Disclosure Document for

Nuclear Fusion Reactor Designs Utilizing Spherical Electromagnetic Fields to Compress, Contain, and Extract Energy from a Nuclear Fusion Reaction

by
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This invention relates in general to Nuclear Fusion Reactors and in particular to reactors that provide active electromagnetic containment.

The Problem:

Estimates of fossil fuel supplies for the world's energy supply indicate that production will drop below consumption within 10 to 20 years. Other energy sources can be improved upon. Hydroelectric, solar, wind, geothermal, tidal are some of the various alternative energy sources other than fossil fuel. One choice, nuclear fission reactors could be relied upon, if needed. However, nuclear fission reactors have become very unpopular due to their risk and highly radioactive waste products. One potential choice for future energy production, that has always been described favorably, is nuclear fusion reactors. One benefit of fusion reactors is they do not rely on dangerous radioactive heavy elements as do fission reactors. Other benefits of fusion reactors are: fusion fuel is safer, fusion fuel supplies are essentially inexhaustible, and fusion waste products are smaller in volume—estimated to be approximately 1,000 time less in volume. Importantly, fusion reactors do not create highly radioactive waste products. While the fusion process does create some radioactive waste products, the volume is small, and the radioactivity is mild and short-lived compared to fission waste products—with half-lives estimated to be tens of years rather than thousands of years. In summary nuclear fusion reactors have always held the promise of unlimited, essentially clean power. The problem is, other than in nuclear fusion bombs, scientists have been unable to get more energy out of a nuclear fusion reaction than has been used to start the reaction. In other words, nuclear fusion reactors, to date, have failed in the goal to produce energy because they consume more energy than they produce. Ultimately, the goal of the type of nuclear fusion reactors described in this document is to create more power than is used to start the process.

The most important, common problem in all past nuclear fusion reactor designs is the formation of instabilities in the plasma which have resulted in less than ideal burns. While many types of instabilities have been described in the past, a physical understanding of the cause of these instabilities has eluded understanding. These reactor designs are in part based upon a new physical understanding of the cause of plasma instabilities, and how they can be thwarted to begin with, and used for benefit when they do result.

The second most important problem in all past nuclear fusion reactor designs is the efficient creation of electrical power from the energy produced by the fusion reaction. Efficient conversion of extracted energy into electrical power is needed. Most designs have assumed the heat produced by the fusion process will be extracted to drive steam turbine and generator systems. Some designs have had the goal of using Magnetohydrodynamics (MHD) to directly create electrical power from a moving plasma. The new reactor designs in this document use the MHD process—converting extracted energy into electrical energy directly using MHD—as the primary energy conversion process and steam driven turbine generators as a secondary energy conversion process.

The third most important goal of nuclear fusion reactors is to create energy economically. This goal has not been approached by prior designs because they failed to produce any net energy. Many designs rely on pulses of fusion burns. In other words, the fusion process does not continuously burn for extended periods of time. To be economical, the fusion burns must last for extended periods of time. A common design trait of all of the reactor designs in this patent application is they entail use of: a spherical geometry of electromagnetic fields in order to contain the fusion burn and thwart instabilities in the fusion burn—which will result in greatly extending fusion burn times; and to utilize any instabilities that are formed to directly create electrical power via the MHD process. Again, while these designs use extracted heat to drive steam turbines, this process is secondary to the MHD process.

Related Art:

Other people have tried to solve the problem of creating nuclear fusion reactors in various ways. In order to provide background information so that the invention may be completely understood and appreciated in its proper context, reference is made to a number of prior art patents and publications as follows:

Inertial Confinement Methods

Inertial Confinement Fusion (ICF)

While the topology of the burn in prior ICF designs has been spherical, there has been no active confinement of the burn. In other words, in prior designs: the reaction is imploded, the fusion burn starts, instabilities form, the process explodes. Numerous types of implosion methods have been tried in prior ICF designs, including: lasers, neutral particle beams, and ion particle beams. ICF reactor designs have succeeded in advancing fusion research, reaching high temperatures and densities. However, they have failed to produce more energy than is consumed.

ICF reactor designs based on lasers are not considered viable long-term options for commercial power plants simply because of the poor efficiency in converting electrical energy into the intense beams needed for inertial confinement.

Key distinguishing features between prior art ICF designs and these new designs are:

- Prior inertial methods have not attempted to stop the resulting explosion via active confinement. (Magnetic confinement techniques have used active confinement methods, but not in a spherical pattern.)
- Prior inertial methods have not attempted to create a harmonic burn or influence the quality of the fusion burn via electromagnetic fields.
- Inertial methods have not attempted to use MHD to absorb the exploding energy.
- Prior art ICF designs have often utilized a surrounding spherical chamber or shield. However, the spherical chamber has only been used as a shield to contain the process and has played no role in keeping the fusion process burning or harmonic. Indeed the chambers are usually pierced with many sensors, holes, ports and other

devices. Such sensors, holes and protrusions through the reactor wall are completely eliminated or minimized in the new reactor designs described in this document. While such sensors provide useful scientific information on the fusion burn, it is believed by the author that such sensors create a non-harmonic situation that reduces the quality of the burn.

- A key difference in prior art is prior ICF spherical containment chambers have had no, intentionally created, spherical electromagnetic fields set up over the surface of the containment shield to electromagnetically contain the fusion burn, influence the fusion burn, or extract electrical power via the MHD process.

Magnetic Confinement Methods

Standard Tokamak Fusion

Tokamak fusion reactor designs contain the fusion fuel plasma in a donut-shaped, or torroidally-shaped electromagnetic containment field. These designs have been able: to contain plasmas for extended periods of time, to reach high temperatures, and to develop high densities. However, the geometry of the torus is less than ideal for containment in comparison to the geometry of a sphere. To properly utilize a plasma in a MHD process, the plasma velocity must be at right angle to the MHD's magnetic field. It is believed, from theory on which these reactors are designed, that plasma instabilities expanding in a Spherical Electromagnetic Containment Field (40) either, always expand at a right angle to the external electromagnetic field, or are deflected back towards the center of the plasma, which is also beneficial. In a torus, the plasma may interact with the containing magnetic field at less than a 90 degree angle. This allows instabilities within a torus to grow and penetrate the containment field.

The geometry of a torus also prevents the coil windings around the torus to be perfectly symmetrical. There is more area on the outside of the torus than on the inside. This geometry prevents the containment field from being symmetrical. Instabilities are more likely to penetrate the outer side of the torus than the inner side. In a spherical chamber, there is no preferential side to the chamber.

The plasma within a Tokamak orbits within the torus-shaped cavity. It does not just sit there. A moving region of plasma in a circular orbit can induce electromagnetic fields that are extremely unpredictable. These forces induce, at the moment of fusion burn, instabilities that the designers of Tokamaks have been unable to understand and control. These instabilities grow too quickly for human operator or computer controlled response, and allow the plasma to penetrate the confining fields. The reactor designs in this patent have electromagnetic fields in place prior to the fusion burn to respond to instabilities as they occur. It is easier to contain a plasma in a spherical configuration rather than a torroidal configuration. The bulk of the plasma does not move or orbit, but is stationary, and thus does not have any orbit induced instabilities. Instabilities exploding outward in a spherical confinement field encounter electromagnetic fields at right angles which easily allows: direct conversion of instability energy to electricity via the MHD process, or deflects the instability back towards the center of the fusion burn.

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Spherical Tokamak Fusion

The cross section of a normal Tokamak is circular. The cross section of a “spherical” Tokamak is more elongated in the vertical direction. Spherical Tokamaks still use a torus-shaped tube. Indeed, the process is not “spherical” at all. Essentially, all of the key negatives of normal Tokamaks apply to Spherical Tokamaks as well when compared to the new designs in this document.

Stellarators

In general, there is little difference between Tokamaks and Stellarators. The orbit of plasma in a Tokamak is planar—i.e., there is no vertical motion. The orbit of plasma in some Stellarator designs is non-planar—i.e., there is vertical motion. Basically, Stellarators using an even more complex path for the plasma to follow than Tokamaks. While Stellarators have reached high temperatures, and densities, their various geometries are not spherical, and the problem of unpredictable instabilities forming due to the motion of the plasma are the same or even worse than in Tokamak designs.

Reversed-Field Pinch (RFP)

Reversed-Field Pinch devices are similar to a Tokamak in that the plasma is confined by both torroidal and poloidal magnetic fields. The main difference is the relative strength of the magnetic fields. The main disadvantages of Tokamaks, as compared to a spherical confinement field, would apply to RFP devices as well.

Field Reversed Configuration (FRC)

The Field Reversed Configuration is another torroidal system with magnetic field lines arranged differently. The overall negatives of this type of torroidal device as compared to a Spherical Electromagnetic Containment Field (40) system would apply as well.

Cylindrical Patterns

Some of the earliest devices for creating high-temperature plasmas used cylindrical patterns. All of these devices suffer in stability and containment when compared to a Spherical Electromagnetic Containment Field (40).

Theta Pinch

Theta Pinch designs take the form of a long tube or a skinny torus. The Theta Pinch uses an electrically induced magnetic field to compress and heat the plasma. However, the plasma is not confined equally in all directions as in a spherical pattern. The plasma can escape down the ends of the tube, with the resulting motion of the plasma inducing various types of instabilities.

Mirror Machines

A Mirror Machine operates essentially like a Theta Pinch except a strong magnet is placed around each end of the tube in an attempt to deflect the plasma backwards towards the opposite end of the tube. To some degree this technique works. However, Mirror Machines have been unable to contain all of the various instabilities that form as the plasma moves and changes direction within the device.

Z-pinch

The idea of Z-Pinch, best embodied in Sandia National Laboratory's Z-Pinch device, is to suddenly apply a massive voltage across a cylindrical pattern of wires. The wires vaporize. The cross-product of the Electric and Magnetic fields produced, described using the Poynting Vector, or classically as the Electromagnetic Momentum, of the induced fields, collapses the plasma in a cylindrical pattern. This collapsing of the pattern—for whatever theoretical reason put forth—is the same process that will be employed in all of the reactor designs in this application. However all of the designs in this patent application use this physical effect within a spherical pattern, rather than within a cylindrical pattern. In other words, the Z-Pinch device is the closest prior art to the designs in this patent application. Since the cylindrical pattern in a Z-Pinch is not spherical, instabilities form. The resulting instabilities disrupt the pattern of the fusion burn.

Another key difference between Z-Pinch designs and the new designs in this document is Z-Pinch devices have made no attempt to actively contain the fusion burn after implosion. Z-Pinch devices have no external, Spherical Electromagnetic Containment Fields (40). There is no attempt to extract energy from Z-Pinch devices using a Spherical Electromagnetic Containment Fields (40) around the burn and the MHD process.

MAGO

Russian researchers have developed a device called “MAGO.” This device passes a large electrical pulse through an approximately cylindrical copper chamber. The geometry of this device is not spherical. In general, the new designs within this application pass an electromagnetic pulse over the outer surface of a spherical pattern, rather than through the center of the device. (In some of the new designs in this application, a fraction of the electromagnetic pulse is allowed to pass over the Conductive Layer (18) of the Reactor Core (1), and a fraction of the electromagnetic pulse is allowed to pass through an inner Spherical Wire Implosion Cage (51) in order to ignite the Fuel Pellet (36) within the Spherical Wire Implosion Cage (51). (See Figures 31, 32, 33, and 38.) The bulk of the electromagnetic pulse passes over the Outer Containment Sphere in a spherical pattern.)

In the MAGO system a deuterium and tritium gas is placed in the approximately cylindrical copper chamber, then a massive electromagnetic pulse heats the gas to a plasma state, then the gas flows past an inner nozzle, further heating areas of the plasma.

There are key differences between how the MAGO device works and the devices described in this patent application. First the external containment geometry is approximately cylindrical rather than spherical. Second, the nozzle inside of the cylinder essentially compresses the plasma outwards. Secondary forces from the outer wall do compress the plasma back inwards. However, in the new spherical designs in this application, the portion of the plasma that is to be fused is always compressed towards the center of the fusion burn. With respect to the MAGO device, the fusion burn would need to occur within the solid nozzle portion of the device if it were to have the fusion burn occur in the center of the device. Third, there is no attempt to actively contain and prolong the fusion burn. Fourth, there is no attempt to extract the energy from the fusion burn via MHD. Fifth, the geometry of the MAGO device is not harmonic, energy basically bounces around this non-symmetrical cavity. If the yields of subsequent fusion burns in a MAGO device were always identical, then it might be possible to estimate where the fusion reactions would occur inside the device and optimize the device. However, variations in subsequent fusion burns, combined with the erratic bouncing of energy inside the device, will cause the physical locations of fusion burns to be inconsistent, unpredictable, and essentially non harmonic.

Magnetized Target Fusion (MTF)

Magnetized Target Fusion is an intermediate approach between Magnetic Confinement devices and Inertial Confinement devices. In a MTF device a “magnetized target plasma” is placed within a containment vessel and is explosively imploded. As far as I know, these containers are cylindrical, or only “quasi-spherical”. Devices such as these have been used by the military to study fusion bombs. In essence, they are bombs. In one planned device by Los Alamos National Laboratory, they describe potential plans to create a quasi-spherical compression by cylindrically compressing a spherically shaped liner. Much of the information in this area is classified due to the similarity to nuclear fusion bombs, and would be excluded from patentability as such. However, these devices: do not attempt to create a prolonged burn since they are explosively imploded by design; are cylindrical or only “quasi-spherical”; do not attempt to contain the burn since they are allowed to explode after they are imploded, and do not attempt to extract the energy using MHD. Finally, the destruction of the containment chamber is a distinguishing feature in comparison to the new designs in this patent application. To be a commercial viable reactor design, the new designs in this patent application do not destroy, or attempt to destroy the device with each pulse.

Whatever the precise merits, features and advantages of the above cited references and the hundreds, if not thousands, of attempted variations—other than nuclear fusion bombs—none of them achieves or fulfills the purpose of providing more nuclear energy output than was put into the devices. All of them, including nuclear fusion bombs, do not work with respect to the intended goal of producing usable, commercially available energy. None of the devices attempts to actively contain the fusion plasma in a spherical geometry. None of the devices attempts to surround the fusion burn in a spherical electromagnetic field. None of the devices attempts to use spherical MHD electrical energy conversion. None of the devices attempts to create an extended, harmonic, spherical burn.

To summarize: all previous devices with the distinct goal of creating commercial energy from nuclear fusion have failed. After about 50 years of research, after billions of dollars of research, there are no commercial fusion reactors. If the patent designs put forth in this application perform as intended and provide more output than input energy, it is proof that the designs contained in this patent application are original, not obvious from prior art, new, and unique, and thus patentable. In fact, there is probably no other area in the history of science where more unsuccessful prior art exists—based upon money invested—than in the area of commercial nuclear fusion energy production.

Summary of the Invention

In an attempt to explain the fundamental nature of time and develop a grand unified theory of physics, I have developed a completely new method to create a nuclear fusion reactor. While I believe these designs will work because I believe I have been able to unify physics, I will not make use of any new physics to describe this patent. I will describe these new designs using commonly accepted physics.

All embodiments of these reactor designs have these common features: fusible matter—in plasma or solid form—is compressed and heated—in a spherical geometry—until the nuclear fusion process begins; the fusion burn is surrounded and wholly or partly contained by a Spherical Electromagnetic Confinement Field (40); as the fusion burn progresses, instabilities in the plasma that surrounds the center of the fusing matter will either be suppressed by the surrounding Spherical Electromagnetic Confinement Field (40) or will move outwardly towards the surrounding Spherical Electromagnetic Confinement Field (40) in the form of positively, negatively, or neutral charged particles; the electric and magnetic fields of the outwardly moving particles will interact with the surrounding Spherical Electromagnetic Confinement Field (40) in a magnetohydrodynamic (MHD) fashion; the MHD interaction will setup a voltage, or a magnetic field differential, across the surrounding Spherical Electromagnetic Confinement Field (40)—in the Core Area—that can be tapped directly—or indirectly, using coils—for commercial electric power; and in all designs the length of the fusion burn will be lengthened by the external Spherical Electromagnetic Containment Field (40). In some designs, the center of the fusion burn may pulsate. In some designs, if the Spherical Electromagnetic Containment Field (40) is strong enough, then the fusion burn will continue until the fuel is almost totally consumed. In all of these designs, the fusion burn will be spatially suspended approximately at the geometric center of the Spherical Electromagnetic Confinement Field (40). (Approximately, due to the gravitational pull on the fusion burn area. Reactors in space would primarily be influenced by any inertial accelerations of the reactor.)

The exact features and materials of designs that can create a spherical electromagnetic field that will compress and ignite the fusion fuel can vary considerably. However, each of the design variations requires a description of: the Electromagnetic Containment Circuit, the Core Area, the method of positioning the fuel, the method of compressing and igniting the fuel, and the method of containing and extracting energy from the burn using MHD and other techniques.

Some hybrid variations of these reactor designs combine features from earlier Magnetic Confinement Reactor Designs and Inertial Confinement Reactor Designs with the new and unique features of these designs.

In all cases, the main goal of each reactor design is to create commercially usable electrical energy. In some designs, amorphous carbon will be subjected to highly compressive loads, high temperatures, and strong electromagnetic fields. Therefore, a secondary product of these reactor designs will be the manufacture of diamonds.

There are numerous major embodiments of these reactor designs and hundreds of significant variations. The version described as the preferred embodiment, described first, is chosen above the other designs based solely upon the likelihood that it would be the first successful reactor to produce more energy than it consumes and that possibly it will be easier to build because it uses a hybrid of technologies and materials currently available to the scientific community.

Overall Layout

Refer now to Figure 1, which is an overall drawing of the preferred embodiment of the invention.

Figure 1 is on Page 109

It has one Reactor Core (1) and 31 Conducting Spheres (2) laid out in an oval pattern. (Variations from the preferred embodiment can use circular-path or straight-path layouts.)

The Core

The Reactor Core (1) is a hollow sphere with many layers of conducting and non conducting materials, described later. The center of this sphere is the location where the fusion reaction will occur. A main goal of the overall reactor design is to have fusion reactions occur at the center of the core, and not to have fusion reactions occur at the centers of the Conducting Spheres (2). (Variations of the preferred embodiment can replace 1 or more Conducting Spheres with additional Reactor Cores.) (An analogy can be made between the Reactor Cores of these designs, and the number of cylinders in combustion engine. Increased power can be obtained from using more Reactor Cores, but at the expense of increased complexity due to timing the fusion burns. Another analogy is the power from one Core can be used to compress the fuel in another Core just like the power in one piston can be used to compress the fuel in another piston.)

Conducting Spheres

The Conducting Spheres (2) are completely solid as shown in Figure 2. (A variation of the Conducting Sphere can be hollow. Another variation of the Conducting Sphere can use a plasma.)

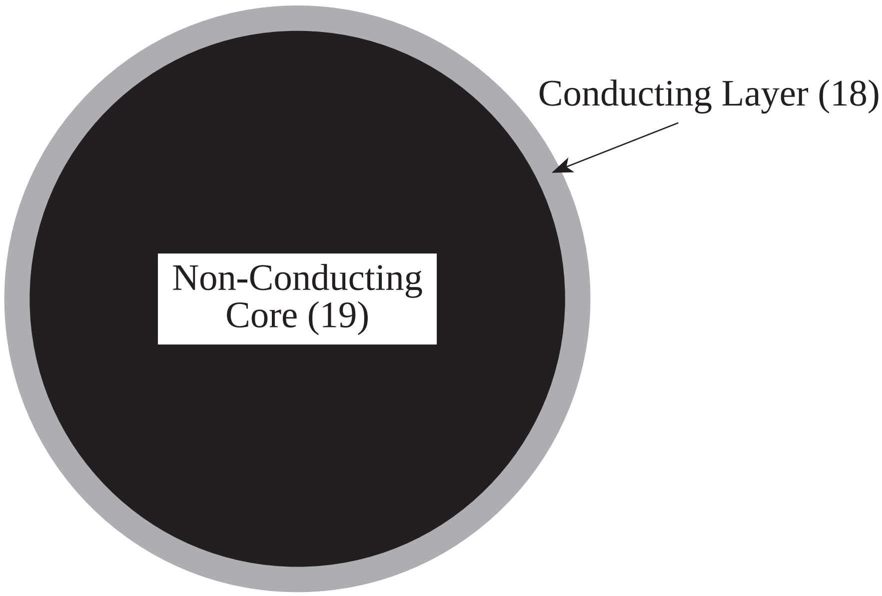

Figure 2

The outer layer of a Conducting Sphere is made of a conducting layer of material (18). The inside portion (19) of a Conducting Sphere (2) is made of a non conducting material, or can be a vacuum. (While some variations of the Conducting Spheres could be filled with gases that are not likely to form fusable plasmas—including, but not limited to Xenon—such variations are not recommended because of the possibility of electrical arcing inside of the Conducting Spheres (2). It is extremely important that the possibility of electrical arcing must be minimized in these designs. Electrical arcing inside Conducting Spheres (2) has the potential to destroy all key components in these reactor designs.)

The dimensions for this preferred embodiment are: outer diameter 5 meters, outer layer thickness 15.25 cm or about 6 inches. The material chosen for the outer Conducting Layer (18) for this preferred embodiment is a Copper-Niobium alloy, Cu-Nb. The material for the inner Non-Conducting Core (19) is amorphous Carbon.

The outer surface of the Conducting Layer (18) of the Conducting Spheres (2) and the Reactor Cores (1) must be polished to a very smooth finish to help improve the electromagnetic harmonics on these surfaces. The inner surface of the Conducting Layer (18) of the Conducting Spheres (2) and the Reactor Cores (1) must be as smooth as possible. In some designs, the smoothness of the inner layer may be limited by manufacturing techniques.

These spheres will likely be formed in two hemispheres with a heat-shrunk overlapping butt joint (20) as see in Figure 3.

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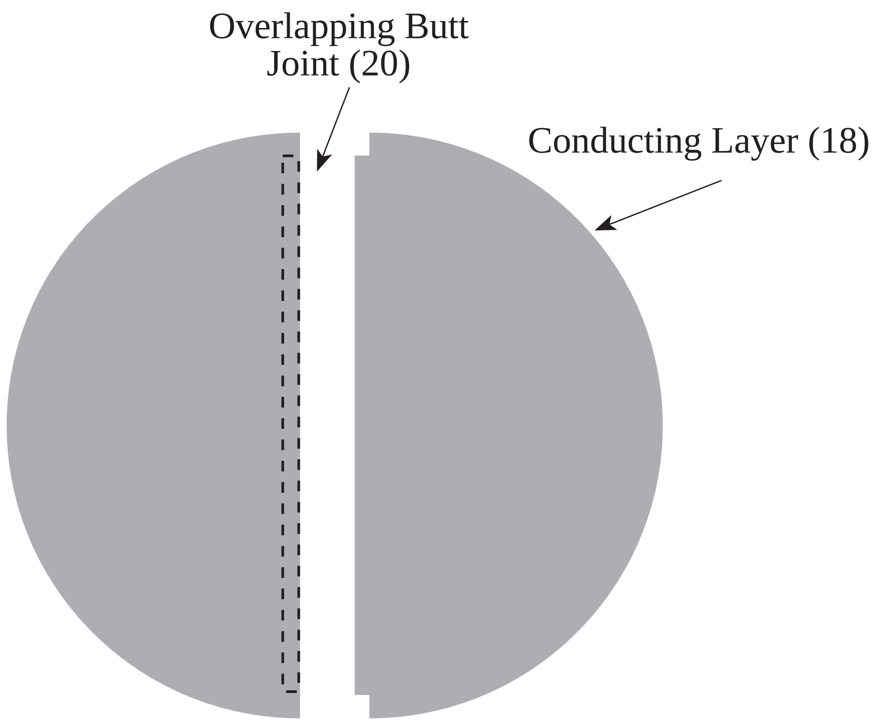

Figure 3

The amorphous carbon fill will be placed into the Conducting Sphere through an Orifice (21) that will be carefully plugged, and smoothed to match the surrounding Cu-Nb material.

If the surfaces of the Conducting Layer (18) of the Conducting Spheres (2) or Reactor Cores (1) are not smooth and consistent, then the conductivity and electromagnetic harmonics may be disrupted to some extent. It is believed, from theory, that every effort should be made to reduce any influence that may cause a non harmonic electromagnetic wave pattern in the Conducting Spheres (2) or Reactor Cores (1).

One possible method—using a funnel to pour the fill through an orifice (21)—for filling the Conducting Spheres (2) with a non conducting fill (19) such as amorphous Carbon can be seen in Figure 4.

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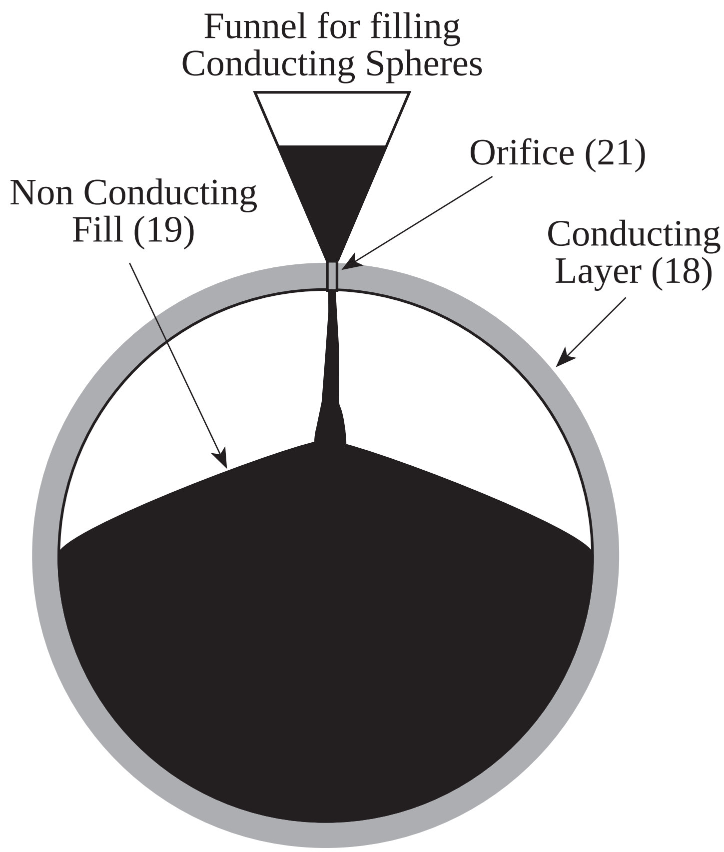

Figure 4

The Overlapping Butt Joints (20) of the Conducting Spheres (2) should be aligned perpendicular to the central axis of the oval Conducting Sphere Track (4), as shown in Figure 5. This may slightly help the harmonics of the Magnetic Circuit.

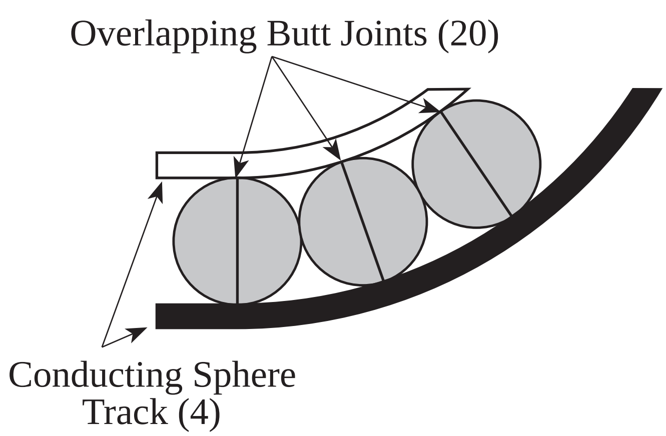

Figure 5

It is expected that the Overlapping Butt Joints (20) will be fused solid after repeated use. The strong electromagnetic fields involved will weld the joints together. When the Conducting Spheres (2) are refurbished, facilities and equipment will be needed to:

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- move these massive spheres (whether they are intact or damaged)
- cut open these massive spheres
- remove the carbon fill
- carefully crush the carbon fill and remove any diamond crystals
- melt and recycle the conducting material
- recycle carbon and graphite, or other fill material

Reactor Core

The cross section of the reactor core is shown in Figure 6.

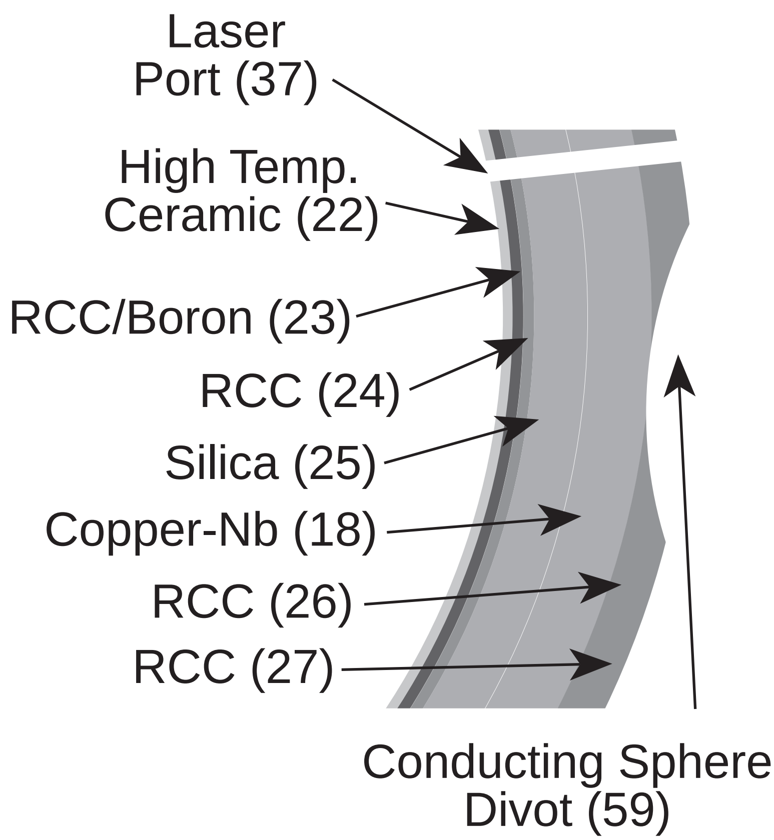

Figure 6

To summarize, an initial reactor core could be designed as such:

1) An inner layer of non-conducting material made up of an Ultra High Temperature Ceramic (22) such as: hafnium diboride silicon carbide; or, Zirconium diboride composite; or, other related ceramic compounds. The exact thickness of this layer is unknown at this time due to the classified nature of these ceramics—they are now used to make nose-cones for ICBMs. The estimated required thickness is 1 inch. They are estimated to be able to withstand temperatures up to 5,000° F.

Preferably, this inner layer of material will have a composition that includes some Boron. Neutral elementary particles such as neutrons may have enough energy to penetrate the Spherical Electromagnetic Confinement Field (40). Boron is known to be able to stop neutrons. Thus, the purpose of the inner layer will be to shield the outer layers from massive thermal shock and neutrons. (Most likely, this inner layer will be manufactured as two interlocking hemispheres. Possibly manufactured as interlocking tiles.)

2) A second, essentially non-conducting layer, that is composed of material that can withstand high temperatures, thermal shock, compressive forces from without, explosive forces from within and can stop neutrons, such as, a 1 inch wall composed of a reinforced carbon-carbon matrix (RCC) impregnated with Boron (23). (Most likely manufactured as two interlocking hemispheres. Possibly manufactured as one piece around the inner layer of Ultra High Temperature Ceramics or SiC-SiC (Silicon / Carbide composites). Preferably, the material would have a low activation, which means the material would not be negatively affected by combining with neutrons coming from the nuclear reaction, creating radioactive material.)

3) A third layer, essentially non-conducting, that is composed of material that can withstand high temperatures, thermal shock, compressive forces from without, explosive forces from within, such as a layer composed of 1 inch of RCC (24). (Most likely manufactured as one piece around the inner layers of Ultra High Temperature Ceramics and Boron impregnated RCC.)

4) A fourth layer, essentially non-conducting, that is composed of a material that can withstand massive thermal shocks and lessen the thermal shock to the next layer towards the outside of the core. This layer could be composed of 5 inches of Silica (25) (99.8-percent amorphous fiber) made rigid by ceramic bonding. This is the same material used in Space Shuttle heat shields. (Most likely manufactured as two interlocking hemispheres. Possibly manufactured as multiple interlocking tiles attached to the outside of the inner 3 layers.)

5) A fifth layer, that is highly conductive and very low resistance, is economical, that can be formed into spherical shells of the size needed, and can withstand the internal electromagnetic forces—e.g., Coulombic and Hall—created by massive electromagnetic fields used in these designs. Such as a layer could be composed of Cu-Nb (18)—Copper-Niobium—that is approximately 6 inches thick. (Most likely manufactured as two interlocking hemispheres that are heat-shrunk to each other with the lap-joint situated at the eventual equator of the electromagnetic field.) (In some variations, this layer may be a plasma instead of a solid.)

6) A sixth layer, essentially non-conducting, that is composed of material that can withstand high temperatures, thermal shock, explosive forces from within. Such as a layer might be composed of 2 inches of RCC (26). (Most likely manufactured as two interlocking hemispheres.) This layer must have a Conducting Sphere Divot (59). This cut out area allows the Anode / Cathode Conducting Sphere (13) to sit next to the Conducting Layer (18) of the Reactor Core (1). Without this Divot, the harmonics of the electromagnetic fields would flow smoothly from sphere to sphere.

