a collapsing bubble will move inwardly more rapidly at the equatorial circumference and will assume a quasi-cylindrical shape.

Superposition of high-frequency acoustic pressure fields on the cavitation zone. The desired result may be brought about by standing wave fields, pulses or a combination of the two. In the arrangement to be described, the radiation pressure of high-frequency, high-intensity pulse trains is employed in order to achieve the necessary field geometry. When a plane wave is incident on a completely reflecting surface, such as a bubble interface, a force called the radiation pressure is exerted on the bubble interface. Intersecting beams of high-frequency (of the order of 1 MHz, for example) pulse trains are generated by transducers arranged symmetrically on the vertical wall of the reaction chamber around the cavitation zone so as to approximate a uniform inward force on a bubble. After a low-frequency pressure field in its negative phase expands a seed to a maximum radius R_o*, pulse trains are simultaneously emitted by the circular array of transducers. The vertical and horizontal widths of any one beam are of the order of magnitude of the diameter of the cavitation zone. The bubbles will then be subjected to a radiation pressure which is a maximum on the equatorial circumferences and a minimum at the poles of the bubbles. Under this force geometry the contracting bubble will become a quasi-cylinder. At the same time, the low frequency field will exert a uniform positive pressure on the bubble.

CLAIMS

Having thus described my invention, what I claim is:

1. A method of producing nuclear fusion, neutrons and Tritium by cavitation of a liquid metal containing Hydrogen isotopes, comprising placing a liquid metal containing Hydrogen capable of nuclear fusion isotopes in a chamber, applying an external force in opposition to the force of gravity on the liquid metal thereby to counterbalance the force of gravity on the liquid metal so as to yield an effective gravity force of approximately zero on the liquid metal and form a cavitation zone therein, and applying an acoustical pulsing field having alternating negative and positive pressure pulses to the liquid metal to vary its ambient pressure sufficiently to induce in the metal in said zone a cavitation effect which causes at least one small bubble in the liquid to expand by means of a negative pressure pulse and then to collapse violently by means of a positive pressure pulse, thereby effecting nuclear fusion of said Hydrogen isotopes.

2. A method as defined in claim 1 wherein the force of gravity is counterbalanced in said cavitation zone by creating a vertical standing pressure wave in said liquid metal, the amplitude and phase of said standing wave being such said standing wave reduces the force of gravity on said bubble during expansion phase thereof in said cavitation zone.

3. A method as defined in claim 1 wherein the force of gravity is counterbalanced in said cavitation zone by means of an acceleration applied to said chamber, whereby applied acceleration reduces the force of gravity during the expansion phase of said bubble in said cavitation zone.

4. A method as defined in claim 1 wherein force of gravity is counterbalanced in said cavitation zone by means of a horizontally directed magnetic field inhomogeneous in the vertical direction, and approximately homogeneous in the horizontal direction.

5. A method as defined in claim 1, including supplying Deuterium to said liquid metal to

replenish Hydrogen isotopes exhausted by said fusion.

6. A method as defined in claim 5, wherein said liquid metal approximately fills said chamber, and said Deuterium is fed to a space located in said chamber above level of the liquid metal therein.

7. A method as defined in claim 5, wherein said Deuterium is mixed with Tritium and fed directly into said liquid metal to form bubbles therein.

8. A method as defined in claim 1, wherein the temperature of said liquid metal is maintained in the range of approximately 1000 K to 1500 K.

9. A method as defined in claim 1, wherein said liquid metal is selected from the group consisting of lithium, beryllium, aluminum, tin, thallium and indium, and isotopes and alloys thereof.

10. A method as defined in claim 1 wherein said liquid metal is selected from the group consisting of normal lithium, lithium-6, lithium 7, beryllium, and alloys thereof.

11. A method as defined in claim 1, wherein said liquid metal is selected from the group consisting of tin, thallium, indium and aluminum.

12. A method as defined in claim 1, wherein variation of said ambient pressure comprises cyclically decreasing and then increasing the pressure in said chamber alternately below and above, respectively, the value of said ambient pressure.

13. A method as defined in claim 12, wherein the cycle of applied acoustical pressure comprises a sequence of a negative pressure of 50-100 bars followed by a positive pressure of 100-200 bars.

14. A method as defined in claim 1 wherein variation of said ambient pressure comprises intermittently lowering pressure in said chamber to a value below said ambient pressure.

15. A method as defined in claim 1, including using acoustical horns for applying said acoustic pressure to said liquid metal, and also for conducting heat from the fusion reaction in said chamber to a heat transfer means positioned externally of said chamber.