7) A seventh layer, essentially non-conducting, that is composed of material that can withstand high temperatures, thermal shock, explosive forces from within. Such as a layer might be composed of 2 inches of RCC (27). The main purpose of this layer would be to add additional structural strength to the 6th layer, but with strands of Carbon and with the joint at a 90° layer to the sixth. (Most likely manufactured as two interlocking hemispheres.) This layer must have a Conducting Sphere Divot (59). This cut out area allows the Anode/Cathode Conducting Sphere (13) to sit next to the Conducting Layer (18) of the Reactor Core (1). Without this Divot, the harmonics of the electromagnetic fields would flow smoothly from sphere to sphere.

8) Laser Ports (37) must be drilled through the Reactor Core in order to allow the Laser Beams—or Ion Beams in some variations—to impart their energy to the fusion Fuel Pellet (36).

In this version of the core wall, the total wall thickness is approximately 18 inches of which 1/3—i.e., 6 inches—is conductive.

Placement of Conducting Spheres and Trough Description

The bulk of the conducting spheres—29 out of 31—sit in a non conducting trough called the Conducting Sphere Track (4). The trough could be made of a non conducting material such as cement. A cross section of the Conducting Sphere Track (4) is shown in Figure 7.

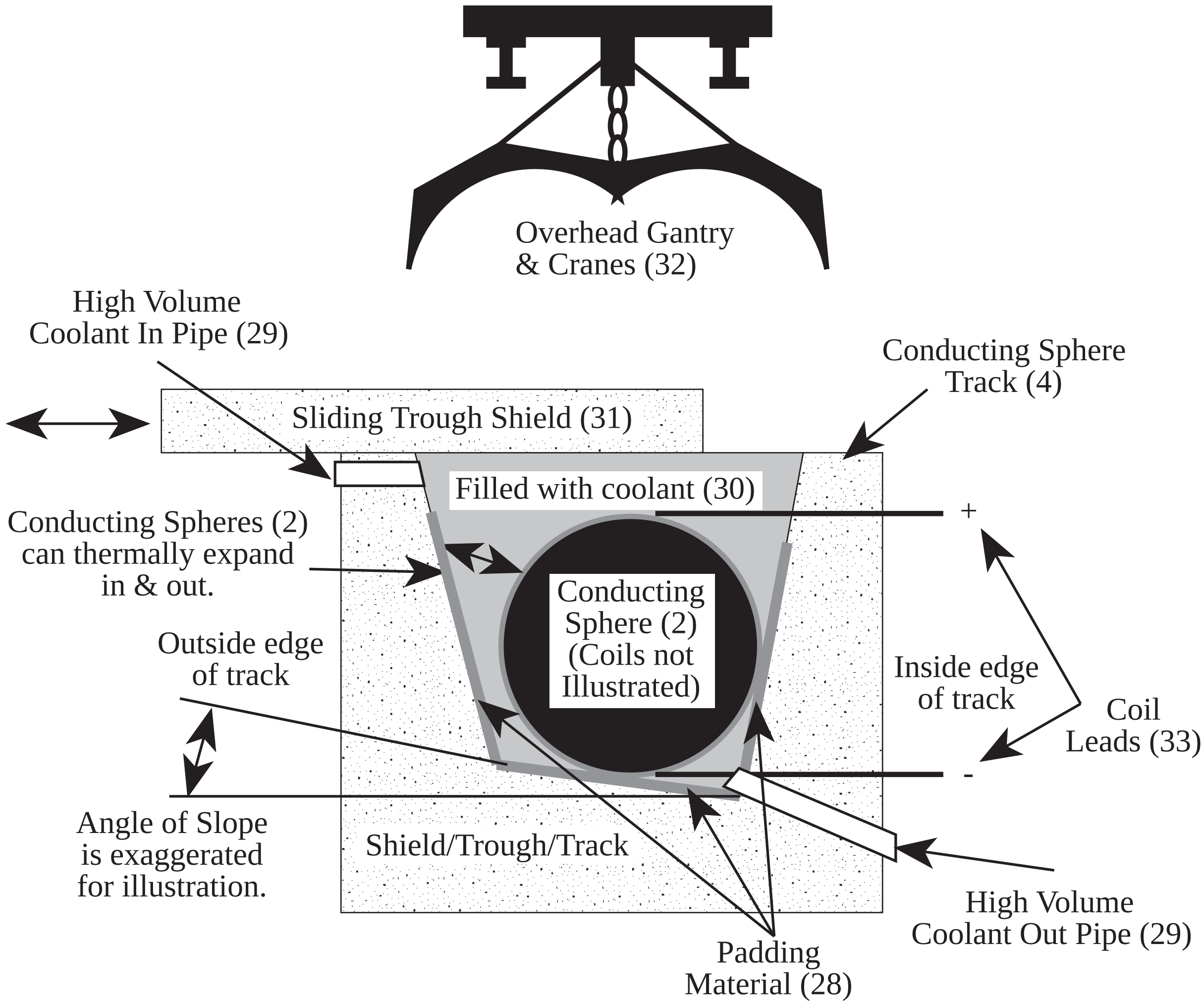

Figure 7

If cement is used, then it should not be reinforced with a metal such as traditional rebar. Instead it should be reinforced with non-conducting material such as glass fibers. Conducting reinforcement materials such as rebar in the cement would be too close physically to the intense electromagnetic fields in the Conducting Spheres. This can cause many problems, including but not limited to: induction of electromagnetic fields in the rebar; heating of the rebar; cracking of the cement, disruption of harmonics in the Conducting Spheres and Core(s).

The cement trough should be lined with a Padding Material (28) such as, but not limited to, vulcanized rubber. The purpose of the Padding Material is to help protect the surface texture and geometrical shape of the Conducting Spheres. If the Conducting Spheres were nicked or dented when placed into the trough, or if the weight of the Conducting Spheres gradually flattened the spheres, then the electromagnetic harmonics of the Conducting Spheres would be reduced or lost.

The Padding Material (28) should be sloped towards the center of the trough. (The slope is exaggerated in Figure 7 for illustration purposes. In reality the slope would be very minor.) In essence, the conducting spheres are gently pulled in towards the center

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of the trough by the force of gravity. This allows the Conducting Spheres (2) to thermally expand outward and inward and always be positioned next to each other on the Conducting Sphere Track (4).

The trough should have numerous, high-volume input and output Coolant Pipes (29). This would allow the trough to be quickly filled with a Coolant (30), such as water, and quickly drained. Cooling of the Conducting Spheres and Core(s) will help the harmonics of the Spherical Electromagnetic Confinement Field (40) to be maintained. For example, if the temperature of a Conducting Sphere dramatically increased, then the conductivity of the Conducting Sphere will change, and, due to thermal expansion, the wavelength of the main harmonic would change.

The top of the Conducting Sphere Track (4) should have Sliding Trough Shields (31) that can be quickly moved on or off the trough portion of the Conducting Sphere Track (4). While over the trough the Sliding Trough Shields (31) will provide shielding in case a Conducting Sphere (2) ruptures. When the lids are retracted, it will allow the Conducting Spheres (2) and other components such as the Hemispheric Coils (6) to be checked, adjusted, or quickly replaced.

There should be a means to quickly replace the massive Conducting Spheres (2) and Hemispheric Coils (6). This can be accomplished via an Overhead Gantry and Cranes (32).

There should be connecting lead wires that attach the Hemispheric Coils (6) to the main Electrical Bus (7), the Capacitor Banks (5) and the Power Grid. These Coil Leads (33) can penetrate through any side of the Conducting Sphere Track (4), or through the Sliding Trough Shields (31). The Coil Leads (33) should be highly conductive, evenly space around the track, and as short and straight as possible. The Coil Leads (33) will be cooled by the Coolant (30) within the trough of the Conducting Sphere Track (4) and by the Coolant Bath (8) outside of the Conducting Sphere Track (4). (An additional cooling jacket may be required within the concrete portion of the Conducting Sphere Track (4) but is not utilized in this design.)

In addition to the above details, the Conducting Sphere Track (4) will have numerous sensors to monitor: temperature, strain, electric fields, magnetic fields, diameters of Conducting Spheres (2), etc..

Placement of the Anode and Cathode Conducting Spheres

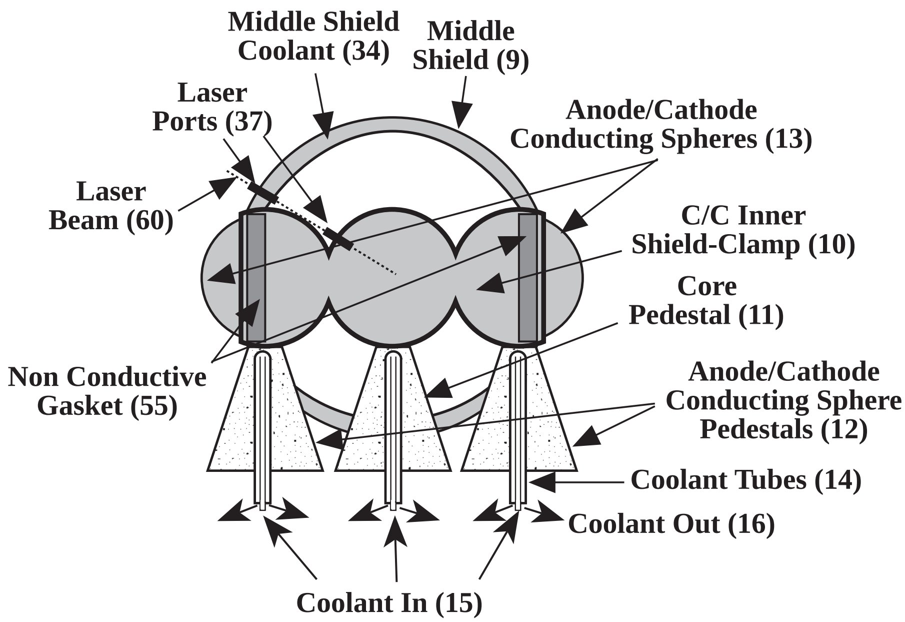

Figure 8

Figure 8 shows some of the major details in the central reactor core area. The term "anode" and "cathode" with respect to this electric circuit is purely arbitrary. Either Conducting Sphere (2) that is adjacent to the Reactor Core (1) could act as an anode or cathode in an electric circuit, or neither, in a magnetic circuit. The "Anode / Cathode Conducting Spheres" term simply refers to the two Conducting Spheres (2) that are closest to the Reactor Core (1).

The Anode (13), Reactor Core (1), and Cathode (13) must be aligned next to each other. In this embodiment, the 3 spheres are held in position by an inner C / C Inner Shield-Clamp (10). This C / C Inner Shield-Clamp (10) is designed with two halves that act in a clamshell fashion. When the Middle Shield (9) opens, so does the C / C Inner Shield-Clamp (10).

The Middle Shield (9) is made with double walls. The walls are made of a strong material that would resist heat and puncture due to the explosion of a Reactor Core (1), or Anode / Cathode Conducting Sphere (13). There are some Stainless Steels—such as 316 Stainless Steel—that are not very reactive to neutrons. Low reactivity for metals is important. After a period of use, the shield material will become radioactive and must be replaced. This will be one of the biggest sources of radioactive waste products from such power plants. The preferred embodiment will use 316 Stainless Steel. Other materials, including, but not limited to reinforced Carbon / Carbon matrixes could be used for the Middle Shield (9).

Inside the two layers of the Middle Shield (9) is the Middle Shield Coolant (34). The coolant is water in the preferred embodiment. It is pumped through the Middle Shield (9) at a high rate. In some variations, this water coolant could be replaced by some other fluid, gas, or material appropriate for cooling.

The Anode/Cathode Conducting Spheres (13) sit on a non conducting Conductor Pedestals (12) of fiber reinforced cement. The center of each pedestal contains Coolant Tubes (14) for coolant to flow in and out. In this design, and there are many other possible designs, the coolant flows into the pedestals through the central Coolant In (15) tube, and flows out of the pedestals through the outer Coolant Out (16) tubes. The purpose of cooling the pedestals is so they do not become "hot spots" beneath the Conducting Spheres. The coolant must also be carefully monitored so as not to cool the pedestals too much, creating "cold spots" beneath the Conducting Spheres. Hot spots or cold spots would affect the conductivity of the Conducting Layer (18) of the Conducting Spheres (2) and the Reactor Cores (1) and thus reduce the effectiveness of the Spherical Electromagnetic Confinement Fields (40).

Laser Ports (37) pierce the Middle Shield (9), the C/C Inner Shield-Clamp (10), and the Reactor Core (1). In the preferred embodiment, the final focusing crystal of the Laser Beam is located in the Laser Ports (37) that are in the Middle Shield (9). The Laser Ports (37) through the C/C Inner Shield-Clamp (10) and the Reactor Core (1) are just holes.

Non Conductive Gaskets (55) are located between the Middle Shield (9) and the C/C Inner Shield-Clamp (10) to reduce the possibility that current flow between the Anode/Cathode Conducting Spheres (13) and the Middle Shield (9) could take place.

The Core Pedestal (11) and the Conductor Pedestals (12) could be located on vertical hydraulic lifts that allow them to move up and down for easier opening and closing of the Middle Shield (9), the C/C Inner Shield-Clamp (10), and to allow fine adjusting of supported spheres as they thermally expand and contract through temperature variations.

Placement of the Reactor Core

While the Reactor Core sits in the C/C Inner Shield-Clamp, its weight is also supported by a non conducting pedestal made of fiber reinforced cement, called the Core Pedestal (11).

The center of the Core Pedestal (11) also contains Coolant Tubes (14) for coolant to flow in (15) and out (16). The purpose of cooling the pedestals is so they do not become a "hot spot" beneath the Reactor Core(s) (1). The coolant must also be carefully monitored so as not to cool the pedestal too much, creating a "cold spot" beneath the Reactor Core(s) (1).

Placement of Fusion Fuel

Initially, the fusion Fuel Pellet (36) will be in the form of spherical D-T pellets, presumably purchased from government sources. (Eventually, if the power of these reactor designs reaches expected levels, the Tritium may be avoided, allowing cheaper and easier to produce D-D pellets, and possibly other combinations of light elements.) The pellets will be prepositioned within the replaceable Reactor Core (1) by a three dimensional grid of Ablatable Wires (35) made of materials such as glass fibers—see Figure 9.

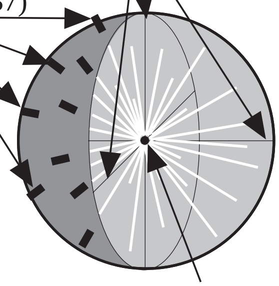

Figure 9

Laser Ports

The Middle Reactor Shield (9), the Inner Reactor Clamp / Shield (10), and the Reactor Core (1) will have small holes—Laser Ports (37)—that will allow the fusion pellet target to be imploded using traditional inertial confinement techniques. The preferred embodiment will use lasers. The design of the lasers and related equipment could be identical to the currently envisioned facility called the National Ignition Facility, or similar to many other inertial confinement devices. It is important that the Laser Ports be as evenly spaced around the reactor core to assist in imploding the fusion pellet in a spherical fashion. (The NIF facility currently envisions compressing Holoraum cylinders rather than the older type of spherical D-T pellets envisioned for this preferred embodiment.)

The Laser Ports (37) in the side of the Reactor Core (1) are needed for this preferred embodiment in order to allow the laser energy to reach the fusion Fuel Pellet (36). Lasers are needed in this design for the purpose of igniting the fusion Fuel Pellet (36). After the initial ignition of the pellet, the lasers are not needed.

The problem of having Laser Ports (37) in the side of the Reactor Core (1) is the disruption of harmonics. The electromagnetic harmonics within the Reactor Core (1) will be disrupted, to some extent, by the Laser Ports (37). This disruption is a result of the electrons flowing around the ports rather than through the conducting material that has been removed to make the ports. If the diameters of the ports are large, then the disruption of the harmonics will be larger. Since the disruption of the harmonics is not desired, the diameters must be minimized.

In some prior art, laser ports have used some kind of glass or crystal structure. The design of these components has been extremely difficult. The design of such “windows” for the Laser Ports (37) that pass through the C / C Inner Shield-Clamp (10) and the Reactor Core (1), in these designs at least, does not seem necessary. In this preferred embodiment, these inner Laser Ports (37) are simply holes. The final focusing optics for the lasers are located just outside of, or within, the Laser Ports (37) that pass through the Middle Shield (9). Their design can be identical to such components already designed for the National Ignition Facility.

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The size of the holes for the Laser Ports (37) that pass through the C/C Inner Shield-Clamp (10) and the Reactor Core (1) will depend on the diameter of the laser beams. Tests with specific reactor core materials and laser energies will be needed. If the diameters of the Laser Ports (37) are too small, then the laser beams will be diffracted by the ports, and the energy will not reach the Fuel Pellet (36). If the diameters of the Laser Ports (37) are slightly too small, then the lasers will vaporize some of the Conducting Layer (18) of the Reactor Core (1) and plug the Laser Ports (37). If the diameters of the Laser Ports (37) are just right, then the lasers will slightly vaporize some of the Conducting Layer (18) of the Reactor Core (1) but not plug the Laser Ports (37). With a slight amount of vaporized Conducting Layer (18) within the Laser Ports (37), and with the diameter of the Laser Ports (37) minimized, when the massive pulse of electromagnetic energy that forms the Spherical Electromagnetic Containment Field (40) passes over the core, then electrons and the electromagnetic pulse will arc through the Laser Ports (37), instead of around the diameter of the Laser Ports (37), and this will help to minimize the disruption of the electromagnetic harmonics within the core.

If the Laser Ports (37) are simply holes, the question is, "Will material pour out the Laser Ports (37) when the fusion reactor occurs?" If there was no electromagnetic confinement field, then the answer would be yes. However, with an electromagnetic confinement field in place, all of, or the majority of the plasma would be blocked.

Laser Port Distribution

The positions and distributions of the Laser Ports (37) over the Reactor Core (1) is important. The key engineering factor is how the ports can be positioned to fire around the Anode/Cathode Conducting Spheres (13) and pedestals (11) and (12). In general, it is preferable to implode the fusion Fuel Pellet (36) in a spherical pattern. The Anode/Cathode Conducting Spheres (13) and the pedestals (11) and (12) create "blind spots" where Laser Ports (37) can not be positioned. If needed, this problem can be minimized by having some of the end lasers aimed slightly off-center. They can be aimed more towards the ends of the fusion Fuel Pellet (36)—the ends that face the Anode/Cathode Conducting Spheres.

An estimated minimum of about 14 laser ports is needed to adequately implode the fusion Fuel Pellet (36) in a spherical pattern. Since the Laser Ports (37) reduce the electromagnetic harmonics on the Reactor Core (1), the number of ports, and thus lasers, must be minimized. However, if too few of lasers are used, then the plasma will not implode spherically, and the initial plasma instabilities would be too large for the Spherical Electromagnetic Containment Fields (40) to contain. The optimum number of ports can not be stated at this time because of the number of variables involved. The laser beam diameter is important. The laser wavelength is important. The energy per beam is a factor. The diameter of the fusion Fuel Pellet (36) is important.

Too many lasers could be used. For example, 50 lasers would probably be too many, creating too much of a disruption in the harmonics. Plus, the cost of the lasers could become prohibitive.

For the preferred embodiment, 24 Laser Ports (37) will be used. Their approximate positions are shown in Figure 10.

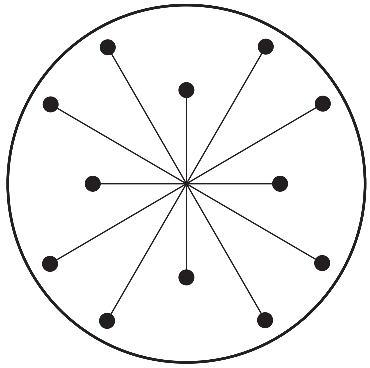

Figure 10

The dots in Figure 10 show the port positions. The circular line represents the Reactor Core's (1) outer diameter. The radial lines represent the angle from the Laser Ports (37) to the fusion Fuel Pellet (36). Figure 10 represents the view of the Reactor Core (1) from inside the oval Conducting Sphere Track (4) looking outwards. There are only 12 ports visible on this side. Another 12 ports would be on the opposite side (i.e., the outside view of the Reactor Core (1)). The angles are chosen to fire around the Anode / Cathode Conducting Spheres (13), and the Pedestals (11) and (12).

Laser Pulse, and Confinement Pulse Timing

In this preferred embodiment, the Confinement Field Pulse must come after the Laser Pulse for the reasons just discussed. If the Spherical Electromagnetic Containment Field (40) is too strong when the lasers pulses pass through the Laser Ports (37), then premature arcing may occur across the Laser Ports (37) in front of the laser pulses, blocking the energy of the lasers. If the Spherical Electromagnetic Containment Field (40) is too weak when the plasma explodes, then the fusion reaction will not be adequately confined. Thus, timing is critical in this design, as is shown in Figure 11.

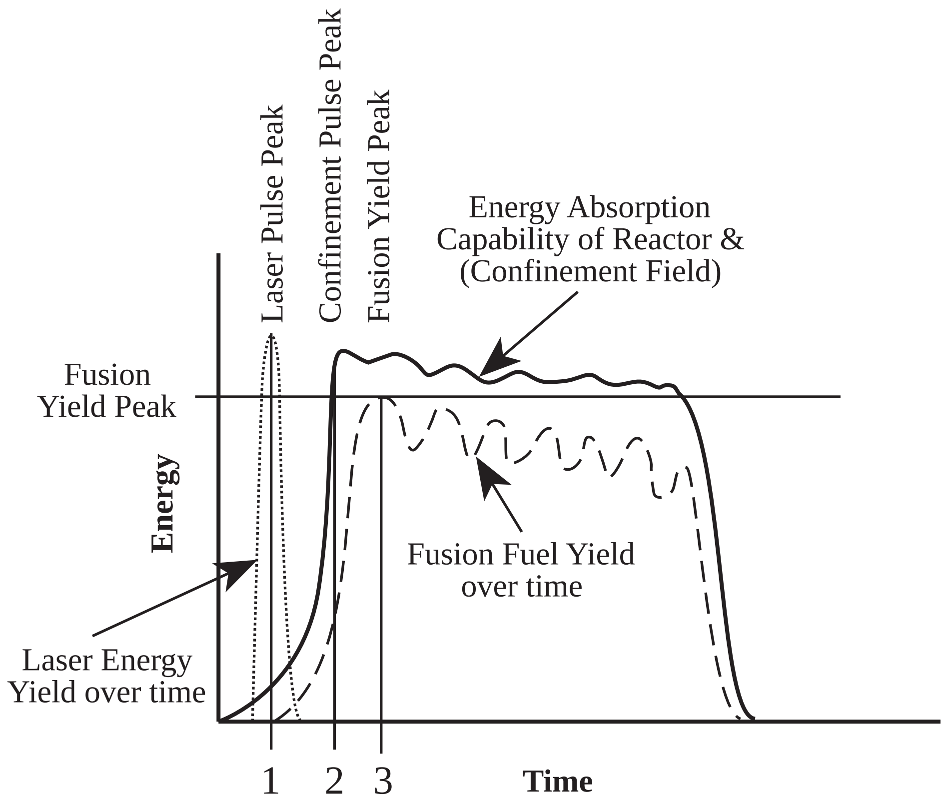

Figure 11

Tests must be performed to time the delay between when the laser pulses pass through the Laser Ports (37) and when the plasma starts to explode outwards. Further tests must be performed to determine the time needed for the energy from the Capacitor Bank (5) to pass through the Electrical Bus (7), through the Hemispheric Coils (6), to induce fields in the Conducting Spheres (4), pass through the Confinement Circuit, and build up to a value that will arc across the Laser Ports (37) in the Reactor Core (1). When the reactor is triggered, the timing of the lasers must be designed so that the peak of the laser pulse at time “1” is just prior to the timing of the peak of the Spherical Electromagnetic Containment Fields (40) at time “2”. (The total time width of the laser pulse and pellet explosion pulse will probably be only about 1 nanosecond. An estimate of the total width of the Confinement Pulse from triggering to peak will probably be about 4 to 5 µseconds—based upon the estimated discharge rate of the Capacitor Bank (5)—if the Marx modules described later are used. Therefore it is likely that the triggering of the Confinement Pulse will be required to begin prior to the triggering of the Laser Pulse.)

The delay and duration of each pulse after its triggering is unknown at this time and will be specific to each reactor design. In the example of timing in Figure 11, the Confinement Pulse is triggered prior to the triggering of the Laser Pulse. The Laser Pulse may need to be triggered first, or they may need to be triggered at the same time. The key detail is the Confinement Field Peak at time “2” lies between the Laser Pulse Peak at time “1” and the Fusion Yield Peak at time “3”.

Middle Reactor Shield

Surrounding the Reactor Core (1) and the Anode / Cathode Conducting Spheres (13) is a large double-walled Middle Reactor Shield (9). This shield is made up of strong material capable of halting debris from an exploding or rupturing core. The center of the double walls is filled with a coolant.

The Middle Reactor Shield (9) is of a clam-shell type. The two halves slide open for access to the central components. In the preferred embodiment, the two halves slide outwards, rather than up and down. This allows the Overhead Gantry and Cranes (32) to easily drop replacement Anode / Cathode Conducting Spheres (13) and Reactor Cores (1) into place.

(Design variations for the Middle Reactor Shield (9) may include one wall with no coolant, multi-wall shields with or without coolant.) Shield materials may be conducting or non-conducting. For the preferred embodiment, 316 Stainless Steel will be used. (Another possible metal alloy based on Vanadium—V-15Cr-5Ti—would be a good example of a suitable material. Metals would have to be resistant to radiation induced swelling and ductility loss and offer low residual activation. Other important considerations are: relatively high thermal conductivity; low thermal expansion coefficient and low modulus.)

If the Middle Reactor Shield (9) material is conducting, then Non Conductive Gaskets (55) must be placed between the Middle Reactor Shield (9) and the Anode / Cathode Conducting Spheres (13)—see Figure 8. The Non Conductive Gaskets (55) material could be a vulcanized rubber, possibly ceramic, or other materials. In essence, the bulk of the electromagnetic confinement pulse must follow the conducting material in the Conducting Spheres (2) and the Reactor Core (2) and not over the Middle Reactor Shield (9).

Ports through the Middle Reactor Shield (9) are required for the Lasers.

Inner Reactor Clamp/Shield

Attached to inside of the Middle Reactor Shield (9) is a non conducting Inner Reactor Clamp / Shield. This shield is about two inches thick, is made of Reinforced Carbon Carbon (RCC) material, is also of a clam-shell type, and shields and clamps into position around the Anode / Cathode Conducting Spheres and the Reactor Core.

Holes in the Inner Reactor Clamp / Shield are positioned to mirror the Laser Ports (37). The diameter of the holes can be larger than the holes through the sides of the Reactor Cores (1).

Description of Electrical Currents

The Conducting Spheres (2) and the Reactor Core (1) create an electric circuit. Potentially, a voltage could be set up so that current flows around the circuit. In this situation, the circuit will be called an Electrical Circuit, and the reactor is acting in the Electric Mode. Alternatively, currents can be set up over the Conducting Spheres to induce a magnetic potential across each Conducting Sphere. In this situation, the circuit will be called a Magnetic Circuit, and the reactor is acting in the Magnetic Mode. This preferred embodiment uses a Magnetic Circuit.

If this reactor design were designed to be an Electrical Circuit, then there would result large-scale transport of electrons around the oval track of the circuit. Large-scale transport of electrons would be relatively dangerous and destructive to the circuit.

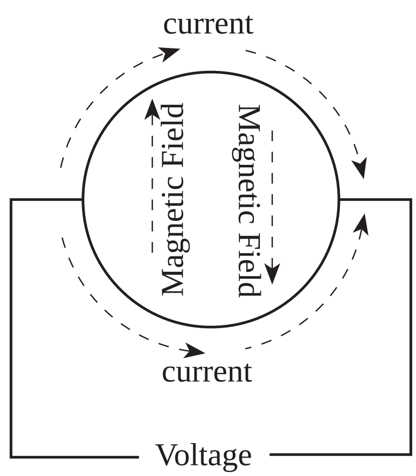

Figure 12

Figure 12 demonstrates how, if a Voltage is set up over the Poles of the Reactor Core (1), then an Electric Circuit is made. The arrows that represent the direction of the current show how large-scale transport of electrons would flow over the core and accumulate on one pole of the core. The magnetic field would obey the left-hand rule on the left hemisphere, and the right-hand rule on the right hemisphere.

If this reactor design were designed to be a Magnetic Circuit, then there would result large-scale transport of electrons around the outer diameters of the Conducting Spheres (2) and Reactor Core(s) (1).

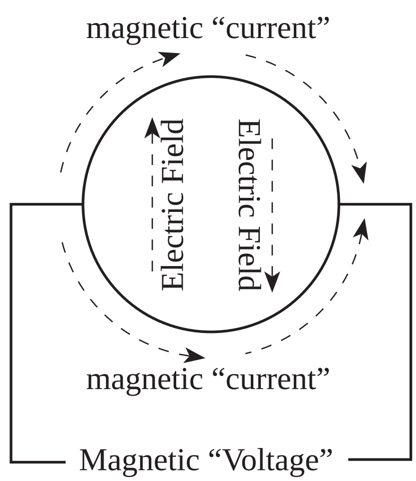

Figure 13

The arrows that represent the direction of the magnetic "current" show how large-scale transport of the magnetic field would flow over the core. The electric field would obey the left-hand rule on the left hemisphere, and the right-hand rule on the right hemisphere. Thus, the large scale flow of electrons would counter-rotate around the opposite hemispheres of the Conducting Spheres (2) and Reactor Core(s) (1) and would not accumulate on one pole. The preferred embodiment of these fusion reactor designs uses a Magnetic Circuit.

In order to induce the magnetic fields in the Magnetic Circuit in the preferred embodiment of these reactor designs, inductive coils will be used. There are many types of coils that can be used.

Hemispheric Coils (6)

I have coined the name "hemispheric" coil because I have not seen them used or named before. Basically the coil is wrapped around one hemisphere of supporting material: which may include but not be limited to: ceramic or RCC.

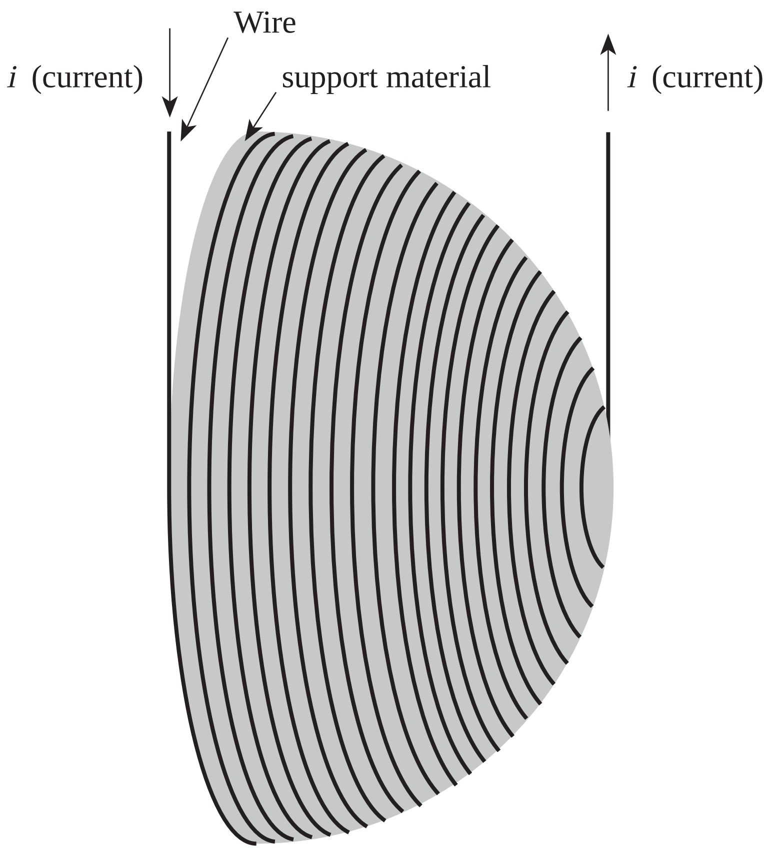

Figure 14

Other coil types could be used. Advantages of this type of coil are: they can use a constant current to create a magnetic field because the flux area is changing, and they create a symmetrical magnetic wave pattern over the Conducting Spheres (2). The symmetrical magnetic wave pattern would be conducive to creating a harmonic Spherical Electromagnetic Containment Field (40) over the Reactor Core (1).

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Because the geometrical design of this type of coil, the flux area of the coil is constantly decreasing—or increasing depending on the direction of current flow. Since the magnetic flux is changing, this will induce an EMF across the coil according to Faraday's Law of Induction. The direction of flow of fields over a Conducting Sphere (2) will oppose the fields in the coil. The fields on the Conducting Spheres (2) will be induced by the fields in the Hemispheric Coils (6). Thus, a magnetic field will be set up across the poles of the Conducting Sphere (2), and the large-scale transport of electrons in the Conducting Sphere (2) will counter-rotate around each hemisphere of the Conducting Sphere as indicated in Figure 15.