16. A cavitation fusion reactor for producing nuclear fusion neutrons and Tritium, comprising a first housing therein a chamber for holding a liquid metal at elevated temperatures and pressures, a neutron and Tritium shield surrounding said housing in spaced relation thereto, an inert gas located in said space and surrounding said housing, means for applying an external force in opposition to the force of gravity on the liquid metal thereby to counterbalance the force of gravity on the liquid metal so as to yield an effective gravity force of approximately zero on the liquid metal and form a cavitation zone therein, and means for applying an acoustical pulsing field having alternating negative and positive pressure pulses to the liquid metal to vary its ambient pressure sufficiently to induce in the metal in said zone a cavitation effect which causes at least one small bubble to be formed and expand by means of said negative pressure pulse and then to collapse violently by means of a positive pressure pulse, said means for applying acoustic pulses including a first plurality of acoustical horns mounted intermediate their ends in said housing and said shield, respectively, and extending through said space to supply acoustical energy to a liquid metal in said chamber, and means for supplying Deuterium to said chamber, thereby to provide Hydrogen isotopes which are subjected to nuclear fusion by said acoustical energy.

17. A cavitation fusion reactor as defined in claim 16, wherein said horns are metallic and function to conduct heat from the fusion reaction in said chamber, and heat transfer means is connected to each of said horns at the ends thereof located exteriorly of said chamber, thereby to

absorb heat conducted by said horns from the chamber.

18. A cavitation fusion reactor as defined in claim 16, wherein a second housing surrounds said first housing in spaced relation both to said first housing and to said shield, and said first housing is lined with beryllium and is immersed in a liquid alloy of lithium and beryllium which approximately fills said second housing.

19. A cavitation fusion reactor as defined in claim 18 wherein the space between said second housing and said shield is filled with said inert gas.

20. A cavitation fusion reactor as defined in claim 18 including a second plurality of acoustical horns mounted on said second housing for supplying acoustical energy to the liquid alloy in said second housing.

21. A cavitation fusion reactor as defined in claim 18, including means for withdrawing Tritium and Deuterium from above the upper surfaces of the liquid metals in said first and second housings and for recirculating mixtures of said Tritium and Deuterium to the liquid metal in said first housing.

CHAPTER 17

The below Patent on **PLASMA CONFINEMENT BY SHOCK WAVES** is an edited version of a United States Patent which, now in 2008, is in the Public Domain because its term has expired. It is published here for educational purposes and is not to be construed for any other purpose. As author of this book, I claim no copyright for any or all of the contents of this public document. Also, I do not indorse nor make any offering of this invention to anyone for any purpose.

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References Cited: U.S. Patent Documents
3762992 October 1973 Hedstrom
Primary Examiner: Schwadron; Martin P.
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Attorney, Agent or Firm: Rusz; Joseph E. Miller, Jr.; Henry S.

DESCRIPTION

BACKGROUND OF INVENTION

This invention relates generally to a system for obtaining useful power from controlled thermonuclear fusion and more specifically to a system which produces electrical power from the consumption of deuterium and tritium gas.

It has long been the ideal of those skilled in the art to be able to harness the energy of thermonuclear fusion and provide a system which would allow this energy to be converted into some useful form in order it might perform work.

In the past, many various concepts, methods and devices have been studied in order to provide a practical, workable system for the production of energy. The concept believed to be most studied by those attempting to achieve a successful controlled thermonuclear reactor has been heating hydrogen isotopes to fusion temperature and isolating and confining the hot plasma by magnetic fields. The reactor wall is considered to be separated from the hot plasma by a vacuum magnetic field region. A multitude of ingenious magnetic field configurations have been studied in detail, however, all have fallen short of the goal for reasons known to those in the art.

Another system under study relied upon the development of very high power lasers or electron

beams and the inertia of matter. This system does not attempt to confine the fusion reaction and is conceded to provide a "mini-bomb" approach. Draw-backs to this type of system are also apparent to those skilled in the art.

An alternative to the aforementioned approach and the subject of this invention is a system whereby a plasma is shock heated and confined by a combination of magnetic fields and solid walls. From the employment of a combination of magnetic fields and solid walls for confinement of the reaction, a relatively small size, high energy density, high Beta, pulsed thermonuclear power system is possible.

Previously, wall confinement of a plasma has been considered as impractical due to the heat and energy involved in the fusion process. A further drawback has been the inability to sustain the process sufficiently to allow for reasonable heat transfer. It has been found with an imbedded transverse magnetic field in the plasma, the energy transfer to the wall may be kept sufficiently small so a hot plasma core will have sufficient time to react.