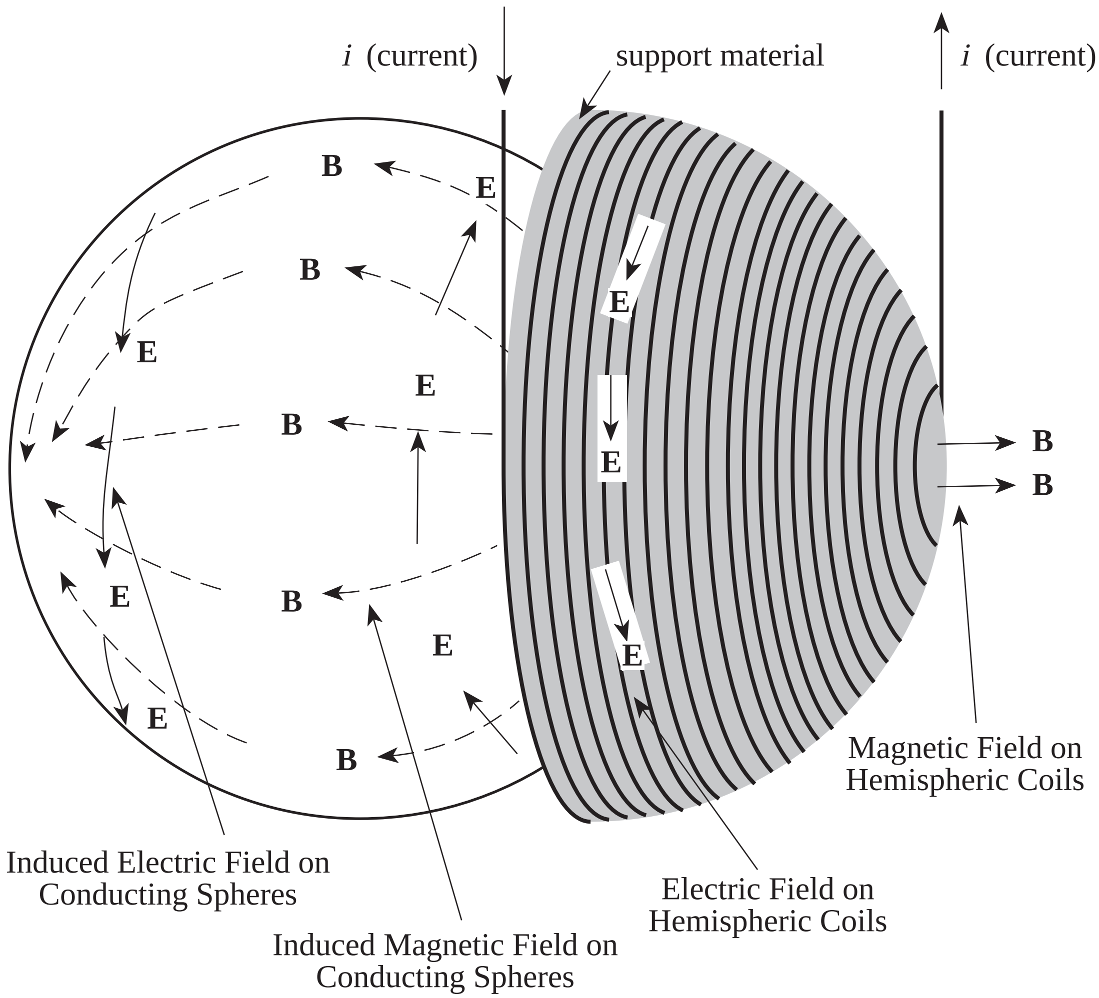

Figure 15

Just as it is possible to layer normal cylindrical coils, it should be possible to create a more powerful magnetic force by layering the hemispheric coils. Such a coil would be like a cup in a cup as shown in Figure 16.

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Exploded View of
Parallel Hemispheric Coils

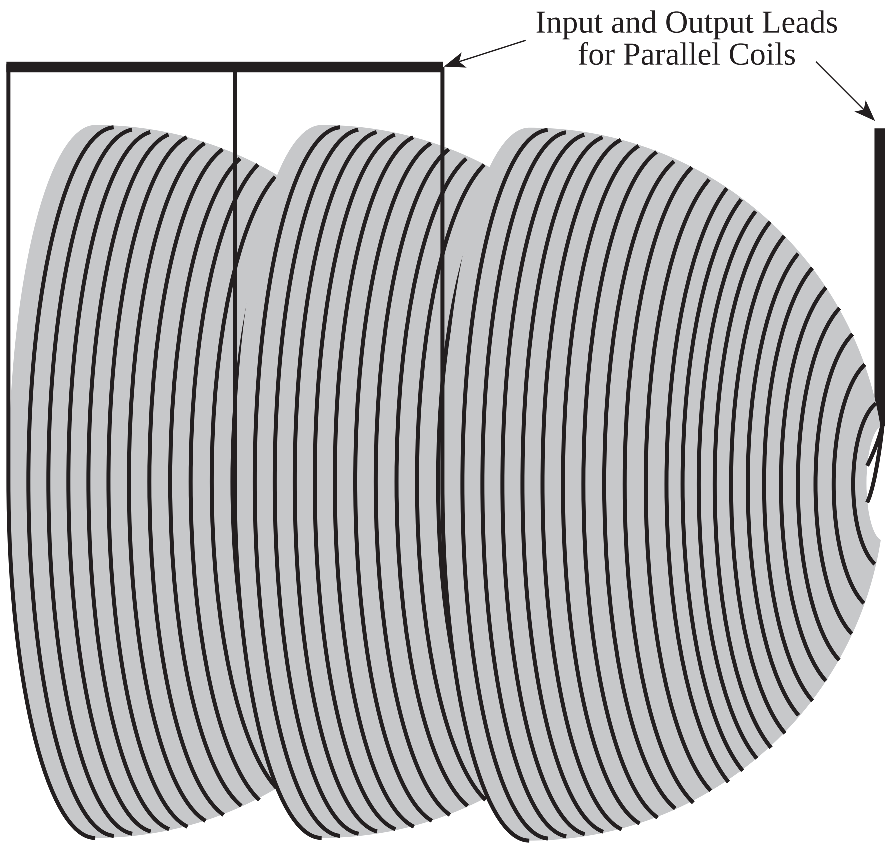

Figure 16

Since I have never seen a hemispheric coil, and have never seen equations for a hemispheric coil I am reluctant to say they will be the best type of coil for these reactors. However, based upon geometry, I believe they hold great promise and are used in the preferred embodiment. Alternate coil designs will be discussed later and can replace the Hemispheric Coils if needed.

The wiring of the Hemispheric Coils (6) could be connected in parallel or in series. I believe the best choice would be in parallel over one conducting sphere, and in series from conducting sphere to conducting sphere,—see Figure 17.

Exploded View of
Parallel Hemispheric Coils
Connected in Series

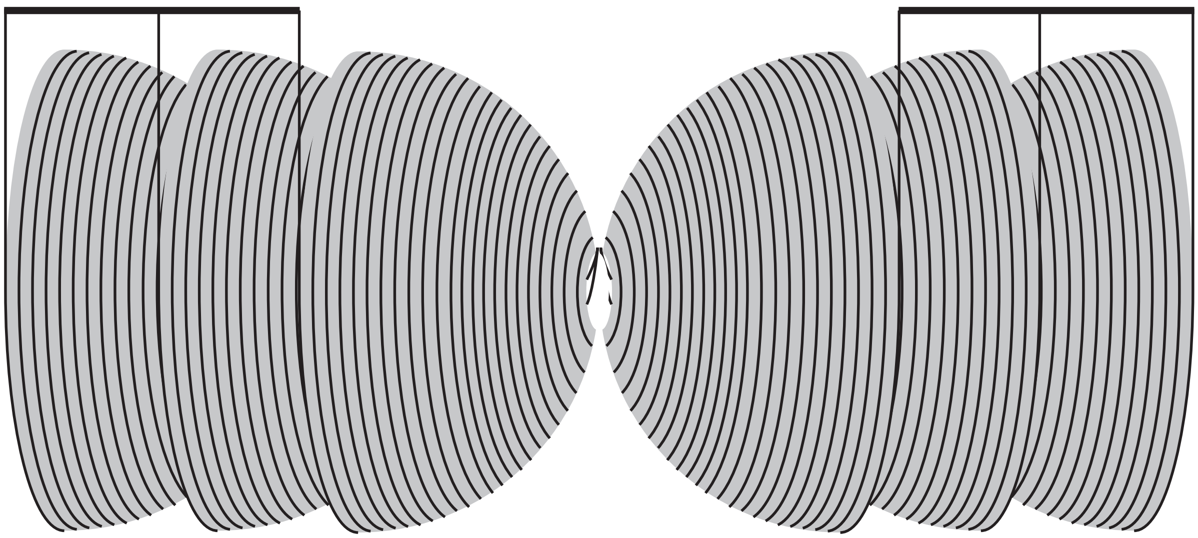

Figure 17

This is one method the Hemispheric Coils (6) can be connected in the preferred embodiment.

Energy Source to initially drive the Coils

As in all other fusion reactor designs, these reactor designs need an external energy source to start up. This external energy source could come from a variety of power sources such as: coal, oil, hydroelectric, fission, etc. Most external power plants would not have sufficient short-term energy to start the fusion process. Thus, some sort of energy collection system is needed.

Capacitor Banks

In many other fusion reactor designs, banks of capacitors are charged. This design utilizes such preexisting equipment. As an example, the Los Alamos National Laboratory is building a device called Atlas. This device will use a 36 MJ array of 240 kVolt Marx modules. These modules can be discharged rapidly. They can deliver a peak current of 45 to 50 MA with a 4 to 5 µsecond rise time.

The exact amount of capacitors that are needed for the preferred embodiment is not known at this time. This design is scalable. To meet the design goal of 1 to 3 Tesla of induced Magnetic fields over the Conducting Spheres (2) and Reactor Core(s) (1), additional capacitors and coils could be added as needed.

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Applying Current to the Coils

Again, I would use preexisting equipment to switch the capacitors to the coils. While tests with each reactor design would be needed, it is assumed that the massive capacitor banks must be discharged in unison. Special High-Speed Switches (38) have been employed for such purposes in other designs and could be purchased for this application. (For example, some inertial confinement reactors use synchronized laser-triggered, gas-insulated switches.)

When the energy in the capacitors is discharged into the Hemispheric Coils (6), then electromagnetic fields would develop in the conducting layer of each Conducting Sphere (2), and these fields would induce electromagnetic fields in adjacent Conducting Spheres (2). The Anode and Cathode Conducting Spheres (13) would induce the fields within the Reactor Core (1).

A key question is whether all of the energy in the Capacitor Bank(s) (5), should be released at once, with one triggering, or, should the initial pulse be followed up with more pulses. The answer is, it depends on economics. The Marx modules are obviously expensive. The initial pulse is the most critical. It confines the initial explosion of the fusion fuel. However, to the lengthen the duration of the fusion burn, additional time in the Spherical Electromagnetic Confinement Field (40) would be beneficial. The long-term costs of adding additional energy storage in the Capacitor Bank(s) (5) would be less than the additional energy captured from the fusion reactions. The bulk of the cost is expended in the initial confinement pulse, not adding additional time to the pulse.

The frequency at which initial pulses are triggered will be determined by the resonance of the Reactor Core (1). This rate is a function of the primary wavelength of the system. If designed correctly, this wavelength will be determined by the wavelength of the Conducting Spheres (2). An example of how an initial pulse of energy could be released by a capacitor bank, followed by additional pulses of energy by additional capacitors, is shown in Figure 18.

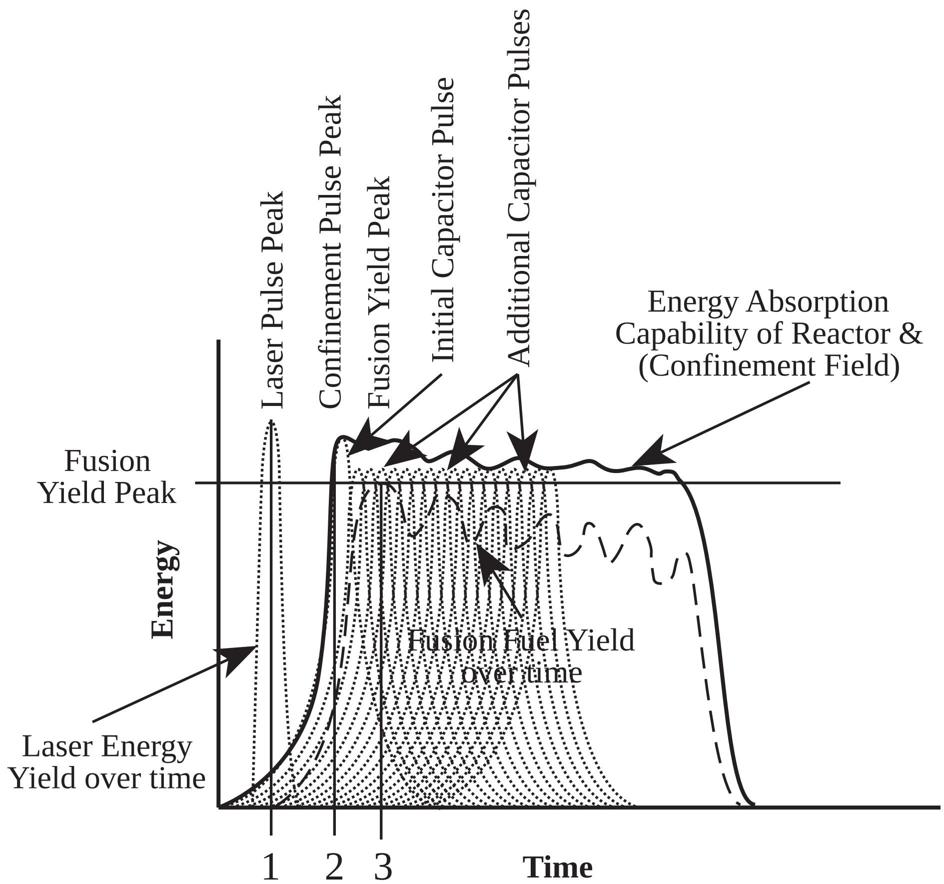


Figure 18

Additional pulses of confinement energy from capacitors would not be needed if, as predicted, the instabilities from the fusion burn combine with the initial pulse of confinement energy to continuously maintain the confinement field over the course of the fusion burn.

Magnetic Field Goals

Due to the custom nature of early reactor designs, and the number of design variables to be tested, it is impossible to state exactly what the goal of the Magnetic field over the reactor core should be. For example, while the conducting material for the spheres will initially be a copper alloy, the conductivity of the manufactured spheres must be tested. Obviously, an initial purchase of capacitors could be made and additional modules added on until a sufficiently high magnetic field is achieved. If sufficiently high magnetic fields are not initially attained, it is likely that additional active cooling of the Reactor Core (1) and Conducting Spheres (2) may be needed. I believe an initial goal of 1 Tesla would be a difficult but reasonable goal.

Organizations such as the National High Magnetic Field Laboratory have reach quasi-continuous magnetic fields of 65 Tesla in small bore magnets, and have numerous magnets with magnetic fields in the 20–45 Tesla range, including a 30 Tesla continuous magnetic field resistive magnet. If current design goals are met, organizations such as the National High Magnetic Field Laboratory are expected to reach 100 Tesla in a non-destructive magnet. Magnetic fields of up to 820 Tesla have been reached using destructive magnets at the Los Alamos National Laboratory.

Incremental increases in reaching higher magnetic fields in test magnets are being made by improving cooling, alloy selection, capacitors—or other energy sources—reinforcement structures, etc.. The modular designs of all of the new reactor designs in this document allow new and improved materials and devices to be tested, and first generation components to be replaced later, by more advanced components.

Reactor Core Spherical Electromagnetic Containment Field (40) Field Goal

The power that it transmitted to the focal point of the core can be found by using the following expressions:

Equation #1 $$P = \vec{S}A$$

(Power is equal to the Poynting Vector times the area of the sphere.)

Equation #2 $$\vec{S} = \frac{1}{\mu_0}\vec{E} \times \vec{B}$$

(The Poynting Vector is proportional to the cross product of the electric and magnetic fields.)

Equation #3 $$E = cB$$

(The electric field is proportional to the magnetic field times the speed of light.)

Equation #4 $$A = 4\pi r^2$$

(The surface area for a sphere.)

Solving:

Equation #5 $$P = \frac{1}{\mu_0}\vec{B}^2 c 4\pi r^2$$

As an example of what this implies for these reactor designs, if a magnetic field can be generated at the surface of a 5 meter conducting sphere with a value of 1 Tesla, then the power transmitted towards the focal point of the sphere would be:

Equation #6 $$P = \frac{1\left[T^2\right] 3\times10^8 \left[m/s\right] 4\pi\ 25\left[m^2\right]}{4\pi\times10^{-7}\left[Wb/A\cdot m\right]} = 1\left[T^2\right] 3\times10^{15}\left[m/s\right]\ 25\left[m^2\right]\left[A\cdot m/Wb\right]$$

Equation #7 $$= 75\times10^{15}\left[\frac{kg\cdot m^2}{s^3}\right]$$

Thus, a 1 Tesla field over a 5 meter sphere would focus 75 petawatts at the core of the reactor. A magnetic field of 1.5 Tesla would focus 168.75 petawatts at the core of the reactor. A magnetic field of 2 Tesla would yield 300 petawatts. A magnetic field of 3

Tesla would yield 675 petawatts. A magnetic field of 4 Tesla would yield 1.2 exawatts. All of these example energies are very extreme. This is energy that is focused towards the center of the reactor core. It is referred to as the Spherical Electromagnetic Containment Field (40). (In some design variations, the Spherical Electromagnetic Containment Field (40) will be relied upon to ignite the fusion fuel.)

With a Spherical Electromagnetic Containment Field (40) that has enough power, the steps to production of usable fusion energy are ready to begin.

General Steps for operation of reactor.

It is believed that the invention operates as follows:

1) The Capacitor Bank(s) (5) for both the Containment Circuit (1) and (2), and the Lasers (3) are charged.

2) A Reactor Core (1), with a spherical fusion Fuel Pellet (36)—held in place at the center of the Reactor Core (1) by 3 Abatable Glass Wires (35) in the x, y, and z axis—is placed on the Central Core Pedestal (11).

3) The Inner (10) and Middle Reactor Shields (9) are closed.

4) The Conducting Sphere Track (4) and Middle Reactor Shield (9) are filled with coolant and cooled. Coolant is pumped through the Anode/Cathode (12) and Core pedestals (11).

5) The Sliding Trough Shields (31) are closed.

6) The Overhead Gantry and Cranes (32) are retracted.

8) High-Speed Switches (38) allow energy stored in the Capacitor Banks to flow into the Laser Circuit and the Containment Circuit. The Lasers are allowed to fire so that their peak energy is applied to the fusion Fuel Pellet (36) slightly ahead of when the peak of the containment energy sweeps around the Containment Circuit (2) and (1) and is applied to the Reactor Core (1).

9) The current through the Hemispherical Coils (6) induces electromagnetic fields over the Conducting Layer (18) of the Conducting Spheres (2). These fields create a Magnetic circuit around the Containment Circuit (1) and (2)—i.e., the electrons in the Conducting Spheres do not flow around the circuit, they counter-rotate around each sphere, as shown in Figure 13, and create a strong magnetic field at each pole of the Conducting Spheres (2). The cross product of the Electric and Magnetic fields—the Poynting Vector—creates a strong central pointing field in each Conducting Sphere (2). The Non Conducting Fill (19) within each Conducting Sphere (2) would be heated and compressed, but not enough to start a fusion burn as in the Reactor Core (1). In the Reactor Core (1), a strong Spherical Electromagnetic Containment Field (40) will start to develop.

10) The Lasers (3) implode the fusion Fuel Pellet (36) and creates a nucleus of fused material.

11) The Spherical Electromagnetic Containment Field (40) over the Reactor Core (1) grows as the peak energy starts to flow through the Containment Circuit. (Extra capacitors are triggered—as needed—to lengthen the duration of the Spherical Electromagnetic Containment Field (40).)

12) Using High-Speed Switches (38), the Containment Circuit (1) and (2) is switched from the Capacitor Bank (5) to the energy grid.

13) In general, the Spherical Electromagnetic Containment Field (40) that is set up over the Reactor Core (1) inhibits the nucleus of fused material from exploding. A more precise way of saying this, is the fused fuel is inhibited from decaying. In general, the Spherical Electromagnetic Containment Field (40) will compress the fusion burn uniformly in all directions, helping the fusion burn to be harmonic. In general, some non harmonic Instabilities (39) will be ejected from the surface of the fusion burn in jet-like flows.

14) The outward exploding streams of plasma, the Instabilities (39), will setup flows at right angles to the Spherical Electromagnetic Containment Field (40). The exploding streams of plasma will interact with Spherical Electromagnetic Containment Field (40) that surrounds the core in a Magnetohydrodynamic fashion. The outward exploding streams of plasma will push out on the Spherical Electromagnetic Containment Field (40) via the MHD effect. The inward pointing Spherical Electromagnetic Containment Field (40) will push back on the exploding streams of plasma. The rate of flow of the outward exploding streams of plasma will be dramatically slowed. The energy lost in the slowing of the outward moving streams of plasma will be transferred to the Spherical Electromagnetic Containment Field (40), effectively increasing its strength, and creating an increased Magnetic differential across the Reactor Core (1).

15) The increased Magnetic differential creates a Magnetic flow, analogous to a current flow, around the Containment Circuit (1) and (2). A current flow will be induced in the Hemispheric Coils (6) by the Magnetic flow around the Containment Circuit (1) and (2). The induced current from the Hemispheric Coils (6) is allowed to flow out into the energy grid. High efficiency is obtained because fusion energy is directly converted into electricity, and the excess energy in the Spherical Electromagnetic Containment Field (40) is recycled.

16) The active confinement of the fusion burn by the Spherical Electromagnetic Containment Field (40) will allow the fusion burn to have a duration that is magnitudes longer than without active containment.

17) The central nucleus of fused fuel continues to eject exploding streams of plasma until the fuel is consumed. Then, when the fuel is almost totally consumed, the process stops. (The rate at which energy is released from the fusion burn will depend on the harmonics of the burn. Smoother harmonics will allow a slower release of energy. Poorer harmonics will release energy faster.)

18) Heat is extracted from the coolant in the Middle Reactor Shield (9) and the Coolant Bath (8) and is used to drive secondary turbine generators.

19) When the Reactor Core (1) is cooled sufficiently, the Outer Shield doors are opened and the Reactor Core is replaced. The Sliding Trough Shields (31) are retracted. Parts are inspected and replaced as needed.

20) The next cycle begins.

The length of the burn will be affected by many variables such as: materials selected for Conducting Spheres (2) and the Reactor Core (1), and the size of the Capacitor Bank (5). These variables do not affect the general design concepts that patent protection is being applied for.

Theory of Operation

The simplest way to describe the idea of spherical confinement, is to take a hollow sphere made of a conducting material—e.g., copper—and to set up a voltage across the sphere as shown in Figure 19.

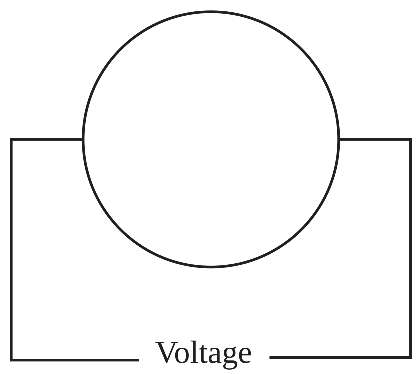
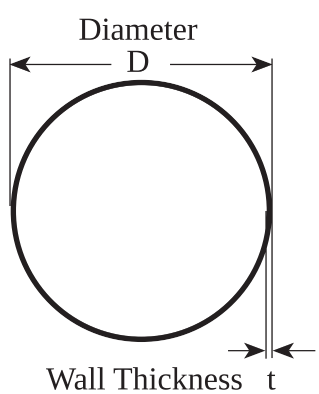


Figure 19

It is important that the sphere is: symmetrical, smooth, of consistent material, and of consistent wall thickness. Also important is that the diameter of the sphere be much larger than the thickness of the wall of the sphere as shown in Figure 20.



D >> t

Figure 20

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The voltage across the sphere will create a current across the sphere. However, on one hemisphere the current density is decreasing as the current spreads out over the greater surface area of the sphere, and on the other hemisphere the current density is increasing as the current comes together at the pole. This change in the current density will induce magnetic fields at right angles on the surface of the sphere. Another way of describing this is the electric flux is changing due to the geometry of the conducting sphere. The changing electric flux induces magnetic fields.

Magnetic fields

If the voltage is set up so the current passes from left to right in this example, then the magnetic fields will form parallel to the equator of the sphere, as indicated in Figure 21.

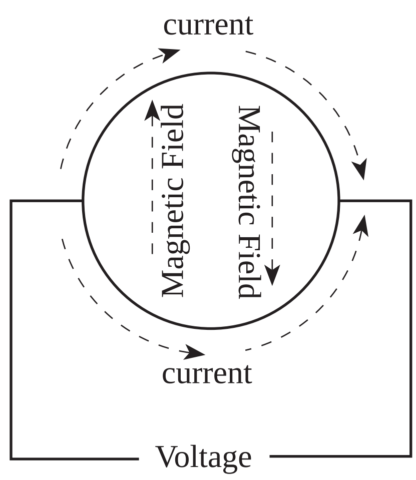

Figure 21

As the current passes over the surface of the sphere, the electrical field will change due to the geometry of the sphere. This changing electrical field induces magnetic fields on the surface of the sphere at right angles the electrical field according to the right hand rule. Since the electrical field is decreasing on the left hemisphere there is a negative sign, thus explaining why the magnetic field is turning around that hemisphere according to the left hand rule.

In essence, the flux of the electrical current is being forced to spread out, by flowing over the sphere, and then is being forced to come back together again. Forcing the current to change direction in such a manner induces the Magnetic fields.

Throughout this document, this central conducting sphere may be referred to as the "core." The core can be described as manufactured with numerous layers of different materials, or as a plasma. In a group of reactor designs described in this document—called "No Core" Reactors—the core will be made of no materials at all—only spherical electromagnetic fields.

The Poynting Vector

One of the important characteristics of an electromagnetic wave is that it can transport energy from point to point. The rate of energy flow per unit area for an electromagnetic wave can be expressed by the vector **S**, and it is called the Poynting vector after John Henry Poynting (1852–1914), who first described it.

For current flowing through a typical wire with constant circular cross section, the Poynting Vector almost always points inwards towards the center of the wire as shown in Figure 22.

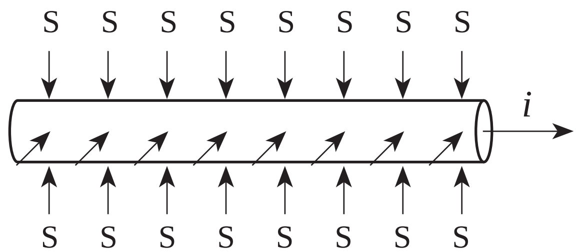

Figure 22

In high voltage and/or high current situations, especially in thick conductors, waves can set up in the conductor, creating a varying direction for the Poynting vector as shown in Figure 23.

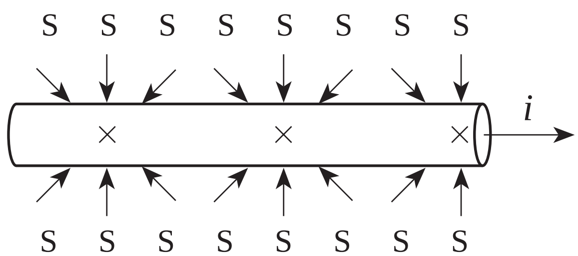

Figure 23

Normally such waves are a major problem. Spherical electromagnetic waves such as these can explode wires, and has been known to crush pipes in a sausage-link-like fashion when the pipes were struck by lightning. Many wire designs—such as cables used with lightning rods—are composed of thin filaments, twisted, or woven, to minimize this effect—see Figure 50. This natural pattern of spherical waves will be utilized in a beneficial manner in these patent designs. In many parts of these patent designs, steps must be taken to prevent such instabilities from exploding components. (This is sometimes referred to as, “the exploding wire phenomenon” and will be explained more in depth later in this document.)

In prior nuclear fusion experiments, all “instabilities” probably are the result of unintended, or unexpected spherical electromagnetic waves in the plasma (i.e., the induced cross product of the time varying, and/or, area varying Electric and Magnetic fields.)

The Poynting vector can be expressed by the equation:

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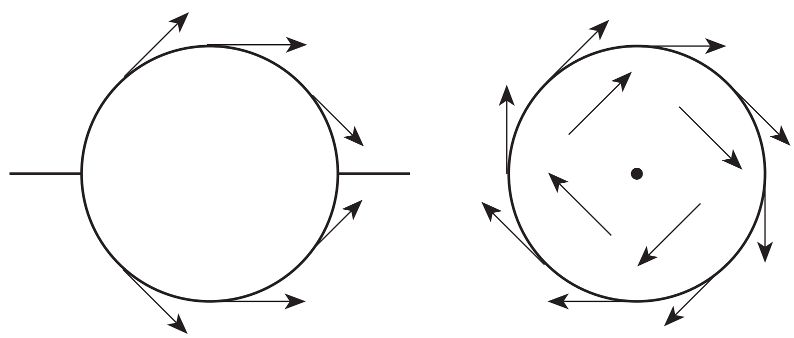
Equation #2

$$\vec{S} = \frac{1}{\mu_0}\vec{E}\times\vec{B}$$

In this form—i.e., with this constant—the Poynting vector can be described using SI Basic Units or SI Derived Units. In IS Derived Units, **S** is often expressed in terms of watts / meter^2. In SI Basic Units, **S** is expressed in terms of kg / second^3. The direction of the vector **S** gives the direction in which the energy moves. The vectors **E** and **B** refer to the instantaneous vectors for the Electric and Magnetic fields.

Over the surface of the cores in the fusion reactors described here, the instantaneous vectors for **E** and **B** are normally tangential to the core's spherical surface. There are two primary possibilities for how the electric and magnetic fields are oriented over the core. (These two possibilities can be equated to "electric" circuits and "magnetic" circuits.)

In one of the two primary orientations of electric and magnetic fields, described in these fusion reactors, the electric fields **E** are aligned so that they travel from pole to pole over the conducting sphere, while the magnetic fields **B** point at a right angle to **E**—essentially parallel to the equator of the conducting spheres, as shown in Figure 24.



Side View of Core
Tangential Electrical Field

End View of Core
Tangential Magnetic Field

Figure 24

In the other of the two primary orientations of electric and magnetic fields, described in these fusion reactors, the magnetic fields **B** are aligned so that they travel from pole to pole over the conducting sphere, while the electric fields **E** point at a right angle to **B**—essentially parallel to the equator of the conducting spheres. This particular arrangement of electric and magnetic fields—essential for "magnetic" circuits—will be the preferred field orientation and is required for the "No-Core" reactor design, as shown in Figure 25.

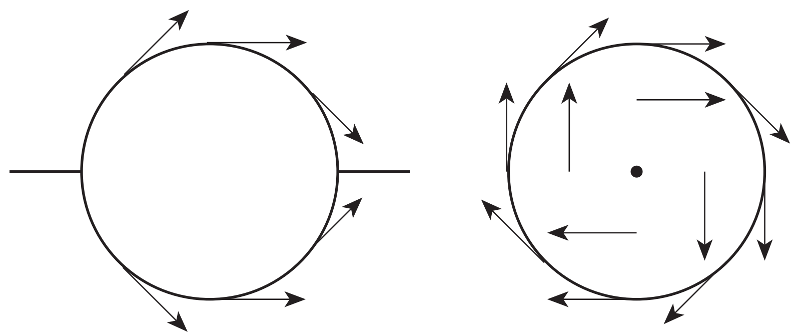


Figure 25

Analyzing the Poynting Vector on a Conducting Sphere or Core

At any point on the surface of a Conducting Sphere or Reactor Core, the electric and magnetic field can be analyzed. By analyzing the cross product of the electric and magnetic fields, the Poynting vector can be found. At all points on the surface of the sphere the cross product **S** is directed towards the center of the sphere. Two example points of analyzing the Poynting vector for a sphere are shown in Figure 26.

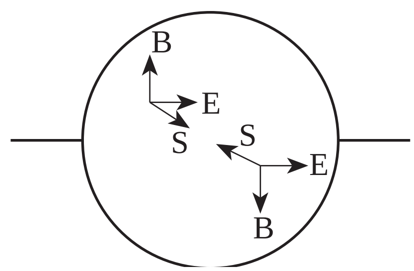


Figure 26

The Poynting vector can be expressed in different forms, but in general, energy is being transported to the focal point—to the center of the sphere.

In essence, the electrical current is being forced to spread out and then allowed to come back together again by the geometry of the conducting sphere. If a current was traveling down a long, straight conductor, then forced to spread out because of a bulge in the conductor, then there must be a force pointing towards the center of the bulge. The equal and opposite force, equivalent to the mechanical force that is spreading the electrical current apart over the sphere's region, is the central pointing energy transport that can be expressed in the form of the Poynting Vector as shown in Figure 27.

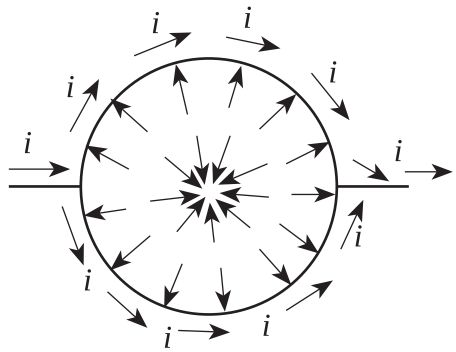


Figure 27

The larger the voltage applied across the conducting sphere, the larger the current across the conducting sphere. The larger the current across the conducting sphere, the larger the electric and magnetic fields. The larger the electric and magnetic fields, the larger the amount of energy that is focused on the focal point—at the center of the core.

It is critical to note that, if a Conducting Sphere (2) or Reactor Core (1) is thin-walled, structurally weak, or in plasma form, then the electromagnetic fields will collapse and implode the Conducting Sphere or Core. This is a problem if you do not wish the Conducting Sphere or Core to collapse. Such a collapsing and implosion can be a benefit if it used as an ignition technique to ignite a plasma into a fusion burn. However, in general, to prevent Conducting Spheres or Cores from vaporizing, imploding, crushing, rupturing or some other catastrophic event, and order to provide massive central pointing impulses of energy at the center of the Reactor Core, the Conducting Spheres, and Reactor Cores must be relatively large, strong, and massive rather than small, and thin.

Plasma Fusion within the Core

A significant early question is, how could a fusion reaction be induced in the core of the reactors designs described in this document? The first two key issues are: How is the fuel placed in the core? and, How is the fuel ignited? The next section on MHD will address the issue of: How will the energy be extracted?

There are numerous techniques that could be used to place the fuel inside the core.

1) In one approach—shown in Figure 28—a Nozzle (49) could be placed in the side of the Reactor Core (1) to inject a hot Plasma (50) into the core just prior to it being ignited. However, a permanently placed nozzle in the side of the core could interfere with the harmonics of the Spherical Electromagnetic Confinement Fields (40) and dramatically reduce their effectiveness to contain the fusion reaction.

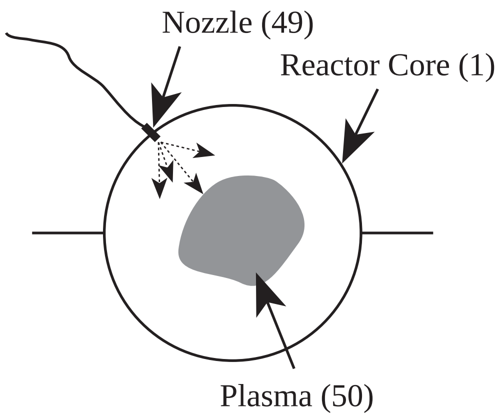


Figure 28

2) A second approach—as shown in Figure 29—would be to place the fusion fuel Plasma (50) into the Reactor Core (1) when it is manufactured and have the plasma completely sealed in the core. Thus, the reactor would need to be designed so that the cores could be easily replaced between each fusion burn. With this technique, the core would need to be preheated before the main confinement/triggering pulse in order to re-ionize the plasma.

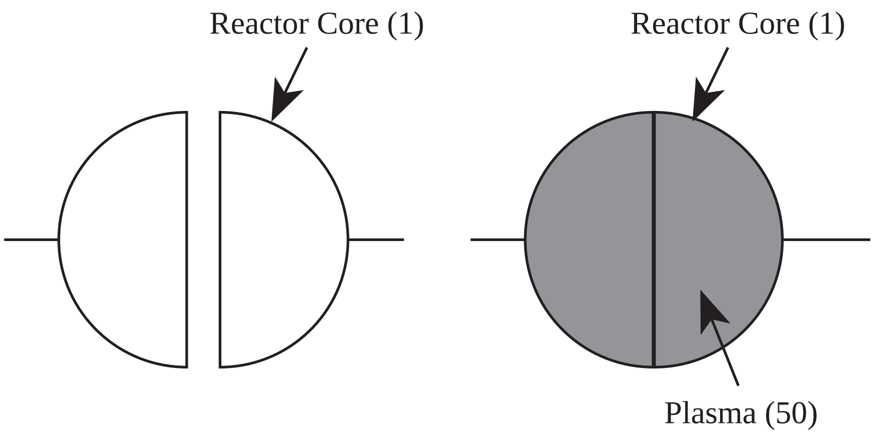


Figure 29

3) A third approach—as shown in Figure 30—would be to place a fusion Fuel Pellet (36) at the center of the Reactor Core (1), pre-positioned and held in place by adjustable, Ablatable Wires (35) made of a materials which may include but not be limited to: Kevlar, carbon or silicon. There may be 1, 2, 3, or more wires used to hold the pellet in place. In this example, there are 3 wires forming a 3-dimensional x, y, z-type grid.

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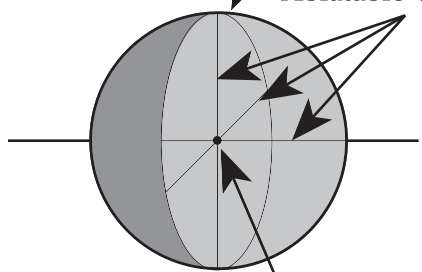

Figure 30

4) A fourth approach—shown in Figure 31—would be to place a fusion Fuel Pellet (36) inside a small Spherical Wire Implosion Cage (51) made of Thin Conducting Wires (52). How this cage is designed depends on if the Containment Circuit is acting in an Electric Mode or Magnetic Mode. In the Electric Mode, the Thin Conducting Wires (52) would be aligned from pole to pole. In the Magnetic Mode, the Thin Conducting Wires (52) would be made of concentric wires as shown in Figure 33.

(The number of strands that make up the cage could be low—e.g., 20–30 wires. However, current tests by Sandia National Laboratories with cylindrical wire cages in their Z-Pinch device would suggest 100–300 wires would be optimal. Examples of materials for the cage's conducting wires would include, but not be limited to: tungsten, copper, aluminum, and gold.)

The purpose of the Spherical Wire Implosion Cage (51) is to implode and ignite the fusion Fuel Pellet (36) located at the center of the cage. The Fuel Pellet (36) would be held in position inside the Spherical Wire Implosion Cage (51) by Ablatable Non Conducting Wires (53). Examples of materials for the Ablatable Non Conducting Wires (53) would include, but not be limited to: carbon, silicon and Kevlar. The Spherical Wire Implosion Cage (51) of Thin Conducting Wires (52) would be held in position within the larger, outer Reactor Core (1) by a Thick Conducting Wire (54).

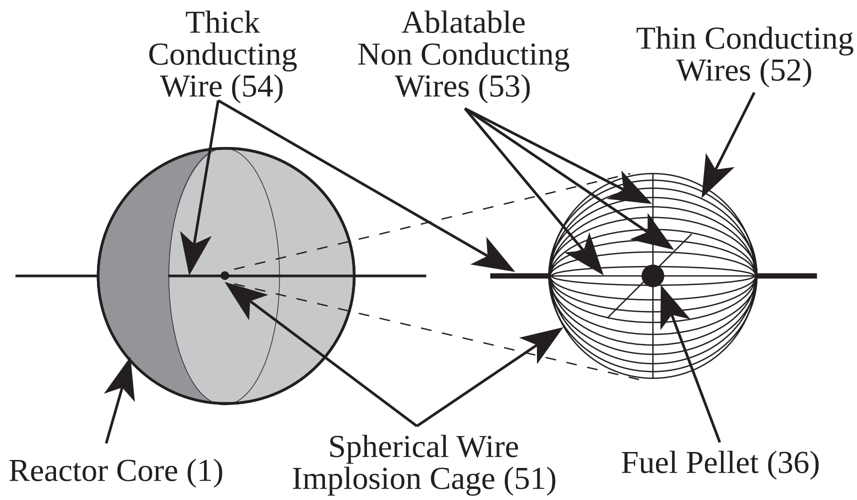

Figure 31

A massive voltage would be setup across the Reactor Core (1)—as shown in Figure 32.

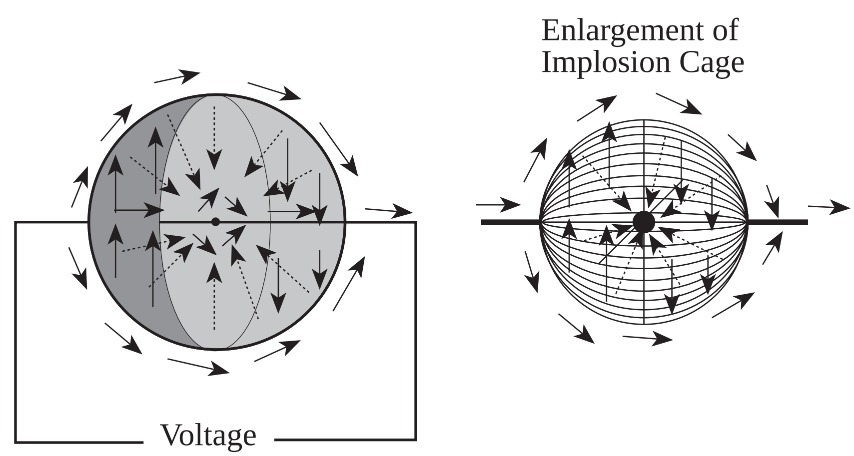

Figure 32

Part of the current would induce a Spherical Electromagnetic Containment Field around the Reactor Core (1). Some of the current would pass along the inner Thick Conducting Wire (54) which would vaporize the Thick Conducting Wire (54) and vaporize and implode the Spherical Wire Implosion Cage (51). This implosion would ignite the fusion Fuel Pellet (36) inside the cage. The remaining current passing over the outer Reactor Core (1) would provide the containment forces for the fusion explosion.

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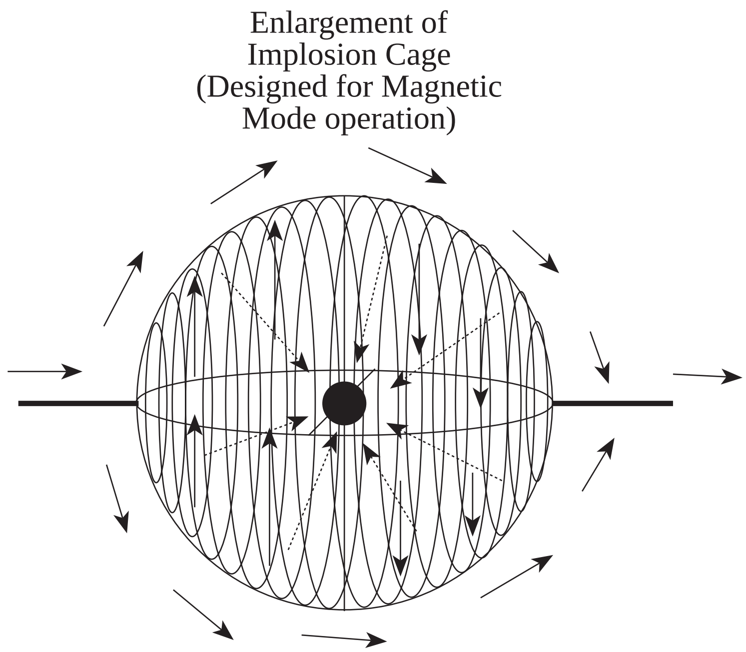

Figure 33

The difficulty of inducing a harmonic Magnetic Mode containment field on the Reactor Core (1) and in the Implosion Cage (51) at the same time probably will inhibit using this technique. The difficulty caused by the mass transport of electrons around the Containment Circuit when using the Implosion Cage (51) technique in the Electric Mode will inhibit using this technique.

5) A fifth approach would be to have the Reactor Core (1) placed inside a larger Plasma Container / Shield (56) that is filled with a low temperature Plasma (57)—see Figure 34 (a). In the sides of the reactor core would be small Plasma Flow Ports (58) that would allow the low temperature Plasma (57) to move inside the Reactor Core (1). With this technique, the Spherical Electromagnetic Containment Fields (40) over the Reactor Core (1) would compress and ignite the Plasma (57) inside the Reactor Core (1) when a massive electric voltage, or magnetic differential is set up across the poles of the Reactor Core (1)—see Figure 34 (b). But this would not ignite the Plasma (57) outside of the Reactor Core (1). At most it would compress it outward. As the reactor cools, there will be less pressure in the Reactor Core than outside of the Reactor Core (1). The small Plasma Flow Ports (58) in the sides of the Reactor Core (1) would allow the plasma outside the Reactor Core (1) back into the Reactor Core (1) between each electromagnetic pulse—see Figure 34 (c).

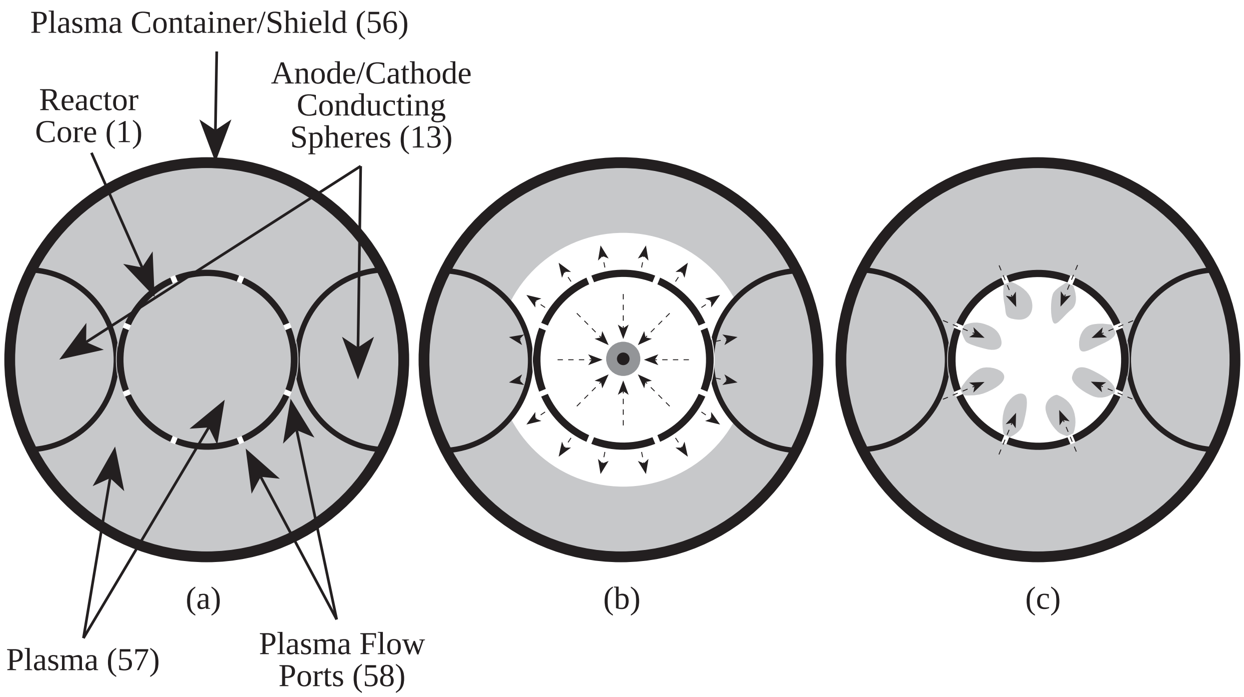

Figure 34

If the small Plasma Flow Ports (58) through the sides of the Reactor Core (1) are small enough, then there should be no disruption to the harmonics of the electromagnetic fields within the Conducting Layer (18) of the Reactor Core (1)—the massive electromagnetic pulses that travel through the Conducting Layer (18) of the core would simply arc across the Plasma Flow Ports (58). This technique may not be feasible if the Plasma Flow Ports (58) disrupt the harmonics of the Spherical Electromagnetic Containment Fields (40) too much. Also, the reactor cores would need to be easily replaced with this design since the arcing of the Spherical Electromagnetic Containment Fields (40) across the Plasma Flow Ports (58) would eventually weld them shut.

6) The previous 5 techniques are meant only as examples. There are other, obvious techniques for placing the fusion fuel into the core, such as placing a fusion fuel pellet through a hole.

With a fusion fuel—such as D-T in plasma or pellet form—in place within the core, a high voltage or magnetic differential is applied across the core just moments before the fuel is ignited. This step is critical, and occurs for all variations of this patent.

The details of ignition depend on which method of fuel placement is used:

1) With approach 1, the electromagnetic fields induced across the sphere would focus a tremendous surge of power to the center of the core—expressed in terms of the Poynting vector. This focused energy would compress, heat and confine the plasma. With strong enough Spherical Electromagnetic Containment Fields (40)—the actual magnitude would be dependent upon many design features—the centrally focused energy would ignite the fuel and a nuclear fusion burn would take place. This technique requires stronger Spherical Electromagnetic

Containment Fields (40) across the core relative to the other techniques described in this document since the Spherical Electromagnetic Containment Fields (40) are used not only for confinement but also for ignition.

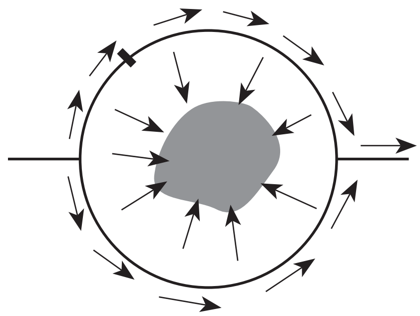

Figure 35

2) With approach 2, the electromagnetic fields induced across the sphere would focus a tremendous surge of power to the center of the core—expressed in terms of the Poynting vector. This focused energy would compress, heat and confine the plasma. With strong enough Spherical Electromagnetic Containment Fields (40)—the actual magnitude would be dependent upon many design features—the centrally focused energy would ignite the fuel and a nuclear fusion burn would take place. This technique requires stronger Spherical Electromagnetic Containment Fields (40) across the core relative to the other techniques described in this document since the Spherical Electromagnetic Containment Fields (40) are used not only for confinement but also for ignition.

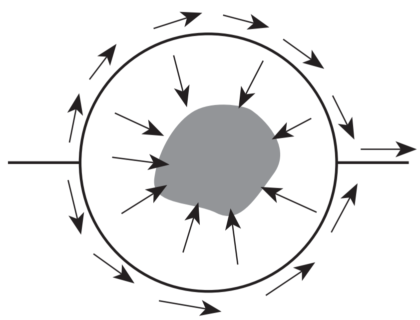

Figure 36

3) With the third technique, just as the Spherical Electromagnetic Containment Fields (40) are growing in magnitude across the Conducting Layer (18) of the Reactor Core (1), the fusion Fuel Pellet (36) is imploded with traditional inertial confinement methods. For example, external lasers, or ion beams would pass through Laser Ports (37 and focus on the Fuel Pellet (36). The key here is the timing—an Electric voltage or Magnetic differential must be set up across the core at the correct moment so that the Spherical Electromagnetic Containment Fields (40) are induced so that they should reaching a maximum just prior to when the fusion implosion changes direction to become an explosion. Since the inertial confinement energy is applied directly to the fusion fuel pellet with relatively easy-to-use and understood inertial techniques, the required magnitude of the Spherical Electromagnetic Containment Fields (40) are less with this technique.

The confining fields are not required to start ignition of the fusion process. They are used to confine and lengthen the fusion burn, and extract energy via the MHD process.

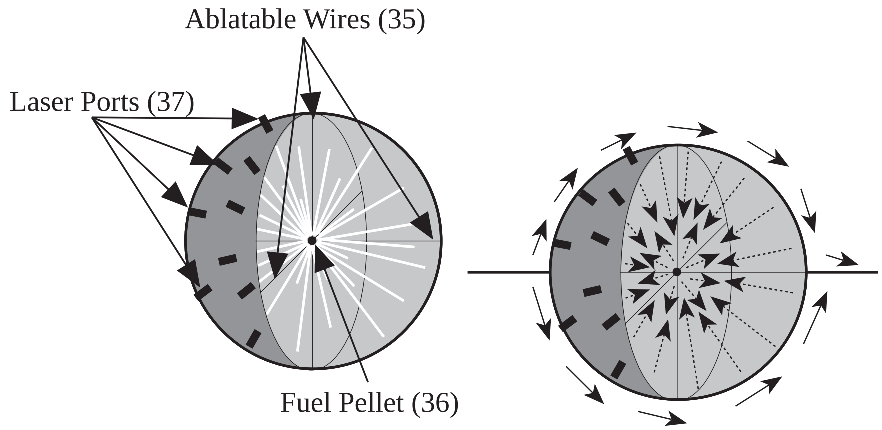

Figure 37

4) With the fourth technique, just as the Spherical Electromagnetic Containment Fields (40) are building, the fusion Fuel Pellet (36) is imploded with an “x, y, z”—or, “spherical”—pinch. This spherical pinch technique is enabled by passing a current through a Thick Conducting Wire (54) that is strung between the Anode / Cathode Conducting Spheres (13) within the Reactor Core (1)—Figure 38 (a). As the massive Spherical Electromagnetic Containment Fields (40) set up across the core area, some of the current (1) will flow over the Conducting Layer (18) of the Reactor Core (1)—Figure 38 (b) left—through the Thick Conducting Wire (54), and through the thin wires of the Spherical Wire Implosion Cage (51)—Figure 38 (b) right. This current will be far too massive for the Thick Conducting Wire (54) and will vaporize it. (According to the ideas expressed in the section below on the Exploding Wire Phenomena.) However, before the Thick Conducting Wire (54) vaporizes, the current will also sweep across the thin wires of the Spherical Wire Implosion Cage (51). This current will be far too massive for the thin wires of the Spherical Wire Implosion Cage (51) and will also vaporize them. Magnetic fields will setup across the Conducting Layer (18) of the Reactor Core (1) and the spherical Wire Implosion Cage (51) as is shown in Figure 38 (c). Due to the same geometry of electric and magnetic fields in both the Conducting Layer (18) of the Reactor Core (1) and the Spherical Wire Implosion Cage (51), the Spherical Wire Implosion Cage (51) will implode into the fusion Fuel Pellet (36)—Figure 38 (d) right—igniting the fusion reaction. The fusion reaction is further compressed and contained by the Spherical Electromagnetic Containment Fields (40)—Figure 38 (d) left—in the much larger, more massive, cooled, shielded and reinforced Conducting Layer (18) of the Reactor Core (1). In other words, if all goes as planned, the Wire Implosion Cage (51) implodes but the Reactor Core (1) does not.

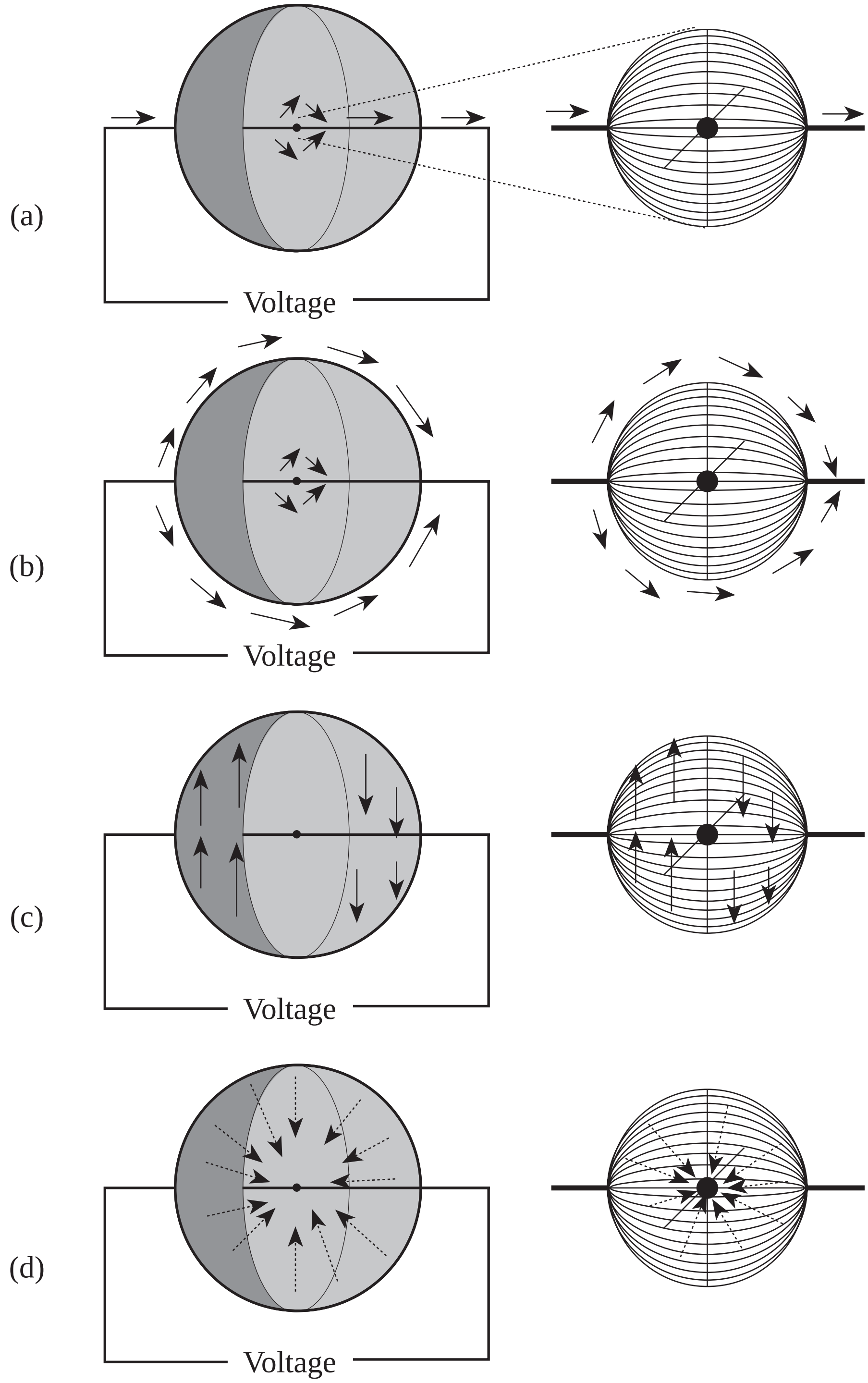

Figure 38

5) With this technique, a plasma is set up in the Plasma Container / Shield (56), some of which will flood the inner volume of the Reactor Core (1). A massive electric voltage or magnetic differential is applied across the Reactor Core (1), inducing massive Spherical Electromagnetic Containment Fields (40) across the core. The cross product of this electromagnetic pulse, the Poynting vector: compresses,

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heats, and ignites the plasma within the core (3)—Figure 39 (a). While the plasma external to the core would also be heated and compressed to some extent, by designing the Plasma Container / Shield (56) to be large enough, it would not be heated and compressed sufficiently to ignite. Inside the Plasma Container / Shield (56), the energy from Spherical Electromagnetic Containment Fields (40) within the Reactor Core (1) concentrates the plasma. Outside the Plasma Container / Shield (56), the Spherical Electromagnetic Containment Fields (40) on the Reactor Core (1) will repel the plasma, heating and compressing it outwards. The plasma inside the core would be burned until the fuel dissipates and the fusion reaction stops. As the Spherical Electromagnetic Containment Fields (40) over the core die off, the remaining plasma within the Reactor Core is free to expand—Figure 39 (b). At some point the pressure of the plasma outside of the Reactor Core (1) will be greater than the pressure of the plasma within the Reactor Core (1), creating a vacuum. Then, the some of the remaining plasma external to the core would be sucked into the core due to the pressure difference—Figure 39 (c). At this point, the next massive electric voltage or magnetic differential would be applied across the Reactor Core (1), inducing another massive pulse of Spherical Electromagnetic Containment Fields (40) across the core and the next fusion burn would occur—Figure 39 (d). This process has many similarities with an internal combustion engine—especially, with diesel engines.

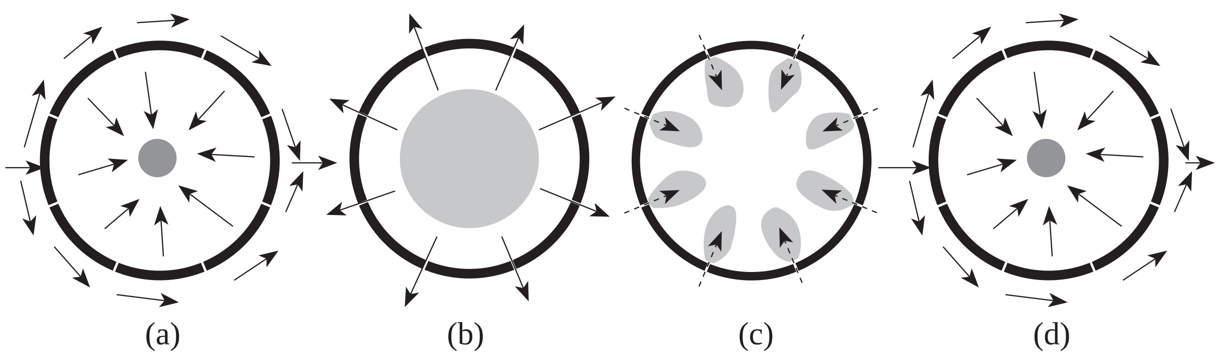

Figure 39

While this process is simple, I don’t like how it relies on a vacuum to form. I would prefer seeing the plasma injected to control the timing better.

MHD (MagnetoHydroDynamics)

When a nuclear fusion burn occurs in the center of the core in these reactor designs, the plasmas will suddenly expand. In each reactor design, the expanding plasmas is surrounded by a massive spherical electromagnetic field. MHD is the study of the properties of plasma flows exposed to intense electromagnetic fields. The three critical factors needed for MHD energy production—a highly ionized and conductive plasma; a strong, symmetrical confining magnetic field; and a high plasma flow speed directed directly at the confining magnetic field (at a right angle to a magnetic field)—are all included in these designs.

What happens next in the fusion reactor designs described here can be described using the MHD effect:

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1) The plasma will suddenly expand. As it expands it will travel at high velocity directly towards the inner wall and confining electromagnetic fields of the reactor core.

2) As the plasma travels with high velocity towards the confining electromagnetic fields, the ions in the plasma will induce new electromagnetic fields—described here as “MHD fields” to contrast from the initial “confining fields”—in the conducting layer of the spherical core. (There will be a superposition of confining and MHD fields.)

3) These new MHD electromagnetic fields will become apparent as a higher voltage across the conducting sphere and can be tapped directly with almost 100 percent efficiency for use as electricity.

This process can be analyzed by looking at a graph of the voltage across the core—i.e., it assumes the core is operating in the Electric Mode—versus time:

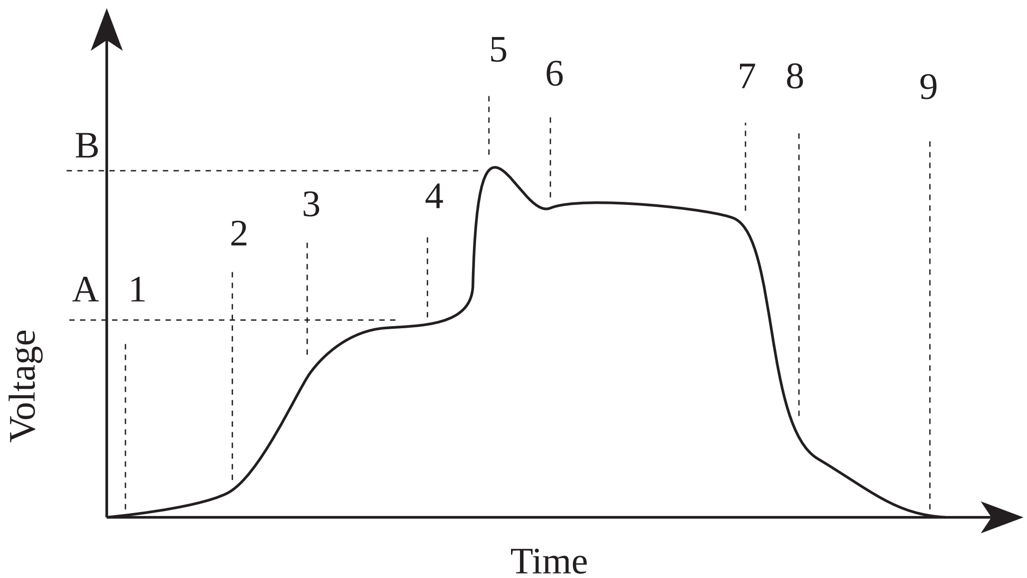

Figure 40

1) At time 1, there is no voltage across the conducting core, but it is just starting to rise.

2) At time 2, the main electromagnetic wave hits the core as the voltage starts to quickly rise. This confining field is created by energy applied to the core from external sources. The energy lost in this process is the largest portion of lost energy that must be made up by the fusion process in order for break-even to occur.

3) Time 3 is found by performing experimental tests on each specific reactor design. This is the time when the voltage stops rising sharply and starts to level out. This is a critical moment. It is the time when the ignition of the fusion fuel must occur.

4) At time 4, the confining voltage has just reached its peak and the fusion burn is starting to explode. At this moment, the external confining field is just starting to

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react to the charged ions that are rapidly approaching it from within. The height of the voltage at this point has the value “A” and is a critical design parameter.

5) Between time 4 and 5, the voltage suddenly spikes. This increase in voltage from “A” to “B” is the induced MHD voltage that resists, and, potentially stops the plasma instabilities. The reactor core and conducting circuit must be designed to withstand this maximum spike. This height difference—B minus A—must be less than the voltage A by 5–10% for safety sake. Otherwise, the MHD voltage will be greater than the confining voltage, and the voltage polarity could suddenly reverse, with dangerous consequences. This spike in voltage should be relatively brief and will end as the initial major instabilities are suppressed and dampened.

6) At time 6, the plasma has had its initial major instabilities suppressed and dampened. However, smaller, numerous instabilities continue to keep the average voltage relatively high. This excess voltage is where most of the useful energy will be extracted. The electrical circuit must be designed to tap off the voltage difference between voltage level B and A. If the voltage were to drop below A, then the fusion explosion would breach the confining field. (To maximize the length of the burn at this stage, more fusion fuel is needed. However, the more fuel, the higher the peak voltage back at time 5 would be. This would require bigger, stronger, more complex reactors.)

7) At time 7, the fusion burn has expended the bulk of its fuel, and the instabilities stop having enough energy to push against the confining field.

8) At time 8—without the addition of new fuel to the burn—the fusion process has stopped. The electrical circuit must be designed to monitor voltage and cut off the any remaining confining voltage when this drop occurs.

9) At time 9, the voltage has dropped to zero. In initial designs, there would now be a period for cooling, safety checks, and maintenance. Then, the cycle would be repeated.

The main source of non-efficiency in these types of fusion reactors will come from resistive heating of the core, which can be cooled—the heat being used for driving secondary steam generators.