This invention solves the problems of the prior art and allows a power system to be operated as a result of thermonuclear fusion.

SUMMARY OF INVENTION

The invention in concept is not unlike the cycle of the diesel engine. A magnetic field piston, formed by a large current in a cylindrical geometry, drives a strong shock wave along a coaxial cavity. The shock creates a hot dense plasma which flows behind the wave front at nearly three-fourths of the speed of the shock. At the end of the cylinder, the shock reflects from the end wall and propagates through the plasma, heating and compressing it further, and bringing the plasma to rest relative to the cylinder.

The magnetic piston sweeps up all gas, heats it and compresses it into the end of the coaxial cylinder. The reflecting end of the cylinder is curved in such a manner as to generate a cylindrical imploding shock wave which will further heat and compress the gas. An additional strong magnetic field is then applied confining the plasma to the end of the tube. Thermonuclear energy is released when the plasma state is at sufficiently high temperature and density.

The plasma is cooled by the wall, the additional magnetic field is maintained and the interior hot plasma core, insulated by surrounding cooler plasma, will have sufficient lifetime to produce more thermonuclear energy than was required by the magnetic piston, the secondary field and other energy inputs. The majority of the fusion energy is transferred through the walls where it is absorbed in a cooling blanket. The hot blanket fluid is used to run a thermal-turbine cycle which produces electricity for powering the next cycle of the cylinder.

It is therefore an object of the invention to provide a new and improved fusion power system.

It is another object of the invention to provide a new and improved system for obtaining useful

power from controlled thermonuclear fusion.

It is a further object of the invention to provide a new and improved means to heat, confine and extract energy from fusion reactions.

It is still another object of the invention to provide a new and improved pulsed thermonuclear fusion engine reactor.

It is still a further object of the invention to a new and improved fusion power system adaptable to converting nuclear energy directly into electrical energy.

These and other advantages, features and objects of the invention will become more apparent from the following description taken in connection with the illustrative embodiments in the accompanying drawings.

DESCRIPTION OF THE DRAWINGS
DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring now to **FIG. 1**, two coaxial cylinders are shown at 10 and 12. The cylinders are connected at one end by a shaped wall 14 and at the other by an adapter plate 16. The volume between the coaxial cylinders contains the fusion reaction.

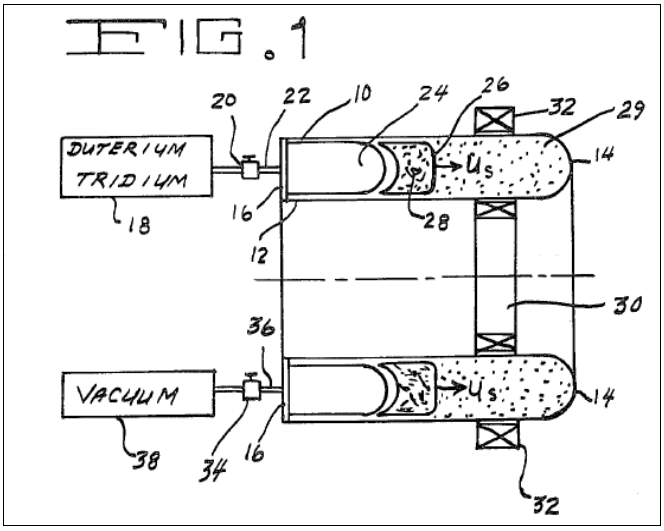

FIG. 1 is a cross-sectional view of the coaxial cylinder utilized in the invention.

The volume is filled with a mixture of deuterium and tritium from the supply 18 past valve 20 through the pipe 22. A magnetic field piston 24, formed by a large current in a cylindrical geometry, drives a strong shock wave 26 along the coaxial cavity. The shock wave creates a hot dense plasma 28 from the gas 29 which flows behind the wave front (26) at about three-fourths of the speed of the shock. At the end of the cavity, the shock reflects from the shaped end wall 14 and propagates back through the plasma.

When the reflected shock wave intersects the magnetic piston, an expansion wave will begin to propagate into the plasma causing it to stream forth from the end of the cylinder with a subsequent reduction in both density and temperature.

To prevent this from occurring, axial confinement is utilized in the form of the magnets 30 and 32. The magnets will contain the plasma in the area adjacent the wall 14.

Confined to the end of the cylinder, the hot plasma in contact with the side and end walls, begins to cool. The outer walls of the cylinder are in heat transfer contact with a cooling blanket which will allow the heat generated to be converted into usable electrical energy.

After the maximum heat has been extracted from the fusion reaction, the magnetic force fields are relaxed and the cavity is evacuated. The valve 34 is opened and the remaining gas is removed via pipe 36 to the vacuum chamber 38. Upon completion of the evacuation, the cycle is repeated.

FIG. 2 shows a complete fusion power system. A plurality of fusion reactor cylinders 40 are assembled with the shaped plasma fusion wall 14 extending into a chamber 42 containing lithium or other appropriate heat transfer medium. The gas control system and magnetic piston electronics are shown as contained in the exteriorly mounted container 44.

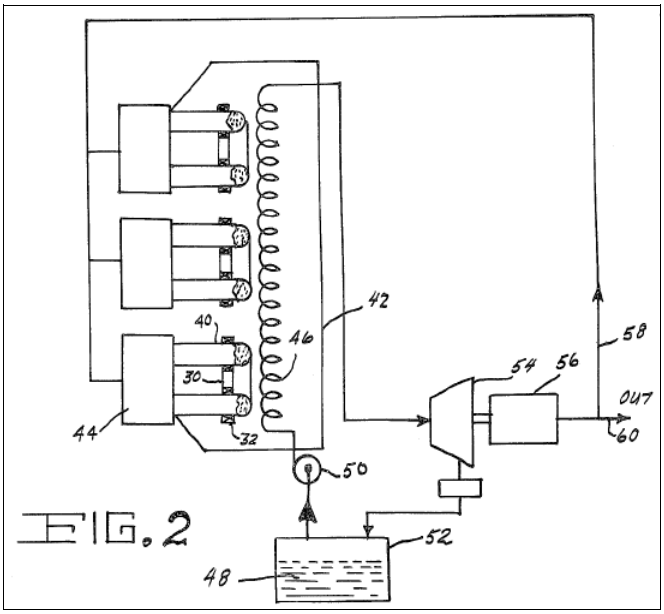

FIG. 2 is a diagrammetric representation of the system of the invention.

As the fusion reaction takes place, heat from the reaction plus liberated netrons and heat from the magnet coils transfers into the lithium blanket which in turn transfers heat to the heat transfers heat to the heat transfer coil 46. A coolant 48 is pumped (50) from the reservoir 52 through the coil 46 where it is converted into steam where it feeds the turbine 54 before condensing and returning to the reservoir 52. The turbine will turn a conventional generator 56 and provide power for the fusion reactor system via line 58 with the surplus power provided via line 60 for

outside power needs.

By combining a plurality of fusion cylinders, a fusion engine-reactor system is capable of providing substantial electrical power in the thousands of megawatt range for industrial and domestic uses.

It should be understood, of course, the foregoing disclosure relates to only a preferred embodiment of the invention and numerous modifications or alterations may be made therein without departing from the spirit and scope of the invention as set forth in the appended claims.

CLAIMS

I claim:

1. A fusion reactor power system comprising: means for controlling and containing a thermonuclear fusion reaction including, a pair of coaxial cylinders, each of said cylinders being closed at one end with a concave shaped reflecting wall and forming a cavity; means for absorbing heat energy from said containing means; heat exchange means located in the heat absorbing means; fluid means; a pump means for pumping said fluid through the heat exchange means; a turbine generator means connected to the heat exchange means whereby the fluid pumped through the heat exchanger will expand and cause the turbine to operate and generate electrical current.

2. A fusion reactor power system according to claim 1 wherein; said means for controlling and containing a thermonuclear fusion reaction includes means for injecting and means for removing a gas from the cavity.

3. A fusion reactor power system according to claim 2 wherein; said means for controlling and containing a thermonuclear fusion reaction includes a magnetic piston means for generating a shock wave in the cavity.

4. A fusion reactor power system according to claim 3 wherein; said means for controlling and containing a thermonuclear fusion reaction includes a magnetic means for containing the fusion reaction.

NOTES

Notes for my papers began in 1987 without my knowing of other similar works in the field going on at those times. From then to now, 2008, much has been done on a similar set of subject matters as are in my papers but by various names. Some of those papers began in earnest when NASA let a contract, NASW 5050, to Lockeed-Martin and subsequently to others, searching for technologies to power interstellar space missions to other star systems, and as a fallout, to power vehicles and generate stationary power. Below is a partial list of Internet accessible published papers centered around that and subsequent NASA and Air Force contracts. When and if these power source technologies become available, the need for fossil fuels for our energy will be a thing of the past with no more oil emperors and barons controlling our lives and wallets.