Depending upon the design of the reactors it will be possible to create direct or alternating currents. In direct current designs, converters will be needed for conversion to alternating currents.

Magnetohydrodynamics and Plasma Instabilities

The main difficulty in all prior attempts at nuclear fusion has been various “instabilities” in the plasma that suddenly stop the fusion reaction and frequently damage the reactor. It is my contention that these “instabilities,” themselves, are very “strong” and “stable.” It is my contention that the sudden strength of the instabilities is a result of the cross product of the Electric and Magnetic fields in the plasma. In essence, all “instabilities” have been induced by time varying, or area varying electromagnetic fields. They could be collectively called, “induced Poynting Vector Fields.”

For example, in Tokamak reactors, as the electric fields and magnetic fields that confine and heat the plasma build, the plasma rotates faster and faster in the torus. Eventually, when the fusion burn starts, the plasma is accelerated in new directions, inducing a powerful cross product of electric and magnetic fields, in a direction that can not be anticipated and counteracted in time. Without an appropriate containment field existing prior to the development the instability, the induced Poynting Vector is too powerful to be contained. Inevitably, the containment fields collapse, and the plasma quickly cools, stopping the fusion burn.

Benefits of Spherical Electromagnetic Containment Field (40)

Many prior designs, such as Tokamaks, have not utilized spherical containment geometries. Only inertial confinement reactors have used spherical geometries for confinement. In the new designs described within this document, the perfect symmetry of the sphere minimizes initial instabilities within the reactor core, thus maximizing the time of the fusion burn.

Some instabilities are still expected to form inside these types of reactors. The expected instabilities will be identical to other previous attempts that used spherical inertial confinement techniques, such as laser implosion of spherical D-T pellets. However, in the new fusion reactor designs in this document, it is exactly these instabilities that will drive the MHD process and be used to extract the fusion energy as useful electrical energy. In earlier spherical inertial techniques, the plasma was allowed to expand and cool without attempting to confine the plasma further after the initial burn.

Thus, the main benefits of having a Spherical Electromagnetic Confinement Field (40)existing, prior to the fusion burn exploding, is that the fusion burn will: be contained, last longer, and push out on the Confinement Field to create energy in a MHD fashion.

Charged Particles/Neutral Particles Ratio

A fusion plasma is made of both charged particles—e.g., electrons, protons, etc.—and neutral particles—neutrinos, and neutrons the primary examples. Charged particles will interact strongly with the confining fields. Since neutral particles still have a magnetic moment, it is expected they will interact at least weakly with the confining fields. However, the higher the percentage of charged particles in the plasma is, then the lower the percentage of neutral particles in the plasma will be, which is better.

It is assumed that the fusion fuel mixture will have some affect on the percentages of charged and neutral particles in the plasma. For example, a D-D mixture may be better than a D-T mixture, or perhaps, the other way around. In these early designs, attempts at fine tuning the percentage of charged to neutral particles will be ignored.

MHD Interaction in Spherical Electromagnetic Containment Fields (40)

In the types of reactors described within this document, as an instability—appearing as a jet of plasma—travels with a velocity V away from the center of the fused material at the center of the core and towards the Spherical Electromagnetic Containment Field

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(40)—essentially, always at a right angle to the electric and magnetic fields, as a result of the perfect geometry of the sphere—the electrical charge of the moving plasma will interact with the confining electric and magnetic fields via the magnetohydrodynamic effect.

Creating this geometrical interaction is one of the key factors distinguishing these designs and prior art.

This interaction will induce the magnitude of the confining fields to higher levels. In an electric mode, the voltage across the core will increase. In a magnetic mode, the magnetic differential across the core will increase. The increase in the magnitude of the confining field will be proportional to the magnitude of the energy of the charged particles in the instability. Since there exists a preexisting confinement field at the time of the fusion burn, and since the instability induces new confining fields in direct proportion to the size of the instability, the instability should dissipate and be confined.

Preexisting Confining Field versus Induced Confining Field

Thus, thus magnitude of the electric and magnetic fields over the core can be thought of as having two components: the preexisting Spherical Electromagnetic Containment Field (40), and the induced Spherical Electromagnetic Containment Field (40) If the combination of the confinement field strength and induced strength is designed to be greater strength than the largest instability, then the fusion burn will remain essentially spherical until the fuel runs out.

Plasma particles, especially in the form of neutral particles, may penetrate Spherical Electromagnetic Containment Field (40) if the containment fields are not designed to have a large enough initial strength.

If the too much energy is lost through neutral particles, then the fusion process will halt, and damage to the reactor could occur.

Description of an Example Plasma Stream (39) interacting with the Spherical Electromagnetic Containment Field (40)

To help visualize how this critical process works, imagine what the instabilities would look like for a spherical target shortly after the implosion reverses direction to become an explosion. At the point the plasma wall changes direction, the plasma will have a geometry approximating a sphere. Shortly after starting to explode, instabilities on the surface of the sphere would start to appear. At this early stage, they would look something like knobs or bumps, as shown in Figure 41.

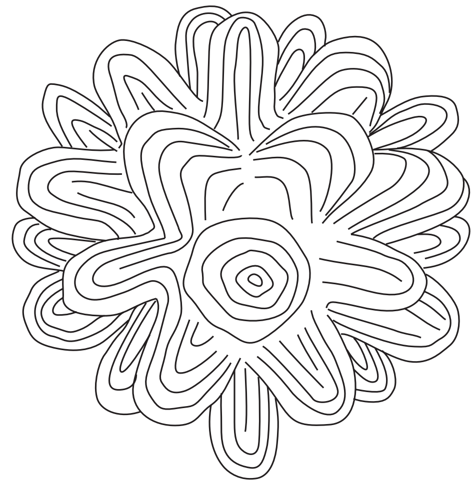

Figure 41

(While this is an approximation of the plasma shape, actual instabilities similar to these have been observed in plasmas.)

As the instabilities worsen, they will grow in length. Also the diameter of the central core of the plasma will expand. For this example, we will examine just one expanding instability and ignore the others as if they were not expanding. The example Instability (39) is indicated in Figure 42.

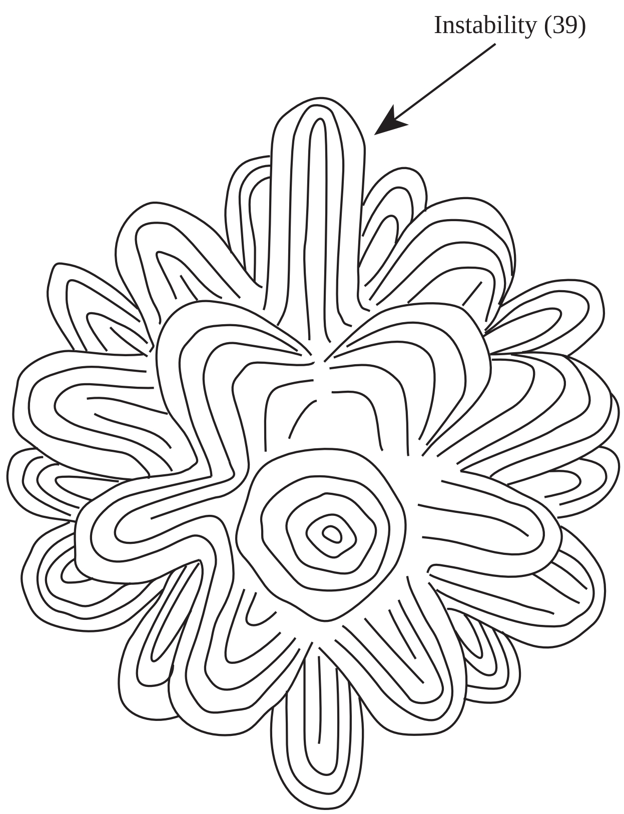

Figure 42

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This instability is made up of plasma. The plasma is primarily made up of charged particles. The charged particles on the outside of the plasma are more likely to be the lighter particles, and therefore negative electrons, as shown in Figure 43. (It does not matter for this example what the charge of individual ions in the plasma is however. If the charge of the ions were positive, the net results would be the same.)

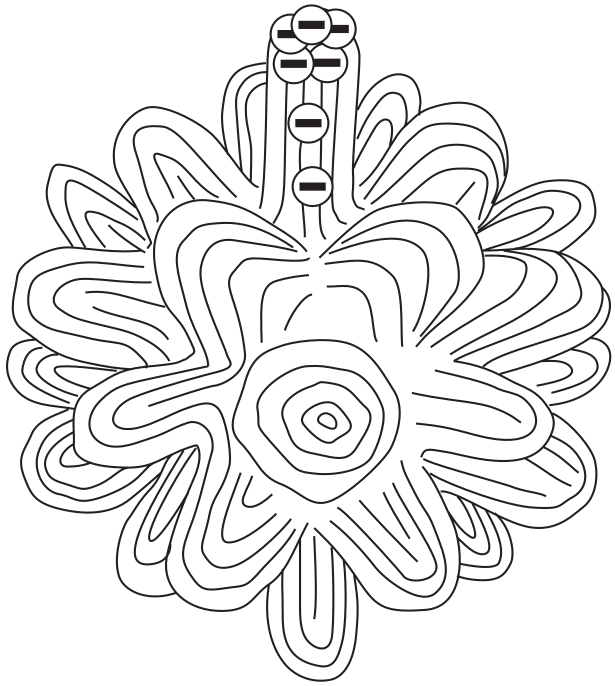

Figure 43

The example Instability is shown in Figures 43 and 44 moving away from the center of the plasma towards the confining wall of the fusion reactor with a velocity V. In essence, it is acting as powerful current.

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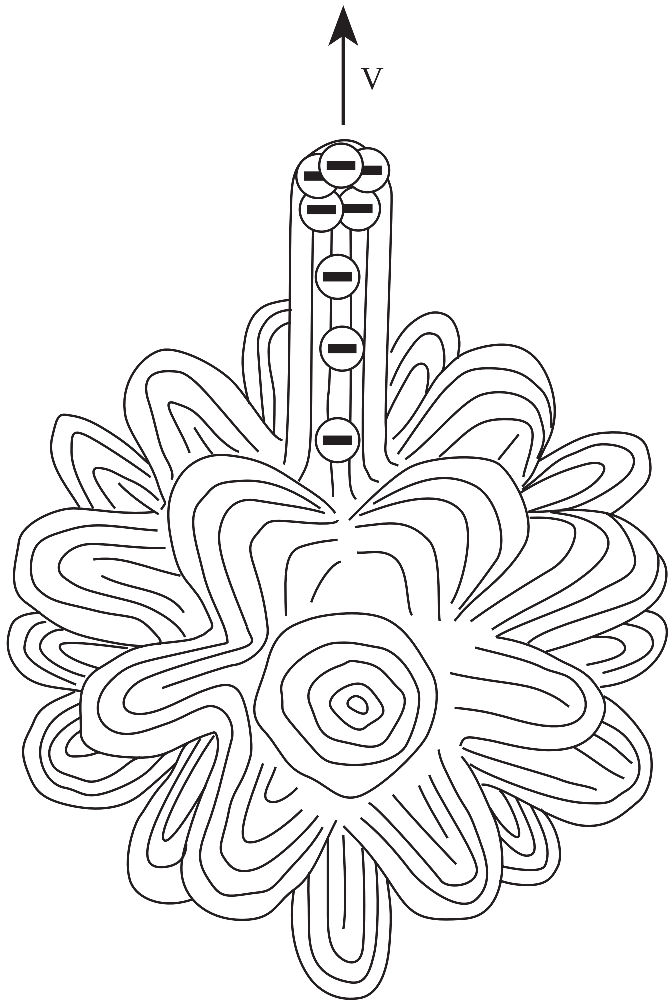

Figure 44

In the fusion reactor designs described in this document, the currents from the exploding instabilities interact with the Spherical Electromagnetic Containment Field (40), shown in Figure 45. Analyzing the example Instability's (39) current for an arbitrary angle of interaction with the Spherical Electromagnetic Containment Field (40)—in this example, acting in an Electric Mode—is shown in Figure 45.

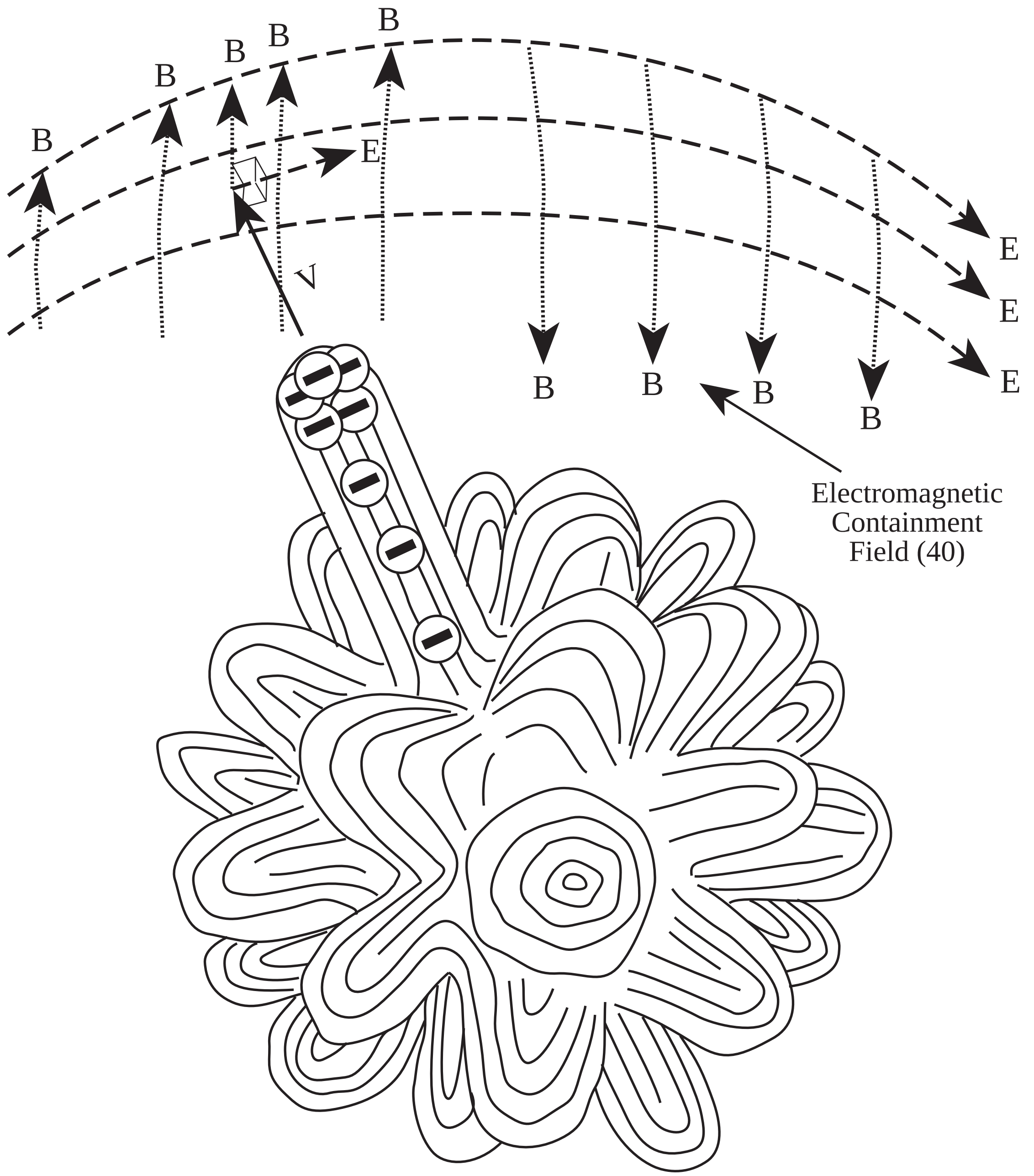

Figure 45

There are only two possible ways the Instability (39) may interact with the Spherical Electromagnetic Containment Field (40). First, the Instability (39) may induce new electromagnetic fields that will combine with the preexisting Spherical Electromagnetic Containment Field (40) creating a more powerful Spherical Electromagnetic Containment Field (40). Second, the Instability (39) may be blocked by the Spherical Electromagnetic Containment Field (40). In essence, the Instability's (39) growth will halt. If instabilities are halted, then the fused material plasma fuel at the center of the Reactor Core (1) will stay essentially spherical and harmonic. With these types of reactors, both the possibility that the Spherical Electromagnetic Containment Field (40) will be increased, or that the fused material plasma fuel will stay spherical and harmonic are good. Because an instability induces the Spherical Electromagnetic Containment Field (40) to higher values, its energy is dissipated and it is blocked. If the instability is blocked, the fusion burn will last longer. If the instability induces new electromagnetic fields that combine with the Spherical Electromagnetic Containment Field (40), then the voltage across the core, if in the Electric Mode—or magnetic differential across the core, if in the Magnetic Mode—will increase and will be available for creating useful electric energy by induction through the coils located around the Containment Circuit.

It is expected that both interactions will occur.

Looking closely at the details, the instability's current intersects with the existing Electric and Magnetic fields of the confining fields. The intersection occurs at right angles. To summarize:

- The Instability's (39) plasma current intersects the confining Magnetic field at a right angle.
- The Instability's (39) plasma current intersects the confining Electric field at a right angle.
- The confining Electric and Magnetic fields were already at right angles, by design.

Thus, the current must induce higher Electric and Magnetic fields in the confining field. Thus, all the requirements for inducing energy via MHD are present.

There are many implications because of this interaction between the instabilities and the confining fields:

1) The instabilities will induce higher voltages or magnetic differentials across the core
2) The instabilities will be blocked
3) The instabilities will be prevented from growing in the first place, in essence the fused fuel will remain harmonic
4) The confining fields will sap the energy of growing instabilities
5) The fusion burn will last longer
6) The plasma will be compressed to greater densities (which is actually a moot point if the fuel fuses into one particle)
7) The plasma will reach higher temperatures (which is actually a moot point if the fuel fuses into one particle)
8) The more powerful any particular individual instability is, the more powerful the induced MHD field will be, and the more powerful the combined confining field and MHD field will be, thus locally blocking the instability
9) Large instabilities are not likely to occur, since the confining fields will inhibit and block their formation, and sap their energy before they can grow to be large

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10) The initial harmonics of the confining fields will have an effect on how harmonic the fusion burn proceeds. Thus, it is beneficial to take all precautions in order to help the initial Spherical Electromagnetic Containment Field (40) to be highly harmonic.

11) Non-harmonic Spherical Electromagnetic Containment Fields (40) may allow a strong instability to burst through the confining fields, possibly even causing the instability to grow. As such an instability bursts through the confining field, a dangerous jet of plasma will exist that could burn through very thick protective shields. Thus, catastrophic failure must be planned for. For example, if a powerful plasma jet punctures the double walls of the reactor shield, which is filled with water coolant, then, the coolant could suddenly explode. This requires that the reactor has an outer shield.

12) The initial confining fields must be stronger than the average large instability, otherwise possible combinations of the added MHD and confining fields could occur that would flip the polarity of the voltage across the core, or flip the magnetic field across the core.

13) The plasma will spherically pulsate—like a ringing bell—with a characteristic frequency—which is unknown at this point—and will depend on many variables of the reactor design. This pulsing plasma will create pulses of energy in the output circuit that will need a dampening mechanism before the current can go out into the power grid—most likely large banks of capacitors and coils. (However, the entire Confinement Circuit (1) and (2), will act as such a dampening mechanism.) The peaks in the pulses will occur at the point the plasma is expanding outward with maximum acceleration. (In designs with two or more cores, an outward pulsation in one core can be used to compress another core.)

14) Smooth harmonics within the initial confinement field will be reflected within the plasma as longer, smoother burns.

15) Poor quality harmonics within the initial confinement field will be reflected within the plasma with shorter, non-smooth burns—possibly catastrophic rupturing of Conducting Spheres, Reactor Core(s), Coils, the Electrical Bus, and other components.

Reactor Efficiency

The overall efficiency of this type of nuclear fusion reactor can be roughly estimated by multiplying the percent of energy carried away from the fusion burn by charged particles by the percent of energy converted directly to electricity by the MHD process in the conducting wall of the reactor core. For example, if 90% of the energy of the fusion burn is carried away in the form of charged particles, and if 10% of the energy created by the MHD process is lost to thermal interaction within the conducting wall of the Reactor Core(s) (1), then the theoretical efficiency of such a reactor would be 81%. The actual final efficiency would be somewhat less due to thermal losses in the Conducting Spheres (2). However, some of the lost heat in the Reactor Core(s) (1) and Conducting Spheres (2) can be recovered using steam drive turbine generators.

Eventually, it might be possible to design the Reactor Core(s) (1) and Conducting Spheres (2) of such reactors with super conducting materials. If possible, the efficiency of such a design could approach 100%. The only loss in efficiency would be due to neutral particles that can penetrate the confining field or add thermal losses to the reactor wall.

An unknown at this point is if the so-called “neutral” particles will also be deflected or slowed by the confining fields. Most neutral particles have magnetic moments that may allow the neutral particles to be deflected to some extent by the massive Spherical Electromagnetic Containment Fields (40). Also, it is possible, that while a neutral particle is “overall” neutral, it may have small, localized spots of electric and magnetic charge that may interact strongly with the confining fields rather than weakly. Thus, even the energy of neutral particles may be absorbed by the confining fields of these reactor designs, pushing these reactor design’s efficiency to higher levels.

Active versus Passive Monitoring of Instabilities

There have been attempts to actively monitor confining fields in other types of reactors, such as in Tokamaks and Spheromaks, in order to actively increase the confining field strength when an instability occurs. With the designs of the nuclear fusion reactors in this document, the Electromagnetic Containment Fields (40) are passively—i.e., without computer interaction—self-healing. The confining forces are automatically electromagnetically induced to greater values by the instability's MHD interaction with the Spherical Electromagnetic Containment Fields (40). This process automatically closes the “wound” in the confining field, thus preventing the plasma from bleeding through. With these designs, there is no need to create sensors or a computer controlled feedback system to try to monitor and respond to the instabilities.

Burn Duration

If the reactor core can be engineered to have enough strength, heat dissipation capability, and current carrying capability—greater than the rate at which energy is released by the fusion burn—then it would be possible to contain the plasma until the fusion fuel is almost totally consumed. Fusion burns of minutes or even hours in duration are possible. With the “No-Core” design, fusion burns of indefinite length are possible. In some designs, plasma injectors could continuously inject small amounts of new fuel into the core to keep the fusion burn going.

The Danger of Polarity Reversals

As the fusion burn is proceeding, it is possible to describe the electromagnetic fields on the core of the reactor in two parts: the initial confining fields created by the voltage or magnetic field across the poles of the reactor core; and the later, plasma induced MHD fields. One potential problem in the nuclear fusion designs described in this document is the electric and magnetic fields induced by the MHD process could be greater than the initial confining fields. If the induced MHD fields are less than the original confining fields, then current or magnetic flow will remain in the same direction—the MHD fields will add to the confining fields. This will manifest itself by the voltage or magnetic field across the conducting spheres and the core suddenly increasing. On the other hand, the

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danger exists that if the induced MHD fields are larger in magnitude than the original confining fields, then current flow or magnetic field in the confining circuit could suddenly reverse direction. This could manifest itself by the voltage across the conducting sphere suddenly flipping values from + to -, to the values - to +, or the magnetic polarity flipping the values from N to S, to the values S to N.

It does not matter which direction an increased voltage or magnetic field appears across the reactor core, the higher voltage or magnetic field could be utilized in either direction. However, it would be better know, and control, which direction the current or magnetic fields will flow for safety reasons. A sudden change in current flow or magnetic fields could explode or vaporize equipment involved. Thus a major design feature would be to design the yield of the fusion fuel to be less than the peak energy-absorption capability of the reactor. This capability is a function of many design features which include: the total mass and material types of the reactor core; the thermal heat dissipation capability of the core; the active cooling capability of the reactor (whether normally conductive or super conductive); the conductivity of the core as a function of time and temperature over the course of the burn; the capacitance and inductance of the confining circuit; and the ability of the electrical circuit to carry away the net MHD electricity, which is also a function of the circuits maximum current load, capacitance, inductance, and conductivity.

Thus, the yield of the fusion fuel must be tailored to be less than the peak energy absorption capability of the reactor. This can be visualized in the Figure 46.

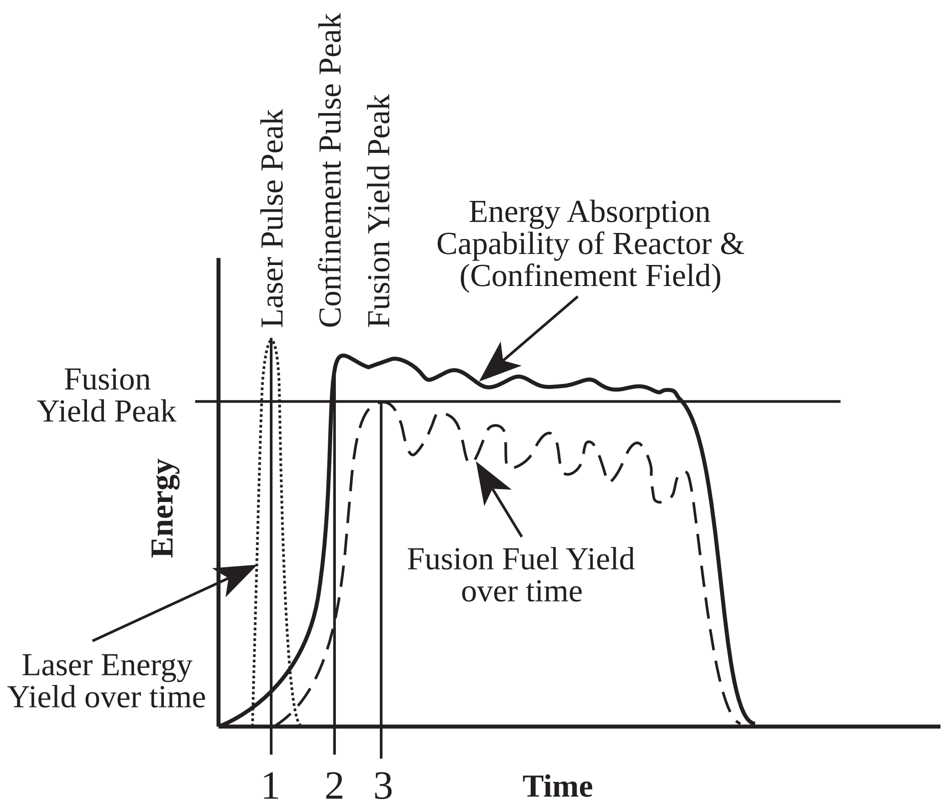

Figure 46

Key details in Figure 46 are:

1) The peak of the fusion fuel yield is lower than the peak energy the reactor can absorb

2) The reactor can absorb the energy faster than the energy will be released from the fusion burn. This is shown by the reactor's peak at 2 coming before the fuel's peak at 3.

3) The long-term ability of the reactor to absorb energy should be greater than the peak energy release from the fusion fuel for safety considerations. For example, if a reactor core with manufacturing imperfections was accidentally used, an abnormally large instability could occur and damage other areas of the reactor.

4) This graph also depicts the expected time-varying release of energy from the fusion fuel due to its interaction with the fusion reactor's confining fields. The yield pulsates up and down. This pulsing in the yield would induce pulsing in the Spherical Electromagnetic Containment Fields (40).

5) The length of the fusion burn, as depicted in this graph, is partly dependent on the initial strength of the Spherical Electromagnetic Containment Fields (40). If they can not be maintained, then the fusion burn will cease before the fusion fuel is consumed.

This situation could be considered with an analogy using a hydroelectric dam. A hypothetical dam is designed, with an empty reservoir, that would be big enough and strong enough to stop a massive tidal wave and then, in a controlled fashion, let the water poor out through the penstocks to electrical generators. The cores of these reactor designs would be like the dam. Just as the dam must be strong enough to stop the initial tidal wave, the core's physical and electromagnetic strength must be strong enough to stop the fusion explosion. The penstock and generator is like the electrical circuit in these reactor designs. Just like the penstock must have enough capacity for water to flow out and relieve the sudden pressure of the tidal wave before the dam would burst, these reactor's electrical circuits must have enough capacity for the electricity to flow out before the core or circuit would electrically burst.

Initial Critical Design Considerations

Initial critical design considerations for these reactors include:

1) A mechanism to place the fusion fuel inside the core of the reactor.

2) A mechanism to start an ignition burn inside the spherical reactor core.

3) Design the reactor core so that massive electromagnetic fields can be supported. Estimated sustained minimum induced magnetic field to be in the range of 0.5–5 Tesla. Estimated peak magnetic field to be withstood briefly without bursting to be in the range of 2-100 Tesla.

4) Design the reactor core to withstand massive forces from its electrons, which will cause Coulombic heating, Hall-effect forces, and others.

5) Design the reactor core so that it will not implode from the initial transport of confining energy, or explode from the latter fusion explosion.

6) Design the core so that it can be cooled, without the cooling process affecting the spherical harmonics of the Reactor Core's (1) Spherical Electromagnetic Containment Fields (40). This will likely preclude active cooling during the fusion burn and will likely require exceptional pre-burn and post-burn cooling ability.

7) Design an electrical circuit that can transfer to, and carry away from the core extremely high electrical currents and maintain extremely high voltages.

8) Design a secondary cooling system that utilizes thermal heat from the core and electrical circuit to power steam generators and increase efficiency.

Breeding Tritium with Lithium
A design consideration that will not be fully addressed in this document, is the use Lithium as a coolant for the core to breed new Tritium. Initial engineering concepts that use Lithium in these designs appear to be too dangerous. The massive electromagnetic fields involved could create explosive currents within the Lithium that could burst containment walls and mix the Lithium with water—another coolant that must be used for reasons of economics. The possibility of the resulting explosive reaction that results from combining water and Lithium creates risks that may be too great to attempt breeding of Tritium in these designs. However, it is possible that these reactors will be so efficient and powerful that Tritium may not be needed in the fuel. Instead, these reactors may rely upon the fusion reaction of D-D fuel or a mixture of Deuterium and Helium 3. (Using Deuterium by itself would provide an almost infinite supply of fuel, but is harder to ignite than igniting mixtures of Deuterium and Tritium. The problem with Tritium is that it is so rare that, in most fusion reactor designs, it must be artificially produced by using the interaction of Lithium and the neutrons released from the fusion reaction.)

High Voltage Containment Circuit

As shown in Figure 12 and Figure 13 the type of circuit needed for containment of the plasma can be quite simple. In the Electric Mode, it consists of a high voltage across a conducting sphere. In the Magnetic Mode, it consists of high Magnetic “voltage” across a conducting sphere. The points of contact between the conducting “wire” and the core define the poles of the sphere. However, while the circuits are simple, there are quite a few engineering hurdles that need to be solved in order safely maintain such a circuit and tap off the excess fusion energy.

The Exploding Wire Phenomena

When a large enough voltage is placed across a conducting wire it will vaporize and explode. If a wire is exploded over a white background surface, the background surface will show regularly spaced transverse striations as is shown in Figure 47.

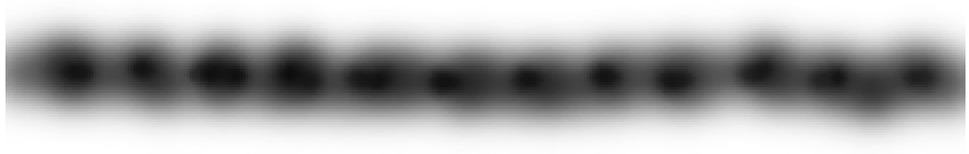

Figure 47

Exactly how the wire explodes depends on many variables: wire composition, voltage, wire resistance, wire length, wire diameter, initial wire geometry, etc. A entire science could be devoted to this important idea.

(For example, thin strands of wire, woven in complex patterns, are used to create cables resistant to this effect for use between lightning rods and grounding poles. See Figure 50.)

As wire is exploded with increasingly more energy, the striations become sharper. An example is shown in Figure 48.

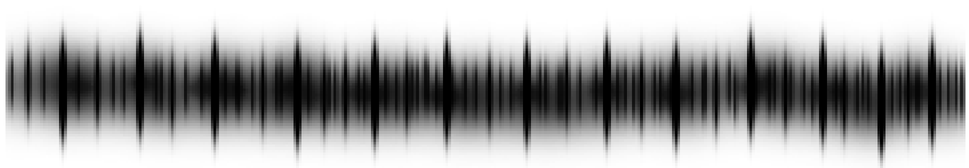

Figure 48

In general, these striations are a result of spherical electromagnetic waves sweeping through the wire. Where the spherical waves come to a point, or node, in the waves, the electromagnetic fields become stronger, and move the electrons in the conductor faster. In essence, the heat becomes more intense at the nodes than at the antinodes. This disparity in temperature vaporizes the wire locally at the nodes first. This creates the dashed pattern observed from exploding wires. Induced magnetic fields—which result from the fast moving ionized plasma—further confine the exploding plasma, helping to direct the flow of the instabilities.

An example of how the electromagnetic waves vaporize the wire locally at the nodes can be seen in Figure 49.