FOR FURTHER STUDY

California Institute for Physics and Astrophysics [CIPA] has physics papers and hyperlinks to other sites with more papers. View in html at: http://www.calphysics.org

AT CORNELL

Cornell University Library has an internet archive of physics papers. View their abstracts in html or full papers in .pdf format. Go to: http://www.arxiv.org You may need to sign in. If you are thinking of posting a paper, you will need endorsements from two of your colleagues who have previously posted within the last 5 years and not later than 6 months ago at arxiv.org.

* physics/9802031 v1 16 Feb 1998 INERTIA AS REACTION OF THE VACUUM TO ACCELERATED MOTION

* physics/9802030 v1 17 Feb 1998 CONTRIBUTION TO INERTIAL MASS BY REACTION OF THE VACUUM TO ACCELERATED MOTION
* hep-th/9901011 v1 4 Jan 1999 THE CASIMIR EFFECT: PHYSICAL MANIFESTATIONS OF ZERO-POINT ENERGY

* quant-ph/9907076 v1 23 Jul 1999 EXPERIMENTAL VERIFICATIONS OF THE CASIMER ATTRACTIVE FORCE BETWEEN SOLID BODIES

* gr-qc/9905084 v5 21 Sep 1999 A ‘WARP DRIVE’ WITH MORE REASONABLE TOTAL ENERGY REQUIREMENTS

* physics/9909043 v1 21 Sep 1999 TOWARD AN INTERSTELLAR MISSION: ZEROING IN ON THE ZERO-POINT-FIELD INERTIA RESONANCE

* gr-qc/0002069 v1 19 Feb 2000 THE CASE FOR INERTIA AS A VACUUM EFFECT: A REPLY TO WOODWARD AND MAHOOD

* gr-qc/9906084 v3 12 May 2000 ON THE RELATION BETWEEN A ZERO-POINT-FIELD INDUCED INERTIAL EFFECT AND THE EINSTEIN-DE BROGLIE FORMULA

* hep-th/0005038 v2 8 Jun 2000 THE PARADOX OF VIRTUAL DIPOLES IN THE EINSTEIN

ACTION

* gr-qc/0005009 v3 7 Sep 2000 LARGE “DIPOLAR” VACUUM FLUCTUATIONS IN QUANTUM GRAVITY

* gr-qc/0009036 v1 12 Sep 2000 INERTIAL MASS AND THE QUANTUM VACUUM FIELDS

* gr-qc/0011030 v1 9 Nov 2000 THE DIPOLAR ZERO-MODES OF EINSTEIN ACTION: AN INFORMAL SUMMARY WITH SOME NEW ISSUES

* gr-qc/0108026 v1 9 Aug 2001 GRAVITY AND THE QUANTUM VACUUM INERTIA HYPOTHESES I. FORMALIZED GROUNDWORK FOR EXTENSION TO GRAVITY

* gr-qc/0209016 v1 5 Sep 2002 UPDATE ON AN ELECTROMAGNETIC BASIS FOR INERTIA, GRAVITATION, THE PRINCIPLE OF EQUIVALENCE, SPIN AND PARTICLE MASS RATIOS

* physics/0205086 v3 9 May 2003 CONNECTIVITY AND THE ORIGIN OF INERTIA

*Quant-ph/0402127 v1 18 Feb 2004 QUANTUM ENTANGLEMENT IN TIME

*physics/0403027 v1 2 Mar 2004 DASHEN-FRAUTSCHI FIASCO AND HISTORICAL ROADMAP FOR STRINGS

*physics/0501132 v1 25 Jan 2005 ON THE NATURE OF THE ELECTRIC CHARGE

ALSO OF INTEREST

* ZP [zero point]

* ZPE [zero point energy]

* ZPF [zero point field]

* ZPEF [zero point energy field]

* NASA Contract: NASW-5050 [This is the one which generated so very much interest in interstellar propulsion systems.]

* NASA/CP—1999-208694

* NAS8-98109

* US AIR FORCE ROCKET PROPULSION LABORATORY CONTRACT FO4611-83-C-0013

* Takaharu, G., et al., *Apparatus for cold nuclear fusion*. 1990: European Patent Application, 90107987.1.

* *Annual Review of Fluid Mechanics* Vol. 32: 445-476. Publication date January 2000 (doi:10.1146/annurev.fluid.32.1.445)

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