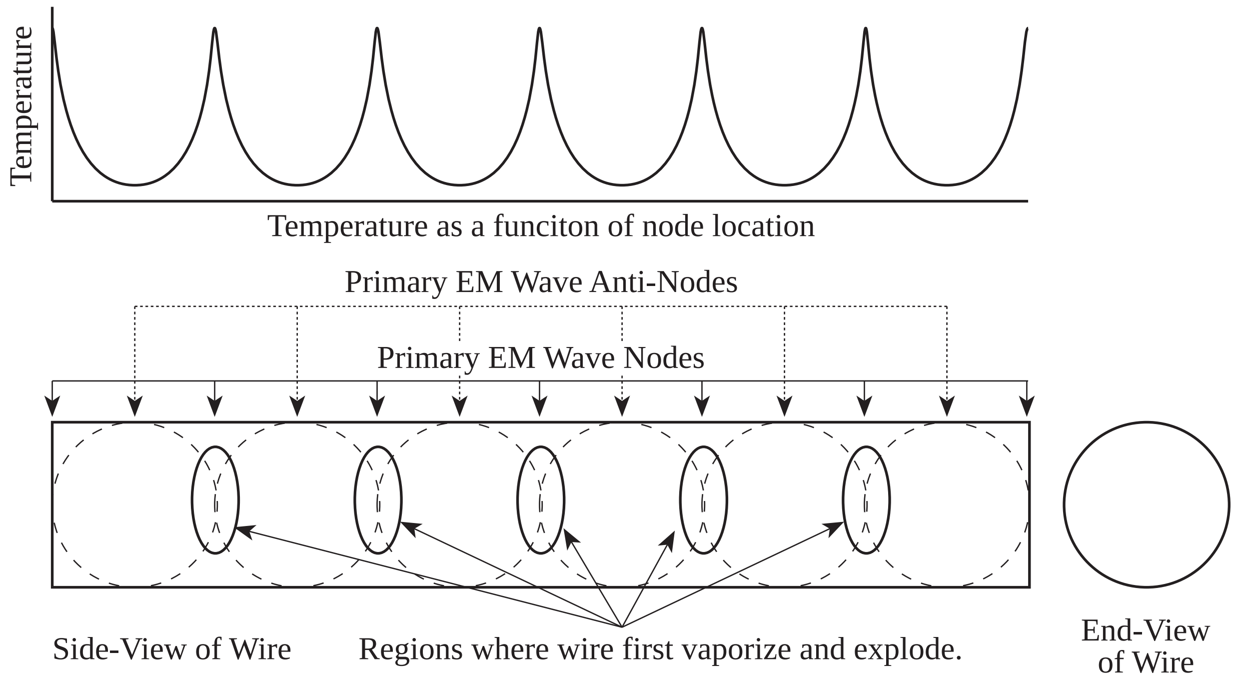

Figure 49

In the lower part of Figure 49 is the side and end profile a round wire. It is believed, when a high-voltage current is set up across the wire, the most likely wave-form for the electromagnetic wave, that sweeps over the wire, to take is a spherical wave where the wavelength is equal to the diameter of the wire. (Other wavelengths and wave-forms are possible, and can be greatly affected by how the voltage is connected to the wire.)

At the nodes of the waves, the local temperature is dramatically higher than at the anti-nodes. At the nodes, the electric field is focused to a very small spot. This intense electric field will induce local electrons to extremely high temperatures and velocities. This effect creates localized regions along the wire that vaporize and explode first—that is, before vaporizing other areas such as at the anti-nodes.

These localized regions of exploding plasma, while primarily caused by focused electrical fields, will be further constrained by a radial pattern of intense magnetic fields curving around the wire according to alternating left-hand and right-hand rules.

The sharp “spikes” that are evident in the more violent examples of exploding wires are caused by induced magnetic fields that axially confine the thin jets of plasmas as they move away from the core of the wire. Thus, magnetic fields take at least two distinct forms. They curve around the wire, and they curve around the jets of plasma shooting away from the wire at approximately right angles.

The danger of exploding the wires in the circuits required for these nuclear fusion reactors is not just great. If not planned for, such explosions are certain.

High Voltage Cabling

Two techniques used to prevent electrical wire or cable from exploding when high voltages are applied are: to use many small strands of wire instead of one large strand; and to weave or twist the individual strands to make a larger wire or cable, as is shown in Figure 50.

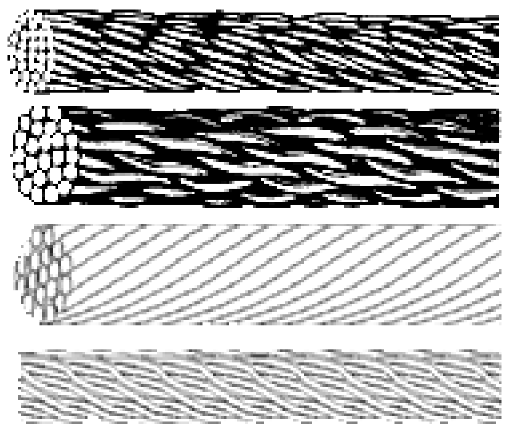

Figure 50

These types of cabling are used in lightning protection systems. The purpose of using thin strands is it reduces the radius of any individual conducting surface area. This reduces the wavelength of any resulting electromagnetic waves the follow along the wave guide formed by the strand. Shorter electromagnetic waves reduce the amount of electrons that can be piled up or focused at the nodes of a wave. The weaving, braiding and twisting of individual strands reduces the effects from induced magnetic fields. The magnetic fields tend to have smaller, more complex fields and interactions. This prevents the intensity of any particular wave from growing and creating localized hot spots that would melt or explode the cabling. The drawback to such cabling is, if overall harmonic wave patterns are desired, then this type of cabling creates non harmonic patterns, or patterns that are too complex to easily understand and control.

Alternative Design Variations

Coils Variations

Hemispheric Coils (6) are used in the preferred embodiment. However, they are untested. There are many other possible coil designs that could be used instead. They fall into two major categories: coils that create Electric Mode operation; and coils that create Magnetic Mode operation. Magnetic Mode operation is preferred because, in general, Electric Mode operation can cause electrons to pile up and burn out components.

In general, the main Electrical Circuit or Magnetic Circuit—i.e., the Containment Circuit made up of Conducting Spheres (2) and Reactor Core(s) (1)—described for these nuclear fusion reactor designs—with the exception of Straight-Line Designs—are closed circuits.

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That is, they form a loop, with no “end” of the circuit directly connected to the commercial power grid. Thus, the only way of adding or extracting energy to the closed loop, and controlling the flow of the energy around the closed loop, is by using inductive coils.

There are three main types of coils that could be used for these purposes: normal wound coils; Rowland Ring coils; and hemispheric coils.

Normal Coil

Normally wound coil are shown in Figure 51.

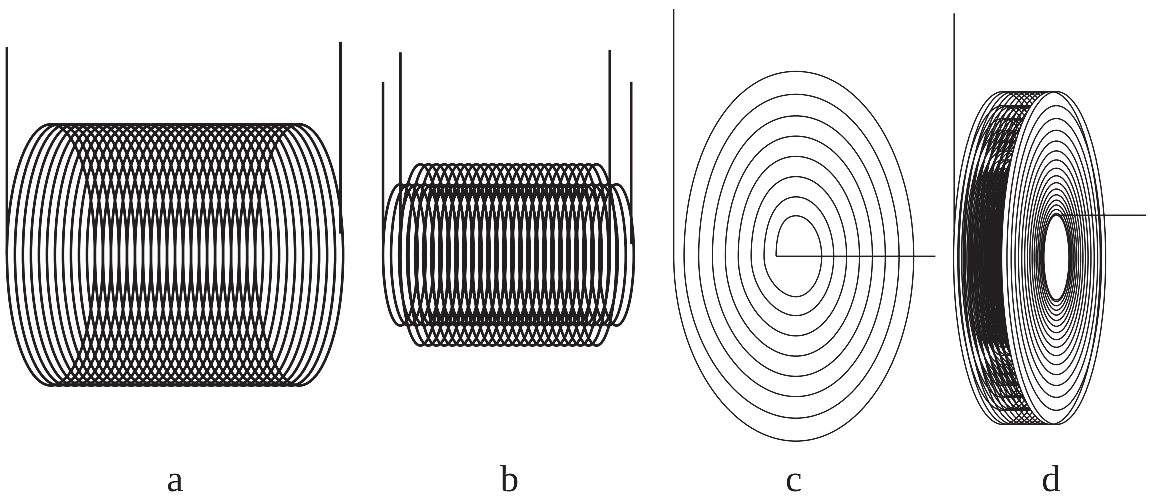

Figure 51

The cylindrical coil in (a) is one of the most common types of coils, it produces a simple, very well understood magnetic field. The strength of the magnetic fields created by these coils is somewhat limited.

The concentric cylindrical coils in (b) combine their magnetic fields, thus creating stronger magnetic fields. Some of the world's strongest magnetic fields are created by magnets that are wound in this way. The more powerful designs using this type of coil must be structurally reinforced both on the inside and out and must be provided with powerful cooling mechanisms.

The helically wound coils in (c) can provide relatively strong magnetic fields but have some harmonics problems. It is difficult for powerful currents to change direction quickly. At the center of a helical coil, the lead changes direction abruptly—see the center of the coil in Figure 51 (c)—and can lead to problems.

The coil in (d) is a combination of cylindrical and helical designs. It can produce large magnetic fields but because of the back and forth, or random, winding patterns typically used in this design, the magnetic fields might not be harmonic enough for these nuclear reactor designs.

Each of these coil types could be used to induce magnetic fields—and indirectly, electric fields over the conducting spheres—in the containment circuits of these nuclear fusion

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reactor designs. These designs do lend themselves to effectively inducing harmonic electromagnetic fields over a sphere. However, there are other reactor designs more appropriate for coils such as these. They use a straight-wire type of Solid Conductor (60) with a circular cross section—See Figure 68—rather than a circuit of spherical conductors. (The design in Figure 68, one of my earliest designs, is very dangerous. I believe that is very susceptible to the exploding wire phenomena.)

Rowland Ring coils

A Rowland Ring coil is donut shaped coil. The current typically flows through the coil as is shown in Figure 52.

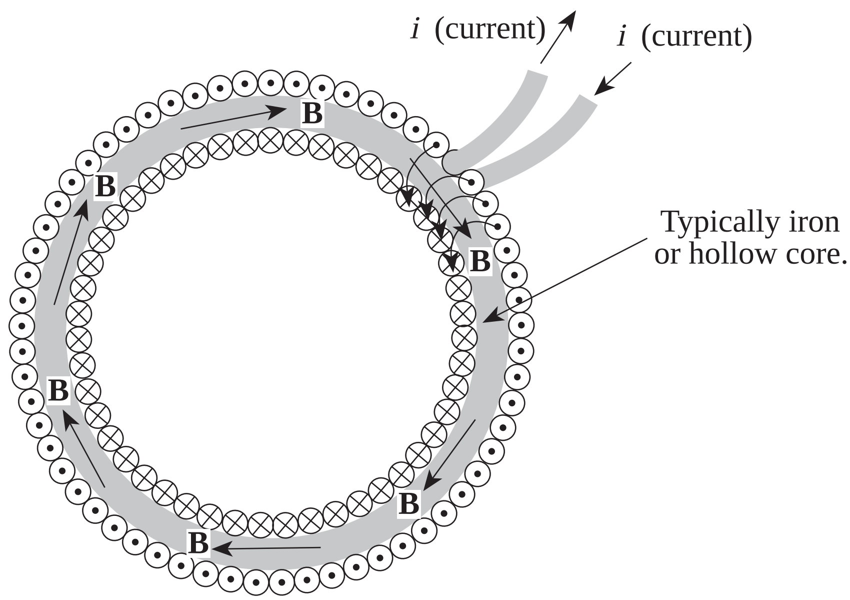

Figure 52

Rowland Ring coils sometimes have a solid, soft-iron core. Such cores allow higher magnetic fields, but only up to a point. Without a core, the coil is less efficient, but it is possible to obtain much higher magnetic fields by using brute strength—by using more turns and higher currents.

All Rowland Ring coils used in the designs described in this document will be designed for very strong currents and magnetic fields. It is assumed that all of the Rowland Ring coils in these designs are completely covered by a high-strength mechanical shield and cooling system.

The Electric and Magnetic Interaction of Coils with Conducting Spheres

When an electric current flows through a coil, according to Ampére's Law, the coil induces a magnetic field. The magnetic field times the area of the coil gives the magnetic flux of the coil.

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If the current through the a coil is changing, then the induced magnetic flux through the coil is changing. According to Faraday's Law of induction, as the magnetic flux is changing, the coil will induce an EMF across the coil.

A coil can be placed next to a conducting sphere. If a current is set up through the coil, so that it grows rapidly from zero to some large value, then the current in the coil will induce electromagnetic fields in the conducting sphere.

According to Lenz's Law, which applies to closed conducting circuits, the induced fields in the conducting spheres will appear in such directions as to oppose the changes that produced them.

Various configurations of coils can create different combinations of electric and magnetic fields on the surface of the sphere. For example, a Rowland Ring coil will induce electromagnetic fields over a conducting sphere in the opposite manner as a regular cylindrical coil, as is shown in Figure 53.

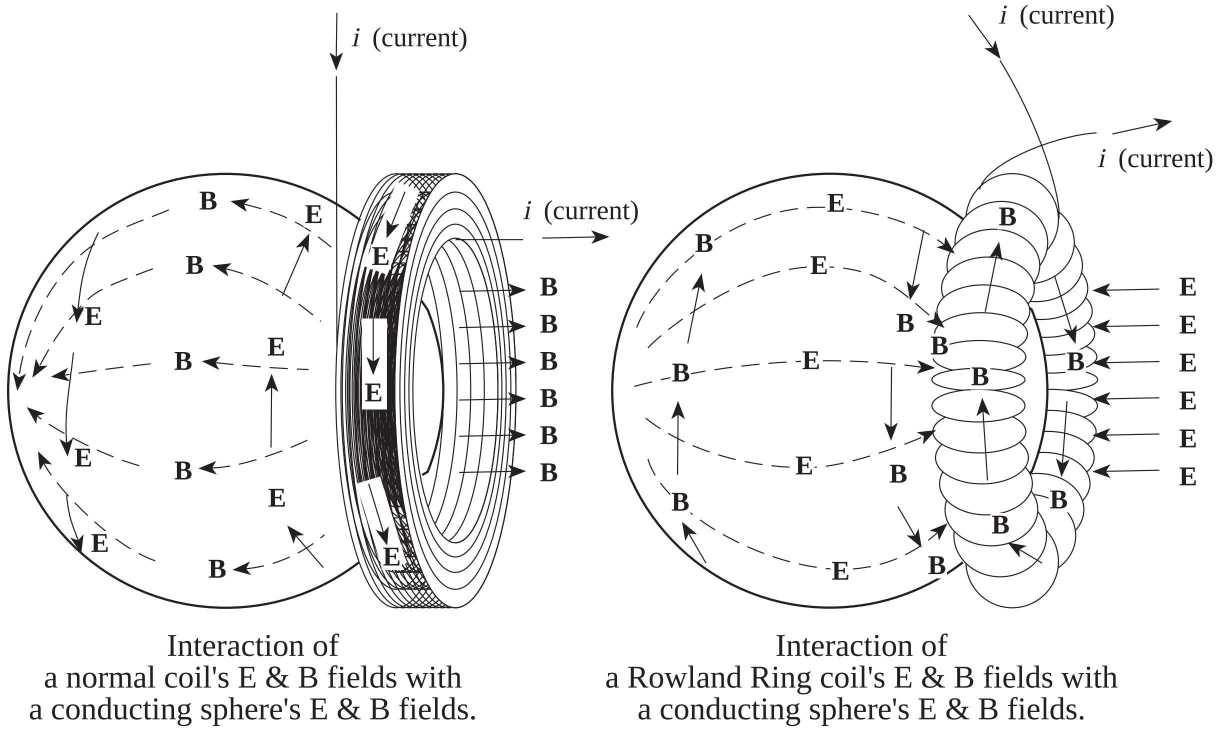

Figure 53

There is a significant advantage and disadvantage to using either types of coils. A Rowland Ring coil that induces smooth electromagnetic fields in conducting spheres would be easy to design, compared with other coil types. This is important for harmonics. All that is needed is for the wavelength of the coil to match the wavelength of the sphere. Also, if the Rowland Ring coil has a soft iron core, then the Rowland Ring coil will efficiently produce large magnetic fields. An added advantage to a Rowland Ring coil having a soft iron core is that this inhibits the flipping of the polarity—a key safety consideration—due to the phenomena of hysteresis in the soft iron core. However, a soft iron core limits Rowland Ring coil designs to “large” magnetic fields, that is, inhibiting induction of “massive” magnetic fields. Without the soft iron core,

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and using the shear brute force of large, brief currents, a Rowland Ring can produce massive magnetic fields.

In Figure 53, note how the rotation of the magnetic field in the Rowland Ring is opposite to the rotation of the magnetic field in the conducting sphere—according to Lenz's Law. Also, note how the electric fields sweep over the sphere from pole to pole. This is the disadvantage to using a Rowland Ring coil to induce electric and magnetic fields in the conducting sphere. The electric field sweeping from pole to pole over the conducting sphere will create a current flow across the sphere. This will concentrate electrons one pole. The electrons will build up only to a point before they will arc across to the next sphere. This arcing will damage the conducting spheres and weld them together. Tests will be required to prove how damaging this will be however.

It is possible that the magnetic fields induced around the sphere by a Rowland Ring will limit the actual flow of the electrons. In essence, the conducting sphere may act as if:

- there is a large voltage across the sphere—from pole to pole
- there will be a massive resistance across the sphere—from the magnetic fields
- and there will be only a small current flow.

On the left side of Figure 53, note how the magnetic field in the coil is induced by the normal coil's current, and how the coil's magnetic field opposes the induced magnetic field sweeping over the Conducting Sphere (2) from pole to pole—according to Lenz's Law. Also, note how the electric fields sweep over the sphere in counter-rotating hemispheres. This is an advantage of using regular coils to induce the electric and magnetic fields over the conducting spheres. Because the fields in this configuration push the electrons in counter-rotating directions around each hemisphere, there is no net electron migration around the main conducting circuit. In essence, the main conducting circuit would not conduct electrons, it would conduct a magnetic field. It would be a magnetic circuit rather than an electric circuit.

As far as the ability of the confining fields at the core are concerned, there is no difference between using an Electric or Magnetic Circuit.

The main drawback in using normal coils is they would be more difficult to design than Rowland Ring Coils or Hemispheric Coils. Because of the pattern in how the wire wraps in the normal coil, the induced magnetic field would not be as smooth as with the fields induced by the Rowland Ring coil. Two possible solutions for creating smoother fields would be to use parallel helical coils or Hemispheric coils. Parallel helical coils are shown in Figure 54.

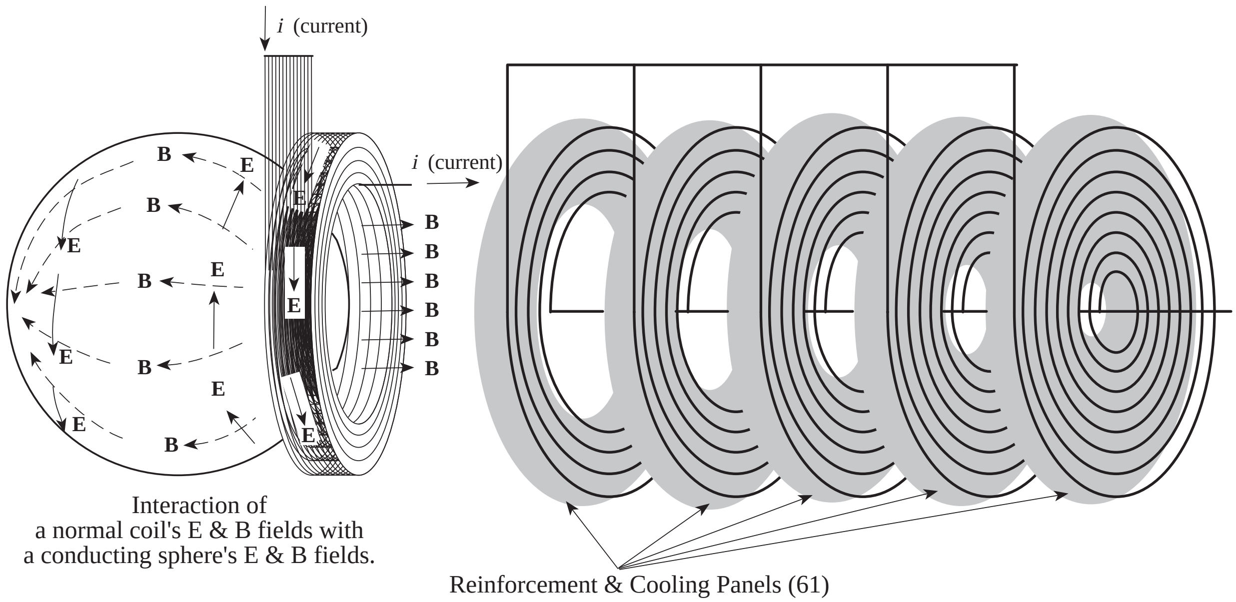

Figure 54

In this configuration, parallel helical coils are separated by structural reinforcement panels that have interior channels for coolant—Reinforcement & Cooling Panels (61). The panels could be made of non-conductive, rigid material such as: ceramics or RCC. The rigid panels will keep the coils in position and prevent them from deflecting under the mechanical forces of the intense electromagnetic fields. The panels will have channels that can handle a high volume of coolant.

In order to maintain equivalent voltages between layers and to maintain the timing of the electromagnetic pulses, the in-flowing wire leads would all have a common connection, as well as the out-flowing wire leads.

The weak point in this coil design will be where the coils connect with the center lead. At this point there will be an abrupt change in direction which will have the potential for burning out the coils, and disrupting harmonics.

Reactor Core and Conducting Sphere Variations

Conducting Layer

The Conducting Layer (18) of the Reactor Core (1), and the Conducting Layer (18) of the Conducting Spheres (2) of the preferred embodiment is represented as solid Copper-Niobium alloy spheres. It has already been mentioned that the material of these conducting layers could be other conducting materials, gases, or plasmas. What was not mentioned is that the "solid" layer of manufacture could be substituted for strands of conducting wire that are woven, braided, or twisted around a substrate to form a spherical shape. Figure 55 shows how this might look for a Conducting Sphere (2)

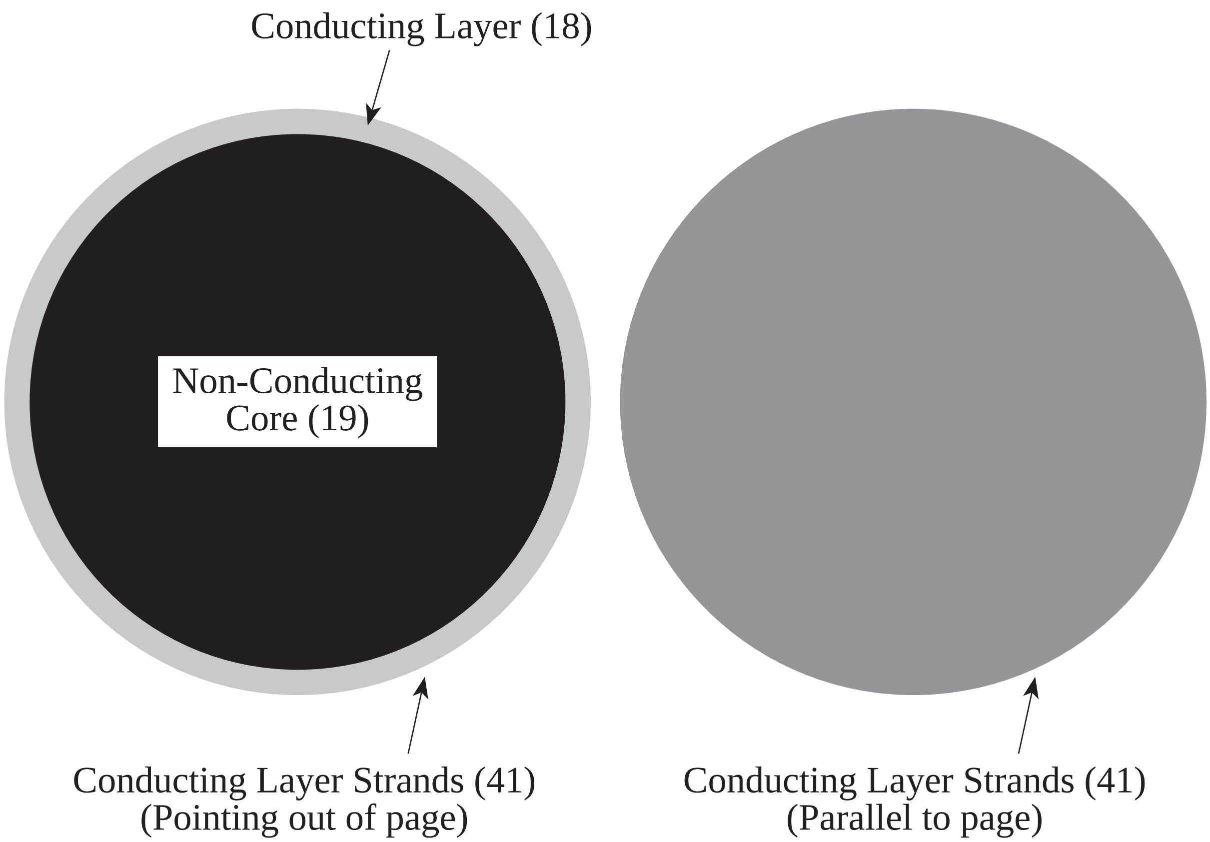

Figure 55

In Figure 55, the Conducting Layer Strands (41) are simply wound around the Non-Conducting Core (19). In essence, they create thousands of closed loops of conductors. This method would work in the Magnetic Mode, but probably not work in the Electric Mode.

Figure 55 does not represent any weaving, braiding or twisting of the strands as shown in Figure 50. However, with a much higher cost of manufacture, this is possible. The added benefits of this method of manufacture versus the potential benefits—reducing the chance that individual strands will burn out—does not seem worth the extra cost of manufacture at this point.

Super Conductors

It would be preferable, if the Conducting Layer (18) of the Reactor Core (1), and the Conducting Layer (18) of the Conducting Spheres (2) and the conducting material in any induction coils used in these designs were made of a super-conducting material. At this point, in the history of super-conducting materials, the costs associated with manufacturing a nuclear fusion power plant following these designs and using super-conducting materials would appear to be too high. The modular form of these reactor designs allows swapping out old materials with new as they become cost effective.

An example of a possible super-conducting material would include, but not be limited to, multi-filamentary Nb3Sn and NbTi superconductors.

Other Conducting Layer Materials

The conducting layer within a core could be made of:

- Copper and copper alloys
- Aluminum and aluminum alloys
- Iron, steel and other ferrous alloys
- Silver, and silver alloys
- Gold, and gold alloys
- Titanium, and titanium alloys
- Vanadium, and vanadium alloys
- Magnesium, and magnesium alloys
- Other conductive metals and metal alloys, including but not limited to: Chromium, Lead, Molybdenum, Platinum, Tin, Tungsten, Mercury and Zinc.
- Conductive forms of glasses, ceramics, plastics and polymers, composites, and multi-compound materials.

Plasma Core

One possible form for the conducting layer of the Conducting Spheres (2) or the Reactor Cores (1) is the plasma form. The plasma form offers some key benefits. First, cooling of the conducting layer is not required, it must be hot to be in plasma form. Second, refurbishment of this layer is not required. Third, costs of materials for this layer are low. Fourth, Hall and Coulombic forces tearing this layer apart are not an issue.

The key issue is, how can the plasma form the spherical shape needed? At first, this issue may seem difficult. Difficult Reactor Core and Conducting Sphere designs will follow. But it may not be difficult at all. A simple solution for using plasmas, at least within the Reactor Core will be presented.

First, in Figure 56 is one “solution” that may be very difficult and problematic.

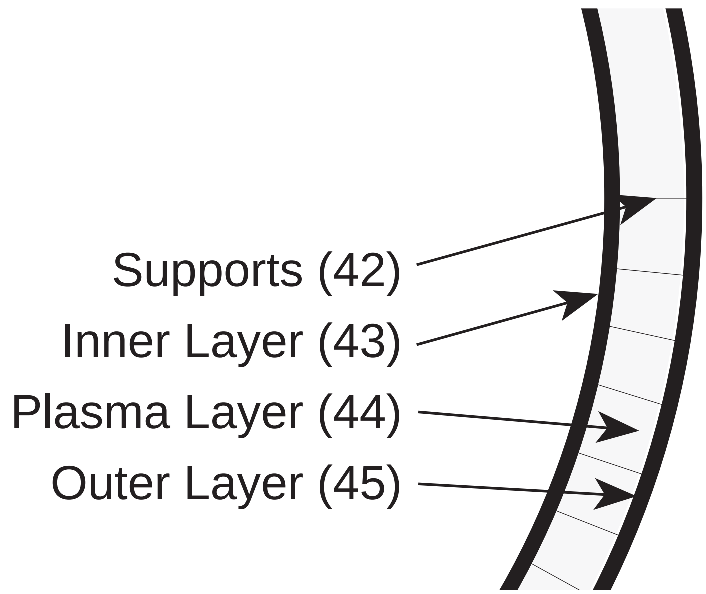

Figure 56

The Conducting Sphere (2), or Reactor Core (1) is made of a strong inner and outer layer of material, which may include but not be limited to Steel, Titanium or RCC. The Plasma Layer (44) is filled with a highly conductive plasma, but offers no support between the Inner Layer (43) and the Outer Layer (45). Therefore, Supports (42) are needed between these two layers.

Here is where the problem starts. The massive electromagnetic fields that will be generated in the Plasma Layer will force the ions in the plasma to rotate very fast. Any Supports (42), of any known material or construction, will be quickly eroded. When they fail, the Reactor Core (1) may collapse, catastrophically. The initial idea an engineer might have would be to make the supports stronger, but this leads to another problem. The stronger the supports are, the more disruptive they will be to the harmonics within the plasma. If the harmonics within the plasma are distorted to too great of an extent, then the physics tells us the instabilities within the plasma burn will become great enough to destroy just about any container.

There may be some optimum trade-off point where Supports (42), for example made of Tungsten, may survive long enough within the Plasma Layer (44) for a typical fusion burn to take place, and where the supports do not create disruptions in the harmonics that are large enough to allow plasma Instabilities (39) to explode through the Reactor Core (1). If so, then this design variation may be viable.

“No-Core” Reactor Core Design

In the long-term development of these reactor designs, perhaps the best “core” design will be to have no core at all. I call this the, “No-Core” Reactor Core. The No-Core design has no hard materials. It is made up solely of electromagnetic fields, or electromagnetic fields within a plasma.

The key to the No-Core design is a Conducting Circuit made of Conducting Spheres that is designed so well that the Magnetic Fields over the core area exceed about 4 Tesla at a distance of about 2.5 meters from the center of the core area. At 4 Tesla, a 5 meter diameter core would focus about 1.2 exawatts of energy at the focal point of the core. (At 5 Tesla, 1.875 exawatts, at 6 Tesla 2.7 exawatts, at 7 Tesla 3.675 exawatts, at 8 Tesla 4.8 exawatts, at 9 Tesla 6.075 exawatts, and at 10 Tesla 7.5 exawatts would be focused at the center of the core area!)

To reach such high magnetic fields at such large diameters would require extremely optimized reactor designs that may involve massive amounts of super conducting materials and unheard of cooling requirements. The capacitor and triggering requirements to start the process would be equaling daunting. However, the engineering is straightforward. There are no magical physics barriers to break through. The battle cry would simply be: more super conducting material, more cooling, more capacitors.

At these energies, many problems with earlier designs would be moot. There would be no need to design complex reactors cores—the No-Core design would have to be used. There would be no need to have lasers to trigger the burn—the confinement field would be powerful enough to be the triggering field. There would be no complexity of having to trigger the lasers and containment circuit in the proper sequence since there would be no lasers.

A possible No-Core containment circuit might look like Figure 57.

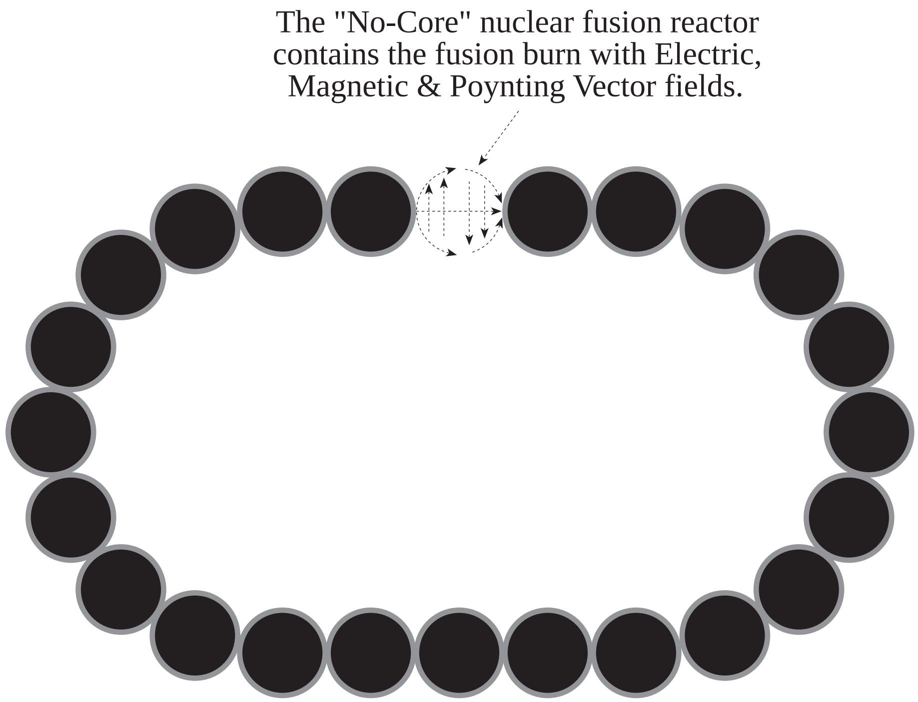

Figure 57

The No-Core Core Area would look like Figure 58.

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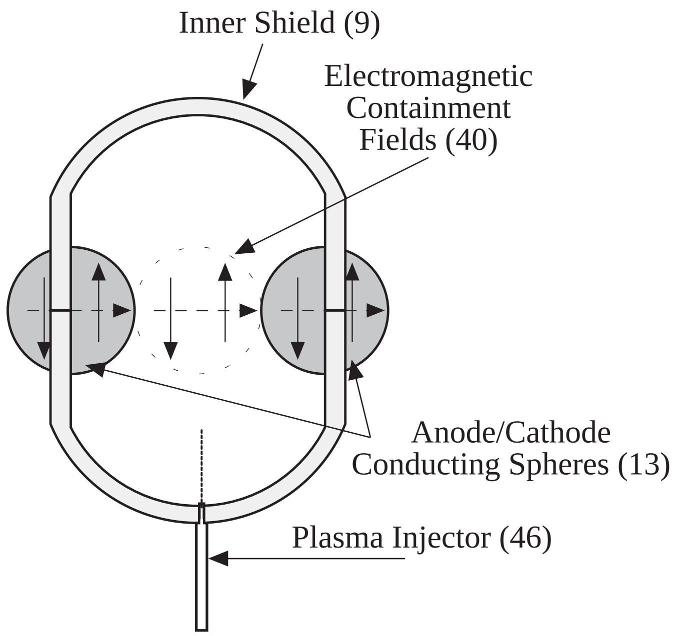

Figure 58

The Inner Shield (9) would have a wider diameter to help make insure that no disruption to the harmonics results from the shield. The Electromagnetic Containment Fields (40) would provide containment of the fusion burn, and provide ignition of the fuel to begin with. The electromagnetic field orientation would be in the Magnetic mode. The Anode/Cathode Conducting Spheres (13) would be the weak link. When they melt, the harmonics would be lost. A fusion Fuel Pellet (36) could be prepositioned in the Inner Shield (9) via Ablatable Wires (35) similar to those shown in Figure 9, and/or, fusion fuel could be injected into the Electromagnetic Containment Fields (40) via a Plasma Injector (46). The advantage of an injection system is it would allow the fusion burn to be continually fed with additional fuel.

A variation would be to coat the Anode/Cathode Conducting Spheres (13) with some material, such as thin layer of Boron impregnated high-temperature ceramic to help them survive longer. Or, it might be possible to actively cool the spheres. The problem in cooling the spheres is that half of each sphere is inside the Inner Shield where no cooling equipment could be placed without disrupting the harmonics of the Electromagnetic Containment Fields (40). If only part of each sphere is cooled, then it would create differences that would likely disrupt the electromagnetic harmonics of the containment field.

Most likely, the cooling plan would be to pre cool the entire circuit and operate until heating disrupts the harmonics. It is possible that burns of several minutes could occur with such a technique. This would not be bad. Thermonuclear fusion burns of several minutes would give off tremendous amounts of energy.

There seems little doubt that the limits of this design would be in cooling the Anode/Cathode Conducting Spheres (13) rather than in fueling the burn area.

The No-Core design emphasizes a key detail of these patents. The design of the core area depends not upon materials selection, but on the formation of powerful, spherical,

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electromagnetic fields, that focus energy at the center of the core area. The other key detail is how the same circuit can not only focus energy on the center of the reaction, but the opposite, how energy coming out of the center of the reaction can be absorbed by the circuit via the MHD process. If this process was not equal and opposite, then the design would not work.

RCC/Boron (23) & RCC Layers (24), (26), (27) in Reactor Core

The element carbon takes a wide range of forms from amorphous carbon, to Graphite, to Graphite fibers, to Diamond. Some of these forms, such as Graphite and Graphite fibers can be highly conductive. Some forms of carbon, such as amorphous carbon (lampblack) are relatively non conductive. Tests must be conducted to test the best form of carbon for layers (23), (24), (26), and (27) as shown in Figure 6. In general, conductive or non conductive forms could be used. It is assumed at this point, that the non conductive forms will perform better, due to smaller eddy currents, smaller inductive losses, smaller thermal losses, and the possibility of being affected by massive Hall and Coulombic forces.

Since materials can change forms under high temperatures, pressures, and electromagnetic forces, it is assumed that the material characteristics will vary over time and possibly reduce the effectiveness of some or all of the Reactor Core (1) materials. Tests will be needed to determine the longevity of these components.

Secondary Diamond Manufacture

In the center of the Conducting Spheres of the preferred embodiment will be amorphous carbon. This material is essentially non conducting when compared with Copper-Niobium Conducting Layer (18). However, after repeated use, under high temperatures, pressures and electromagnetic forces—highly resonant electromagnetic forces—it is expected that the amorphous carbon will be transformed into other forms of carbon, including graphite and diamond. It is not the intended purpose of these fusion power plant designs to manufacture diamonds. However, they may be extremely efficient at doing exactly that. If the Non Conducting Fill (19) in a Conducting Sphere (2), or if carbon layers (23), (24), (26), (27) within the Reactor Core (1) transform into more conductive forms of carbon, then failure may occur due to sudden increases in currents within these components of the reactor.

Thus, to offset costs, to remove radioactive materials, and to prevent failure of these key components, the Conducting Spheres (2) and the Reactor Cores (1) must be refurbished at regular intervals. This will involve removing any diamonds forming at the center of Conducting Spheres (2).

Containment Circuit Variations

Circuit design

These designs need a closed electric or magnetic circuit for the confinement circuit. The conducting spheres must be placed in a straight, circular or oval geometrical fashion.

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Straight-Line Containment Circuit Designs

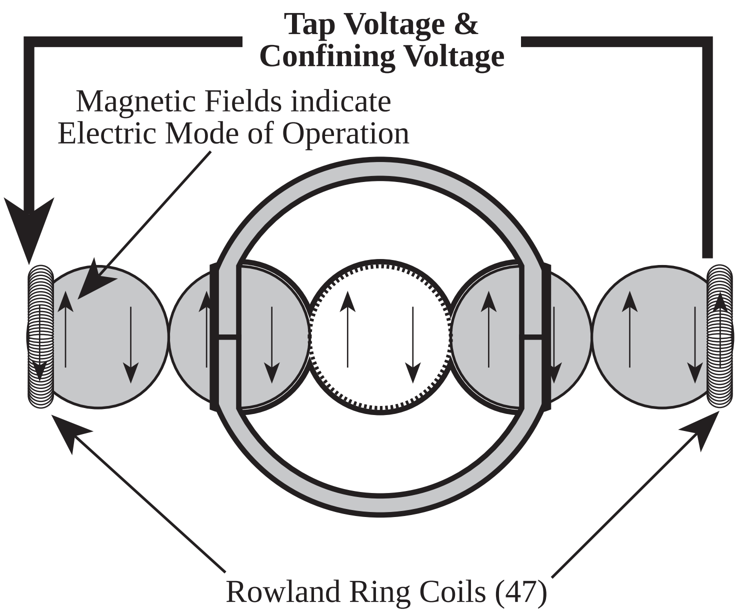

Figure 59

Figure 59 represents a type of straight-line configuration. It utilizes Rowland Ring Coils (47), and operates in the Electric Mode. In other words, the magnetic fields lines are as in Figure 12. The key to this design is very powerful, and harmonic coils. There is no oval or circular circuit in this design. The load is connected almost directly to the circuit. (There would be circuitry that includes capacitors and DC to AC inverters between the Reactor and the load.)

The number of Conducting Spheres (2) in this design can be increased to improve harmonic over the core area, or reduced to reduce the overall reactor design costs. The design in Figure 59 has 4 Conducting Spheres (2). The number of Conducting Spheres (2) could be reduced to 2 or 0. If zero Conducting Spheres (2) are used, then an almost perfect set of Hemispheric Coils would be needed to enclose the core area. While this might be the limit to reducing these designs to a minimum set of components, I do not believe anyone has the capability to manufacture such coils at this time.

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Circular Containment Circuit Designs

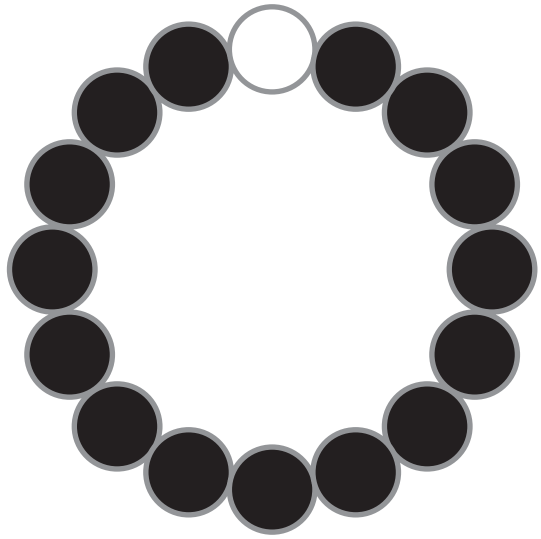

Figure 60

Circular Designs to not seem to offer an advantage over other designs except perhaps in reduced cost. The number of Reactor Cores (1) can be increased to provide more power, or reduced to minimize costs. The number of Conducting Spheres (2) can be increased to improve harmonics, or reduced to minimize costs.

Oval Containment Circuit Designs

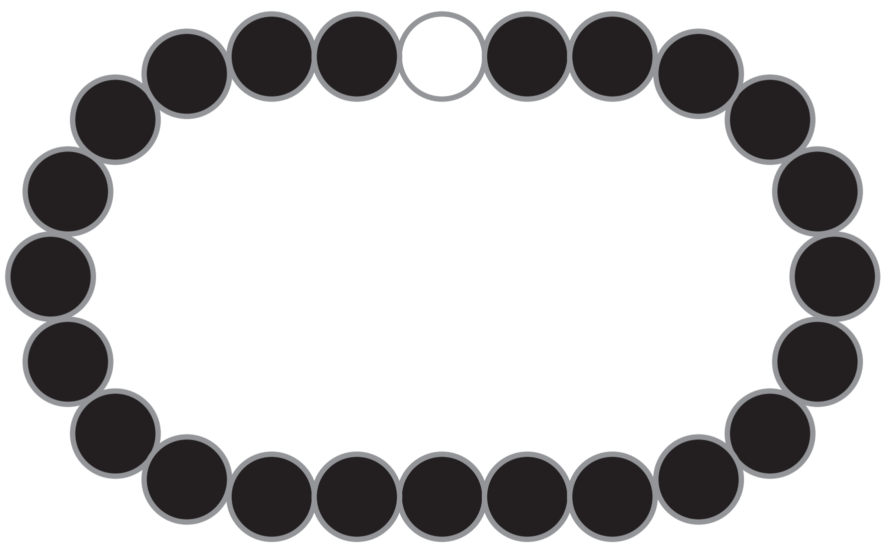

Figure 61

There is a symmetry problem with the circular and oval layouts. If a conducting sphere is analyzed, it is found that either the electric or the magnetic field sweeps over the sphere from pole to pole—in the Electric Mode or Magnetic Mode. However, the poles of the spheres are not perfectly aligned—pole to pole—in the curved sections of the circular or oval layouts. There is an offset as shown in Figure 62.

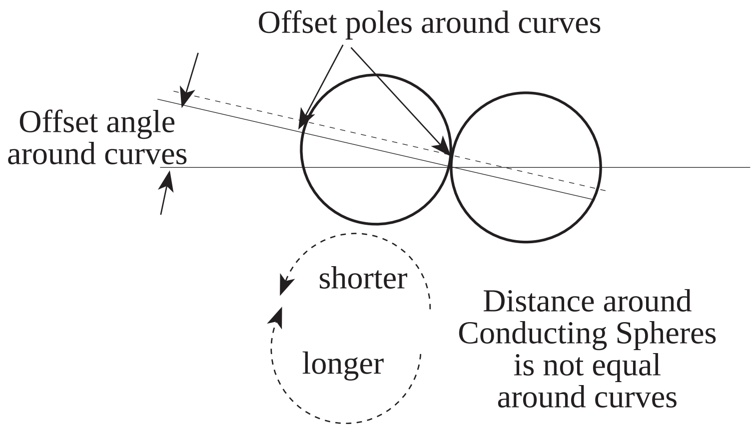

Figure 62

Because the poles are not aligned, the electromagnetic wave takes longer to sweep around the outside edge of the conducting sphere than the inside edge. This path difference is where the bulk of eddy currents and heat loss in these designs will occur. It is the main problem that might prevent these reactor designs from working well.

If the track were enlarged by adding more conducting spheres then this effect would be lessened. If it had less conducting spheres, then this mismatch between the poles would be greater. The smaller the quantity of conducting spheres in the track design, the greater the mismatch between the poles will be, and thus, the greater the eddy currents, the greater the Coulombic heating and the greater the loss of efficiency will be. The larger the track, and quantity of conducting spheres, the less the mismatch between the poles will be, but the greater the cost of the reactor will be.

A possible solution to this problem is having variable cooling for the Conducting Spheres (2) in the curved portions of the Conducting Sphere Track (4). If the coolant was pumped into the track from the outside edge of the track, and removed from the inside edge of the track, then the outside of the Conducting Spheres would be slightly more conductive, and the inside of the Conducting Spheres would be slightly less conductive. This might reduce the non harmonics caused by the offset of the poles to the point of not being a factor.

The advantage of an oval track is: there are a number of conducting spheres adjacent to each side of the reactor core that are aligned in a straight line. This would allow the eddy currents to diminish in each successive conducting sphere in the straight-line portion of the oval leading in and out of the Reactor Core (1). This would tend to “clean up” the main electromagnetic wave and allow for a more harmonic wave to pass over the reactor core. Once again, here is a situation where there are trade-offs that create questions that only experiments with different configurations of reactor designs and different materials can answer. However, I believe these are optimization and cost reduction problems, not fundamental questions of whether these reactor designs will work.

In the preferred embodiment, there are 31 conducting spheres and one reactor core, each sphere with a 5 meter outside diameter.

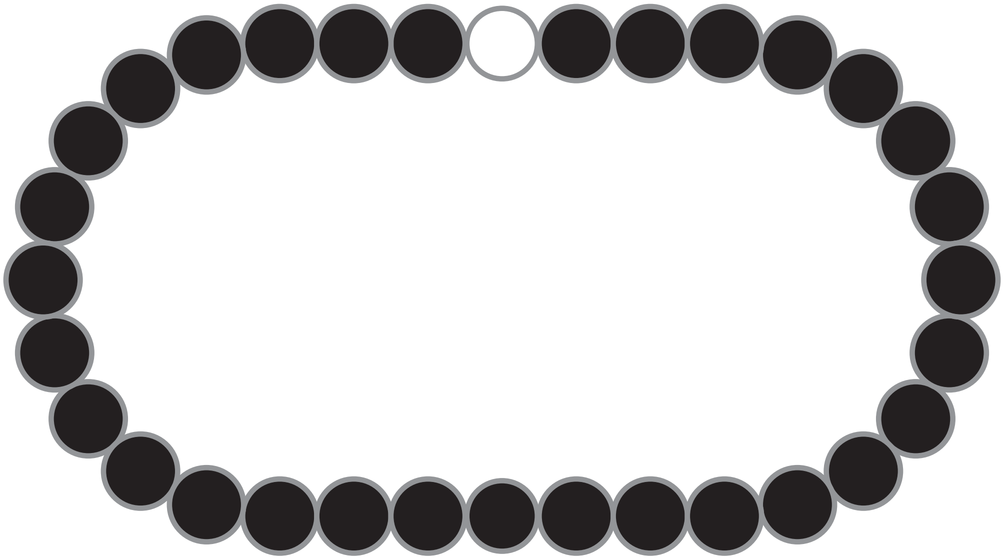

Figure 63

Thus, the mean center path-length of this example circuit would be 160 meters long.

Multi-Core Reactors

Initially, the fusion reactors built on these designs would probably have one core per electrical circuit. Later, as the design variations are perfected, at different price points, it will be possible to create reactors with different numbers of cores. Each core would be analogous to a piston in a gasoline engine. The energy produced from one igniting core could be used to compress the next core in the electrical circuit while excess electricity is siphoned off using induction coils.

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In Figure 64 two major design variations are demonstrated: the track is circular, and there are two Reactor Cores (1).

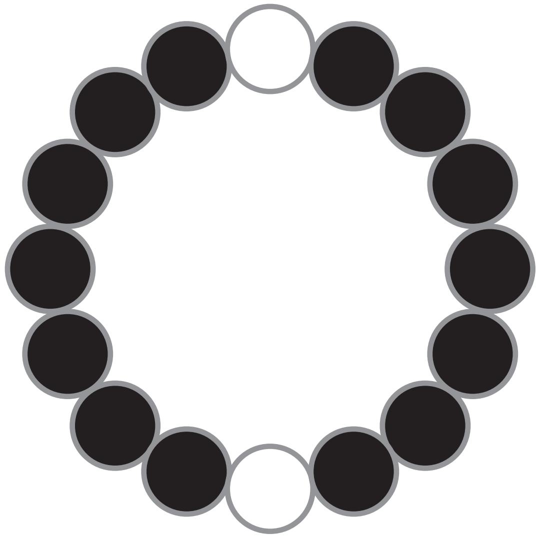

Figure 64
2-Core Circular Circuit Design

An advantage of a two Reactor Core (1) design is that one Reactor Core (1) can be igniting and compressing the fuel in the other Reactor Core (1). The circular design reduces costs as compared to an oval design.

In Figure 65 two major variations are demonstrated: the track is oval, and there are two Reactor Cores (1).

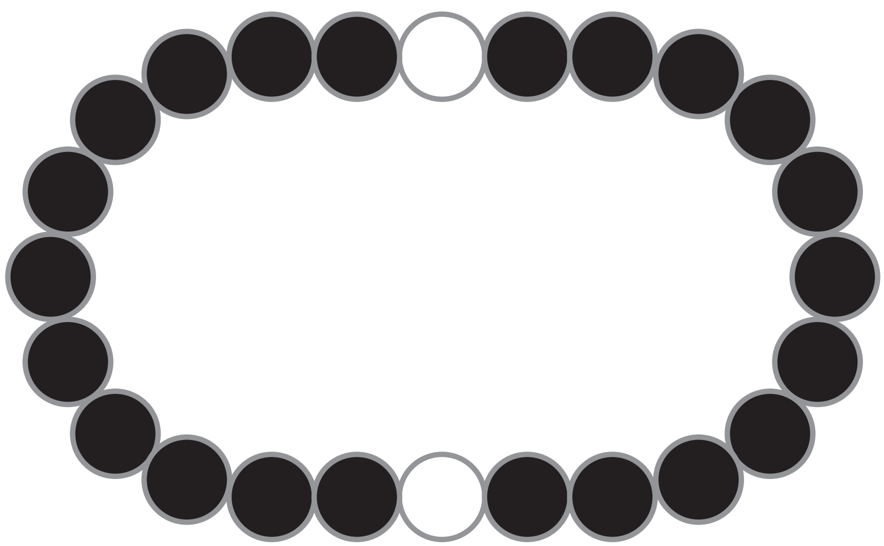

Figure 65
2-Core Oval Circuit Design

An advantage of a two Reactor Core (1) design is that one Reactor Core (1) can be igniting and compressing the fuel in the other Reactor Core (1). The oval design improves harmonics as compared to a circular design.

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In Figure 66 two major design variations are demonstrated: the track is circular, and there are four Reactor Cores (1).

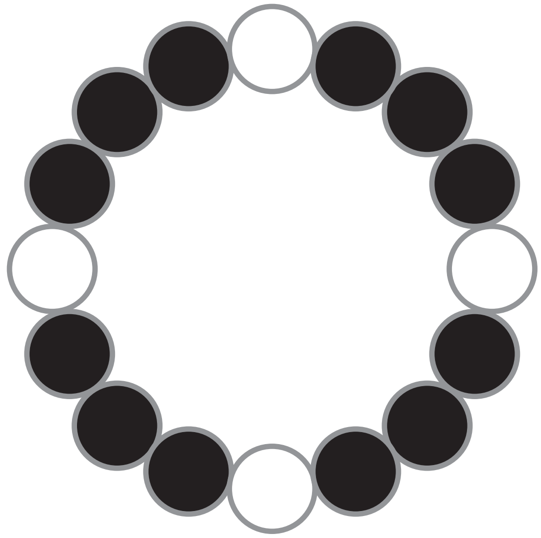

Figure 66
4-Core Circular Circuit Design

Increasing the number of Reactor Cores (1) is possible, but does not seem to offer any key benefits over a 2 Core design. The complexity of timing more than 2 cores appears to be a major drawback.

Conducting Sphere Wavelength to Reactor Core Wavelength

In all design variations shown so far, the diameter—or wavelength—of the Conducting Spheres (2) and Reactor Cores (1) were the same. Observations of planetary nebulae using the Hubble Space Telescope indicate that there would be an advantage to having Conducting Spheres (2) that have wavelengths that are larger than the wavelengths of the Reactor Cores (1). An example, of such a planetary nebula is shown in Figure 67.

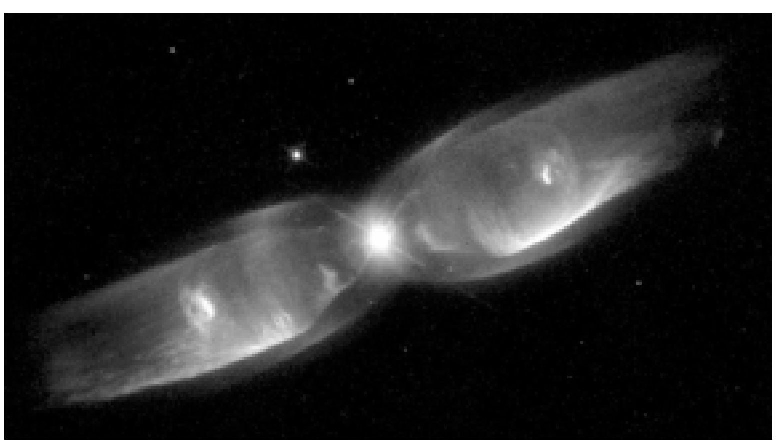

Figure 67

The ratio of the wavelength of the Conducting Spheres (2) to the Reactor Cores (1) could be 2:1, 3:1, 4:1, and so on. A design like this amplifies the energy transmitted from the Conducting Spheres to the core area and reduces the stress on the Conducting Spheres (2). An example of such a design is shown in Figure 68. The Diameter of the outer lobes in the planetary nebula in Figure 67—equivalent to the Anode / Cathode Conducting Spheres (2)—is a multiple of the diameter of the central star—equivalent to the Reactor Core (1).

(Note: Figure 67 visually shows how the electromagnetic confinement techniques in these reactor designs work. There are two obvious shells of plasma in both lobes of this planetary nebula—which is not uncommon for planetary nebulae. There is an inner and an outer shell in each lobe. The outer plasma lobes are being ejected from the core of the central star. The inner plasma lobes are being created by nuclear explosions within each lobe. They are trying to explode outward but are being confined. The explosions within the lobes are pushing out in a MHD type fashion, strengthening the confining forces provided by the outer layers of each lobe. This is an astronomical example of the self-healing design feature of these reactor designs. Because the electromagnetic confinement provided by the outer layers is not completely spherical, the plasma from the explosions within the lobes can vent out the two ends of the nebula. The reactor designs within this document explicitly are designed to close the ends of the core area to prevent plasma from escaping like this.)

Figure 68 on page 110

This is a very advanced design. It has many advantages over the preferred embodiment. The main disadvantage is the increased sophistication and cost of components. Details of the Figure 68 design are:

- It is a No-Core design.
- It is a Dual Reactor Core (1) design.
- It operates in the AC mode.
- The left and right halves of the Conducting Sphere Track (4) are mounted on massive Core Wavelength Adjustment Tracks (48) that allow the two halves to be adjusted in a left-to-right direction. (This allows fine tuning of the core wavelength during the burn. This will be important for long-duration burns as thermal expansion and contraction causes changes in the primary wavelength of the electromagnetic fields.)
- It uses hemispheric coils.
- It does not use lasers since implosion, ignition and confinement are performed solely by the conducting circuit.
- It uses plasma fuel that is continuously replenished via Plasma Injectors (46).

There are many advantages to this design. First, because of the Core Wavelength Adjustment Tracks (48), the reactor can be continually adjusted to optimize the harmonics, even if thermal expansion of Conducting Spheres (2) occurs. Second, as one fusion reaction explodes, it will implode the other fusion reaction. The two cores can continually cycle back and forth like a two piston engine—creating an Alternating

Current. But in this case, at the center of the Reactor Cores Areas will be two pulsating stars. The burn length of this design is potentially days or weeks—or longer—depending on active cooling capabilities.

Alternate Core Designs

The core must be designed to be highly conductive or super conductive. One likely material choice would be to use copper, or a copper alloy.

A Copper alloy, Cu-Nb, will be used as an example for the conducting layer in this document but does not limit from a patent's legal point of view the use of other conducting or superconducting metals, ceramics, fluids, plasmas and materials. The key design aspect is placing a spherical conducting or superconducting material around a nuclear fusion reaction for the purposes of confining the reaction and extracting energy from the reaction. (Or, a Spherical Electromagnetic Confinement Field (40) in the "No-Core" designs.)

Some possible copper alloys include, but are not limited to: Cu, Cu-Al203, Cu-Ag, Cu-Nb, Cu-St.St., Cu-Be.

Some possible super-conducting materials include: niobium-titanium; and ceramics.

Some possible fluids include: liquid lead, liquid lithium.

Some possible gases include: vaporized water, and Xenon.

A vacuum is also a possibility as is explained in the "No-Core" reactor.

As the large electromagnetic fields are generated over the conducting layer of the core, mechanical forces are exerted on the material of the conducting core itself. Electrical energy within the core is converted to heat as the electrons in the material are excited and collide with atoms. In order to withstand these mechanical forces and stresses, and to minimize heating of the conducting layer of the core, a conducting material that combines both mechanical strength and electrical conductivity is needed. However, it appears that these two requirements oppose each other. Mechanically strong materials appear to be poor conductors, and good conductors appear to be mechanically weak.

If copper, or some other similar conductor that could easily melt were used, then there must be an inner wall to protect the conductor from the heat of the fusion reaction, otherwise the conducting layer would melt. Thus, since the conducting layer will be prone to melting, it must be shielded internally by a non-conducting inner wall. The purpose of the inner wall is not necessarily to completely prevent the melting of the cores. For a commercially viable reactor, all that is needed, is to significantly delay the heating of the conducting layer.

A shield material similar to that used to protect the exterior of space craft and rockets—such as space shuttle's exterior—from high temperatures during reentry would be an ideal inner shield material. One of the shield materials used on NASA's Space Shuttles is made of a low-density, high-purity silica consisting of 99.8 % amorphous fiber insulation (fibers derived from common sand, 1 to 2 mils thick) that is made rigid by ceramic bonding. This tile is 90 percent void and 10 percent material. This material is used in 1 to 5 inch blocks on Space Shuttles and can withstand tremendous thermal shock. For example, experiments have been done where the material is transferred from an oven at 2300 degrees Fahrenheit to cold water without suffering damage.

For these reactor designs, a slurry of this silica material containing fibers mixed with water and a colloidal silica binder solution would be formed over metal hemispheres, partially heated to remove the bulk of the moisture, removed from the metal forms, and then sintered in high temperature ovens to form rigid hemispheres. The inner cores of these reactor designs would be made of this material by attaching two hemispheres with an overlapping lap-joint. This layer would protect the conducting sphere from a massive thermal shock.

A thermal expansion problem may exist for this inner silica-based thermal shield material. The solid hemispheres might not expand well, cracking when heated. If this is the case, a more complex—but still relatively simple—design of smaller tiles attached to a more flexible inner or outer wall may be required.

This silica type of shield material will work well if the temperature does not exceed about 2300°F. If the temperature of the inner wall will exceed 2300°F, then another layer inside of the silica layer would be needed. Such a layer could be made of Reinforced Carbon Carbon. RCC could withstand temperatures inside the core up to about 3000°F.

When the massive pulse of electromagnetic energy sweeps over the conducting layer of the core, forces within this layer will effectively try to implode the core. To prevent the implosion of the core, the layers within the conducting layer must be able to withstand very strong crushing forces. RCC is a material that can stand up well to these crushing forces. This is another good reason that an inner wall of RCC should be planned for.

RCC fabrication begins with a rayon cloth graphitized and impregnated with a phenolic resin. This impregnated cloth is laid up as a laminate and cured over a metal hemisphere in an autoclave. After being cured it is removed from the metal form, then the laminate is pyrolized to convert the resin to carbon. This material is then impregnated with furfural alcohol in a vacuum chamber, then cured and pyrolized again to convert the furfural alcohol to carbon. This process is repeated three or more times until the desired carbon-carbon properties are achieved. Such a layer can withstand temperatures up to 3000°F.

In a reactor design by the Lawrence Livermore National Laboratory, for a reactor with slightly larger inner dimensions—6.5 meter inner diameter versus this example that uses a 5 meter conducting wall diameter—called “Sombrero”, 400 MJ yield fusion fuel Holoraum targets were calculated to create a surface temperature at the inner wall of about 2100°C. If this inner wall temperature is correct—2100°C is equal to 3812°F—then another layer of material would be needed that can withstand higher temperatures, or larger diameter cores of approximately 10 meters in diameter would be needed, or targets with lower yields would be needed. Only tests will verify the temperature. It is possible that the Spherical Electromagnetic Confinement Fields (40) will slow the fusion burn and reduce the inner wall temperature.

If the temperature of the inner wall will exceed 3000°F, then another wall inside of the RCC wall should planned for. It could be made of Ultra High Temperature Ceramics. One such material is hafnium diboride silicon carbide which has been tested to temperatures of at least 5,000°F. There are other similar ceramics that could be used.

The primary material characteristics should be: the ability to withstand temperatures between 3000–5000°F; strength; the ability to withstand thermal shock without cracking; little or no conductivity; and ease of forming into rigid, spherical shapes. Therefore, since such materials already exist, temperatures at the inner wall of the core up to 5000°F could be designed for at this time.

The conducting wall of the core will confine elementary particles in the fusion plasma that have a charge. Neutral particles such as neutrinos and neutrons, in all likelihood, will not be sufficiently contained by the electromagnetic shield. Thus the inner wall must have some compound to stop neutrons. The element Boron has been found to be excellent at stopping neutrons and would be a suitable material for the inner wall of a fusion reactor. It has been considered in many other fusion reactor designs just for this purpose.

In these reactor designs, either the silica wall could be coated or impregnated with a layer of Boron, the inner RCC wall could be coated or impregnated with Boron, or if used, the innermost layer of Ultra High Temperature Ceramic could be coated or impregnated with Boron. Some Ultra High Temperature Ceramics contain Boron, thus eliminating this decision.

If Boron is to be impregnated into a RCC layer, to reduce costs, it might be best to create one inner layer of Boron RCC, and a second, thicker wall, just of RCC.

The fusion burn will also subject the inner wall to x-ray radiation. With the reactor designs described here that burn fusion pellets—hybrid inertial confinement designs—the inside of the core could be filled with approximately 0.5 torr of xenon gas. The purpose of this gas would be to absorb the x-ray radiation and re-radiate it over a longer time at longer wavelengths to help reduce the surface temperature and damage to the inner wall. If the density of the gas were greater, then it could cause the inertial confinement laser beams to break-down.

The primary goal of the conducting layer is to create smooth, harmonic, massive electromagnetic fields. It is not intended to with withstand the forces of the internal fusion explosion. The conducting layer would need reinforcement from the outside to withstand explosive mechanical forces from within. Another layer of material, external to the conducting layer, for purposes of reinforcement would be needed. In general it should be made of a non-conducting material or be essentially non conducting. Another layer of RCC would be ideal for this. RCC is thermally conductive, allowing heat to flow out of the conducting layer and thus improving passive or active cooling.

The materials of these core designs must be able to withstand mechanical stresses to within 90–95% of their yield strength for continuous operation. For pulsed operation, the strength of the materials may be exceeded for brief periods. The calculations of forces for all layers of the core material should be taken into account. For example, if a copper alloy is used for the conductive layer, even though the extreme heat involved may melt this layer at some point later in the process, the initial ductility of the metal should be considered in the calculations that determine if the core can withstand the internal fusion explosion.

To summarize, an initial reactor core could be designed as such:

1) An inner layer of non conducting material made up of an Ultra High Temperature Ceramic such as: hafnium diboride silicon carbide; or, Zirconium diboride composite; or, other related ceramic compounds. The exact thickness of this layer is unknown at this time due to the classified nature of these ceramics—they are now used to make nose-cones for missiles. The estimated required thickness is 1 inch. Preferably, the material will have a composition that includes some Boron to stop neutrons. (Most likely manufactured as two interlocking hemispheres.)

2) A second, essentially non-conducting layer, that is composed of material that can withstand high temperatures, thermal shock, compressive forces from without, explosive forces from within and can stop neutrons such as a 1 inch wall composed of: RCC impregnated with Boron. (Most likely manufactured as two interlocking hemispheres. Possibly manufactured as one piece around the inner layer of Ultra High Temperature Ceramics.)

3) A third layer, essentially non-conducting, that is composed of material that can withstand high temperatures, thermal shock, compressive forces from without, explosive forces from within, such as a layer composed of 1 inch of RCC. (Most likely manufactured as one piece around the inner layers of Ultra High Temperature Ceramics and Boron impregnated RCC.)

4) A fourth layer, essentially non-conducting, that is composed of a material that can withstand massive thermal shocks and lessen the thermal shock to the next outer layer such as a layer composed of 5 inches of silica (99.8-percent amorphous fiber) made rigid by ceramic bonding. (Most likely manufactured as two interlocking hemispheres. Possibly manufactured as multiple interlocking tiles attached to the outside of the inner 3 layers.)

5) A fifth layer, essentially conductive, that is composed of a material with very low resistance, is economical, that can be formed into spherical shells of the size needed, and can withstand the internal forces, Coulombic and Hall, created by massive electromagnetic fields such as a layer composed of Cu-Nb, 6 inches thick. (Most likely manufactured as two interlocking hemispheres that are heat-shrunk to each other with the lap-joint situated at the eventual equator of the electromagnetic field.)

6) A sixth layer, essentially non-conducting, that is composed of material that can withstand high temperatures, thermal shock, explosive forces from within such as a layer composed of 2 inches of RCC. (Most likely manufactured as two interlocking hemispheres.)

7) A seventh layer, essentially non-conducting, that is composed of material that can withstand high temperatures, thermal shock, explosive forces from within such as a layer composed of 2 inches of RCC. (Most likely manufactured as two interlocking hemispheres with the joint oriented 90° from the hemispheres in the sixth layer.)

Total wall thickness approximately 18 inches of which 1/3—i.e., 6 inches—is conductive.

An example of this core wall, with possible sample materials, is shown in the following graphic.

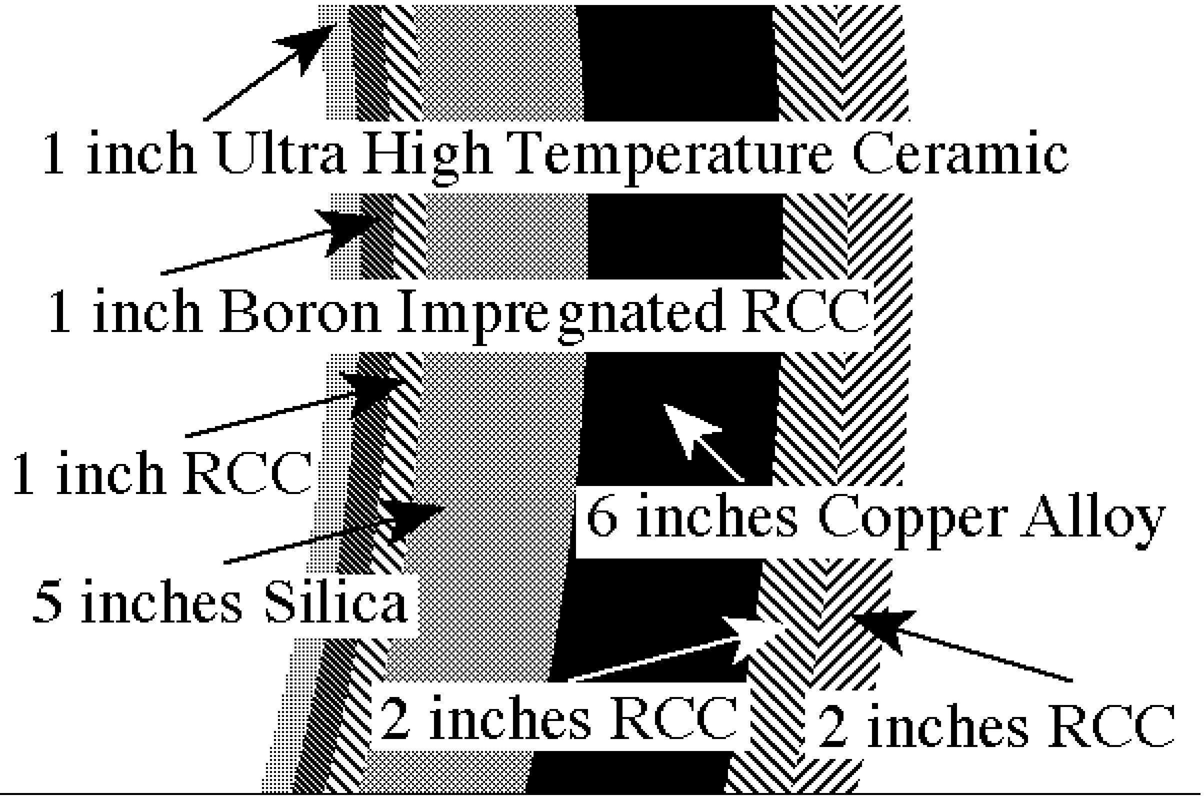

Figure 69

To compensate for differences in thermal expansion, the inner and outer sides of individual layers may be designed with a grid of grooves—e.g., the outer side of layer 4 and the inner side of layer 6. Using a copper alloy, as in this example, the inner surface of the conductive layer will thermally expand more than the external surface of this layer. This is due to the greater temperatures experienced on the inner layer due to the fusion burn. The internal side of this layer may even melt. To compensate for this volume change, the outside of layer 4, of Silica in this example, and the inner side of the 6th layer, RCC in this example, could be composed of voids created by a cross-hatched grid of grooves. In this example, as the conductive layer expands, it would expand into the voids created by these grids of grooves. These voids are illustrated in Figure 70.

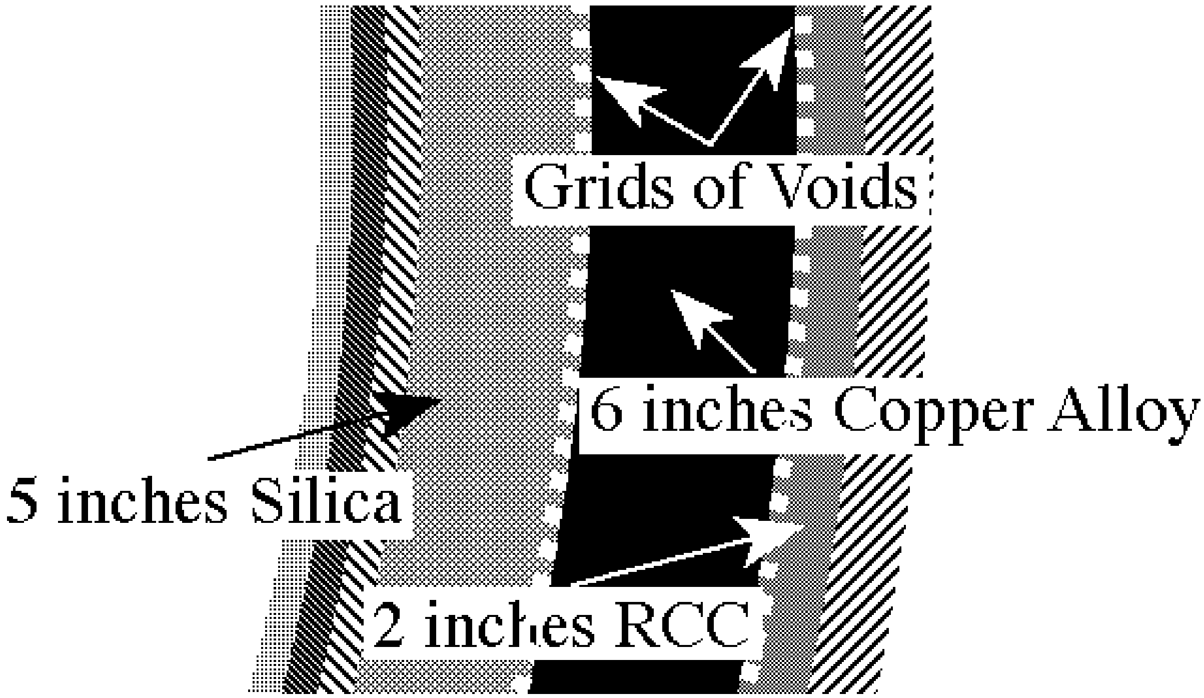

Figure 70

The voids would need to have a vacuum at the time of the fusion reaction. If they were fill with a gas, the gas would expand during heating of the core and potentially rupture the core. Small channels through layers 1, 2, and 3 to the central core could be used to relieve such pressure. In most of these nuclear fusion reactors, the core will either be under a vacuum, or will be filled with a low pressure gas such as Xenon. Periodic test of the cores for melting will be required. If the conductive layer melts into the voids after a number of fusion burns, then the geometry required for harmonic containment fields will be lost. The melted core can be replaced with a new core, and the used core can be refurbished.

Expansion of the fourth layer would be easy to plan for since it is primarily a thermal barrier and not key in preventing implosion or explosion of the core. This layer could be designed, if needed, with overlapping panels created with a tongue-and-groove type joint. The panels could simply slide together for a tighter fit to deal with thermal expansion.

It is not critical that the fourth layer be made of a solid material. It has been discovered that small ceramic spheres that have a hole drilled in them are not only excellent thermal barriers, but also excellent sound barriers. It should be expected that the internal fusion explosion should create, not only a massive thermal shock, but also a significant sound shock. Such shocks repeatedly reverberating through the core could cause core failure. Therefore, layer four might simply start out as a hollow void, that is filled with sound-deadening, thermally resistant, small, ceramic spheres. Currently, these spheres are rated to a temperature of about 2,000°F. But with more expensive, Ultra High Temperature Ceramics, temperatures of up to 5,000°F should be possible and still retain the shock dampening characteristics. An example of this type of wall—with a thicker layer 3—might look like:

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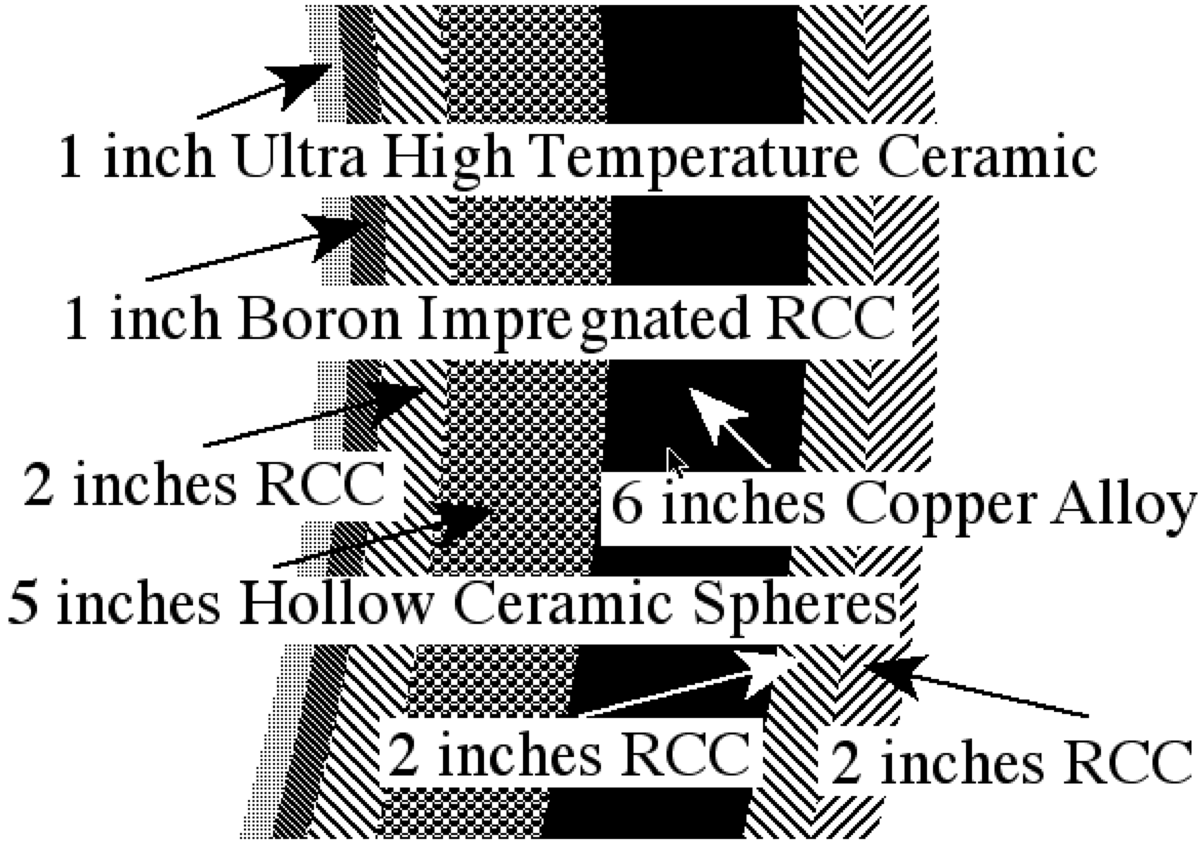

Figure 71

To summarize this wall design:

1) An inner layer of non conducting material made up of an Ultra High Temperature Ceramic such as: hafnium diboride silicon carbide; or, Zirconium diboride composite; or, other Ultra High Temperature Ceramic compounds. The exact thickness of this layer is unknown at this time due to the classified nature of these ceramics. (Their material composition is classified because they are now used to make nose-cones for missiles.) The estimated required thickness for this layer is 1 inch. Preferably, the material will have a composition that includes some Boron to help stop neutrons. (Most likely manufactured as two interlocking hemispheres.)

2) A second, essentially non-conducting layer, that is composed of material that can withstand high temperatures, thermal shock, compressive forces from without, explosive forces from within, and can stop neutrons, such as, a 1 inch wall composed of RCC impregnated with Boron. (Most likely manufactured as two interlocking hemispheres. Possibly manufactured as one piece around the inner layer of Ultra High Temperature Ceramics.)

3) A third layer, essentially non-conducting, that is composed of material that can withstand high temperatures, thermal shock, compressive forces from without, explosive forces from within, such as a layer composed of 2 inches of RCC. (Most likely manufactured as one piece around the inner layers of Ultra High Temperature Ceramics and Boron impregnated RCC.)

4) A fourth layer, essentially non-conducting, that is composed of a material that can withstand massive thermal and sound shocks and lessen the thermal shock to the next outer layer, such as a layer composed of 5 inches of small hollow spheres made up of High Temperature, or Ultra High Temperature Ceramics. (Most likely manufactured as small—1/16–1/2 inch spheres with a small hole drilled or formed in them. The spheres would be poured into the void between layer 3 and layer 5 through temporary openings in layer 5. The voids between the spheres would be pumped to a vacuum or be allowed to fill with a slight pressure of Xenon gas as an added measure to absorb X-ray radiation.)

5) A fifth layer, essentially conductive, that is composed of a material with very low resistance, is economical, that can be formed into spherical shells of the size needed, and can withstand the internal forces, Coulombic and Hall, created by massive electromagnetic fields such as a layer composed of Cu-Nb, 6 inches thick. (Most likely manufactured as two interlocking hemispheres that are heat-shrunk to each other with the lap joint situated at the eventual equator of the electromagnetic field.)

6) A sixth layer, essentially non-conducting, that is composed of material that can withstand high temperatures, thermal shock, explosive forces from within such as a layer composed of 2 inches of RCC. (Most likely manufactured as two interlocking hemispheres.)

7) A seventh layer, essentially non-conducting, that is composed of material that can withstand high temperatures, thermal shock, explosive forces from within such as a layer composed of 2 inches of RCC. (Most likely manufactured as two interlocking hemispheres with the joint oriented 90° from the hemispheres in the sixth layer.)

Having the fourth layer filled with small ceramic spheres may have advantages. But under the unusual circumstances being described here, there are no guidelines to be sure by. Only experiment will discover if this method is superior to using a more traditional thermal barrier such as silica.

It is key that the conductive layer—a copper alloy in this case—be magnitudes more conductive than the non-conductive, or essentially non-conductive layers. It is believed this would exclude metals, plasmas and conductive gases for materials in layers 1, 2, 3, 4, 6 and 7. However, the Spherical Electromagnetic Confinement Fields (40) may inhibit the burn so efficiently that the conductive layer may be used for the inner layer. Tests may prove that only a thin inner layer of material may be required to protect the conductive layer.

If conductive materials were used for these layers, then the main conductive layer, layer 5 in this example, would induce dissipative, eddy-like currents in the other conductive layers, increasing Coulombic and Hall forces, increasing thermal loss, and decreasing efficiency. In addition, if internal layers were made of conducting material—layers 1, 2, 3, and 4 in this example—then it is possible that these layers might shield the fusion reaction from the Poynting vector energy transport, and from the confining electromagnetic fields. A solid internal conducting layer—for any one of layers 1, 2, 3, or 4 in this example—might be the worst possible choice because it could reduce or eliminate the MHD effect altogether.

While materials for the inner layers should be chosen for their essential characteristics—non-conductivity, resistant to high temperatures and thermal shock, resistance to high energy particles and photons, ability to absorb neutrons, and high strength—they should also be tested ahead of time to the transport energy induced in the conductive layer. It is quite possible that the massive, central-pointing energy-transport, expressed in terms of the Poynting vector, could still shatter these inner layers. While the inner layers may be non conductive, or essentially non-conductive—as in Boron impregnated silicas, carbides, ceramics or RCC structures—when compared to the conductive layer, the center pointing transport energy may interact at the elementary particle level, creating massive forces against charged elementary particles—such as electrons, and atomic nuclei within the inner layers. However, even if the induced central pointing energy creates forces at the elementary particle level, these inner core materials may still be able to withstand the shocks without absorbing too much energy for these reasons:

1) The inner core layers are directly next to the conducting layer
2) The diameter of the core is large compared to the wall thickness
3) The imploding energy per square inch at the inner wall will be small compared to at the focal point of the core
4) The materials are strong by their nature
5) Also it is believed, the characteristic wavelength of the imploding energy will be large, roughly equal to the diameter of the conducting layer of the core. This long wavelength will take time to excite charged elementary particles within the inner layers of the core wall. By the time this happens, the exploding forces will be counteracting the imploding forces.

All core designs, except the “No-Core” core design, will face tremendous thermal, compressive, and explosive forces. It should be expected that early core designs may: crack, melt, crush, shatter, be pierced by instabilities, and possibly catastrophically explode. The Core Shields and Reactor Room Walls should be designed for these possibilities. Again, the overall reactor design should allow for the cores to be quickly and efficiently replaced.

Misc. Induction Coils Notes

Two key issues are:

- How can massive electromagnetic pulses be induced in the circuit of conducting spheres?
- How can excess electromagnetic energy be extracted from the circuit for use in the power grid?

The circuit could be directly connected to the power grid. However, this would not be practical since the massive pulses would easily burn out many components in power grids.

Instead, induction coils and capacitors should be used to act as an intermediary between the conducting circuit and the electrical power grid.

There are hundreds if not thousands of possible combinations of arrangements for the coils in such reactors. Possible coil arrangements include:

1) If a solid “wire-type” conducting circuit is used, then one large coil could be wrapped around the circuit. For this type of circuit to work, the coil must induce an electromagnetic pulse through the conductor with a wavelength much longer than the diameter of the conductor, otherwise nodes in the waves will vaporize the conductor and explode it as explained in the section on the exploding wire phenomena.

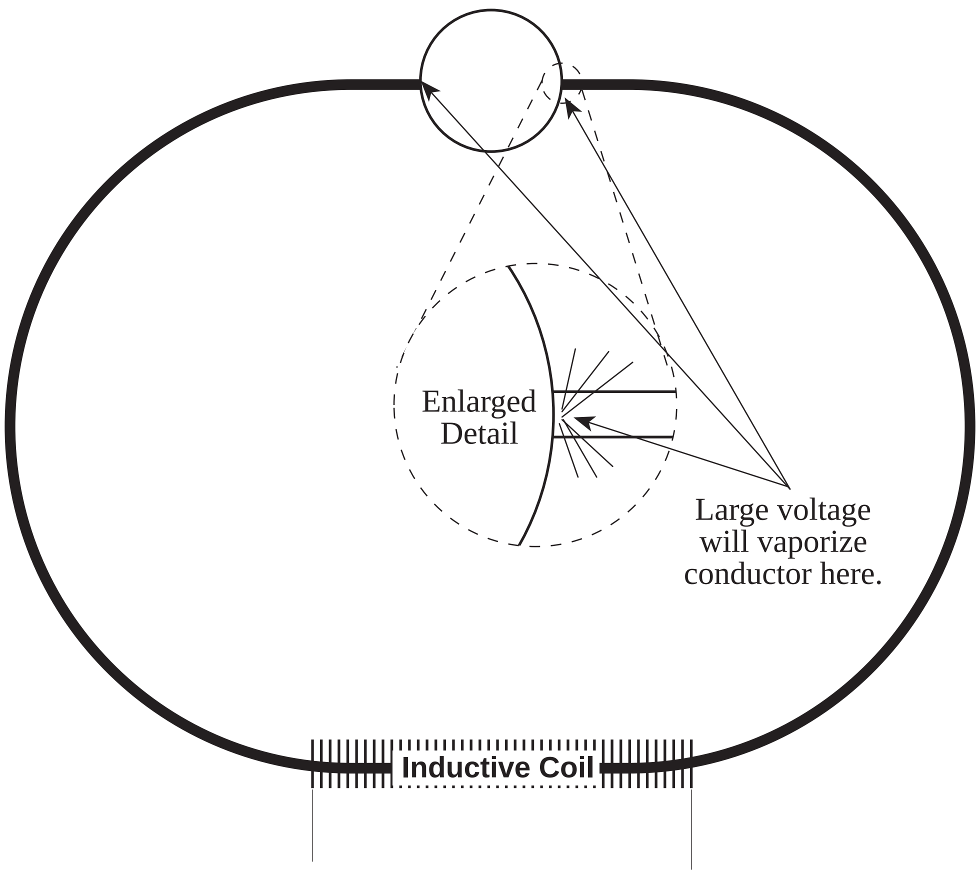

Figure 72

However, even if it were possible to induce very long wavelength pulses using the inductive coil, the wavelength of the MHD effect in the core will be equal to diameter of the core, and if powerful enough, will explode the conductor at the anodes and cathodes as is shown in the enlarged detail of Figure 72. It appears inevitable that too much energy will be focused on these small points to prevent the conducting wire from exploding.

2) A simple attempt at solving this problem might be to use a thicker conductor:

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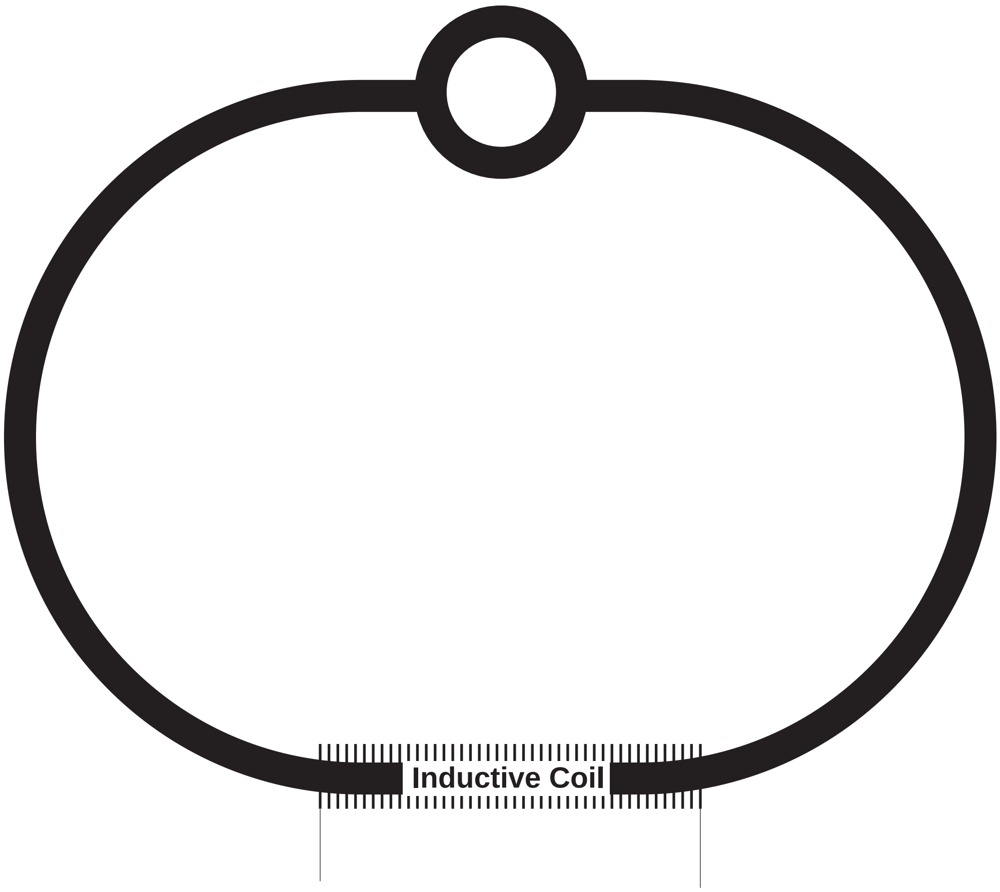

Figure 73

There are many problems with this approach. First, the massive energy will still be focused at the anodes and cathodes at the confinement wall. The type of focused energy that would occur reminds me of how the hollowed charge cone in a military anti-armor round focuses energy and pierces the toughest armor. Second, the larger the conductor, the less of a change in direction will occur at the confinement wall, and the smaller will be the induced confining fields. Third, with thicker conductors, there will be more avenues for currents to "cut corners" and creating eddy currents. There will be increased numbers of possible harmonic waves around the conductor with corresponding increased numbers of nodes that will vaporize and explode the conductor.

3) One possible approach is to create a conductor that is exactly as thick as the containment core. However, there would be no induction of confinement fields. A fusion explosion in the core might be confined radially but not axially. It would explode in opposite directions—straight down the conductor in both directions. Besides, the Reactor Core will still create waves of electromagnetic energy that will focus at nodes and explode the conductor.

4) To focus the energy, which would still allow the induction of the intense containment fields over the surface of the core, the cathode and anode could be capped with a hemispherical dome as shown in Figure 74.

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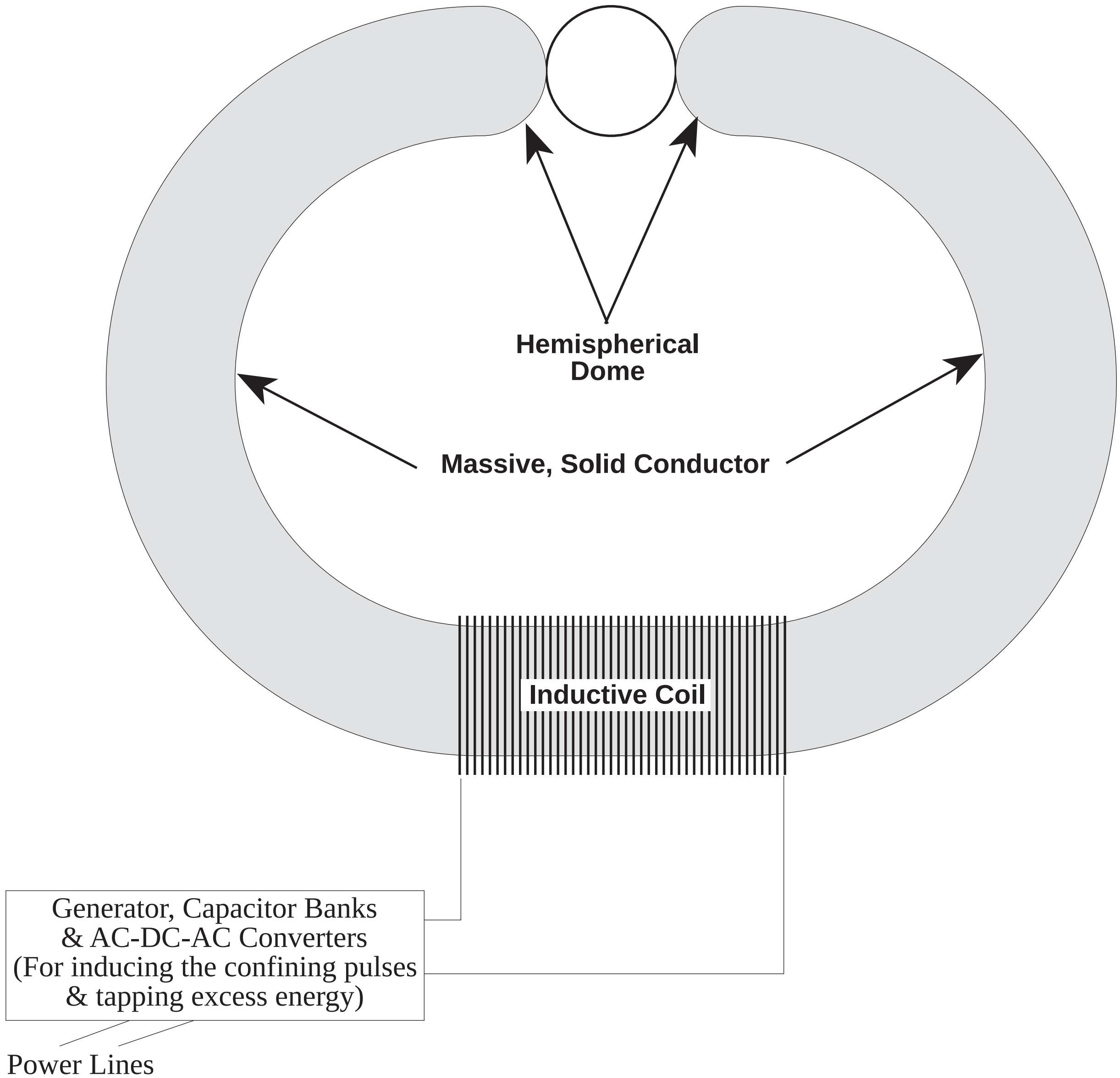

Figure 74

With enough active cooling of the conductor / superconductor, this is a possible configuration that might work. However, the conducting “wire” would be extremely massive and expensive. The overall length of the conductor would need to be extremely precise—a multiple of the primary wavelength—to focus the energy. But when heated, the harmonics would be lost since the conductor length would not be a multiple of the primary wavelength. Manufacturing the conductor with the incorrect length would be very difficult to correct for. The exploding wire danger still exists at nodes of the primary electromagnetic wave. Finally, if damage did occur to either the conductor or coil, in this design they would be extremely difficult to repair or replace.

A two core version of this design is shown in Figure 75 on page 111.

5) Another possible arrangement would be to place numerous coils in series around the conductor in an attempt to create electromagnetic pulses which have wavelengths equal to the diameter of the conductor and core, and then to try to actively cool the conductor to prevent it from overheating and exploding. I do not think this technique will be feasible. It would certainly be dangerous.

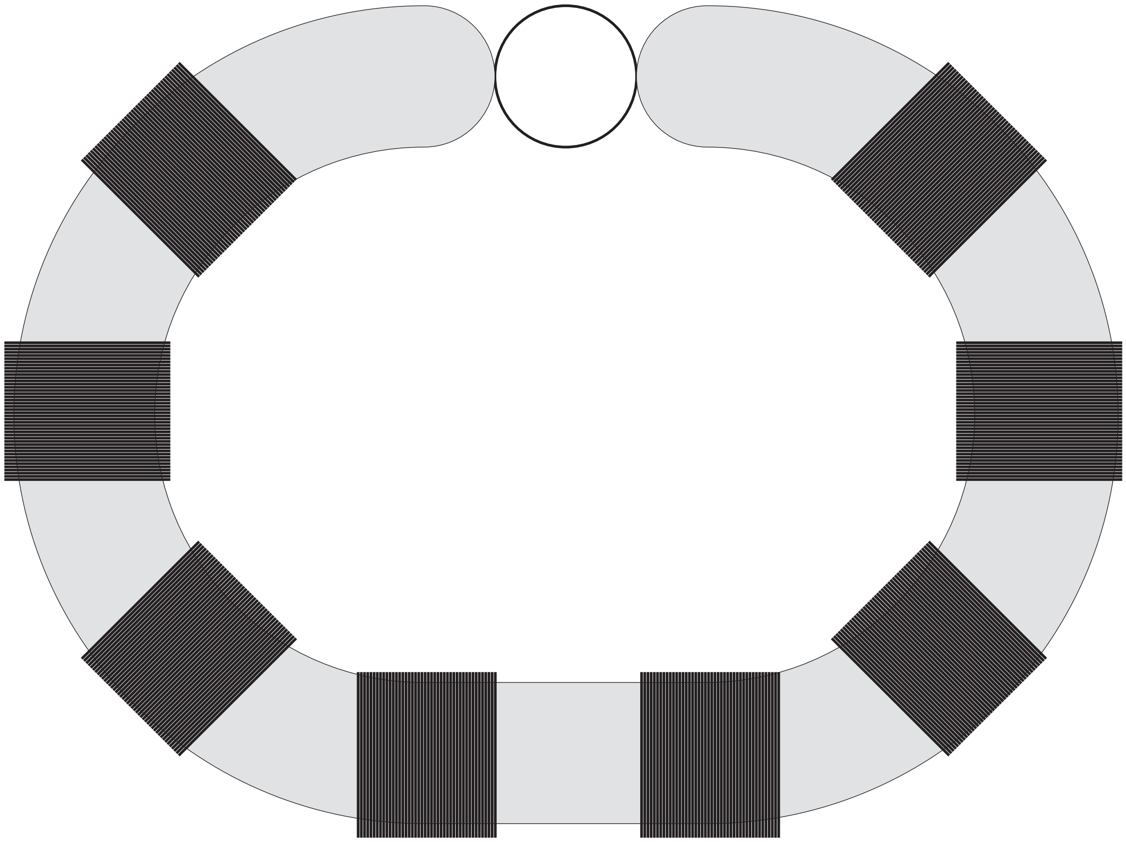

Figure 76

The main advantage of this design is not for it practicality, but that it emphasizes the importance of analyzing the primary electromagnetic wave: its wavelength, its shape, the locations of nodes, the locations of eddy currents, the locations of intense temperatures, etc.

6) This leads to the approach, indicated earlier, of using spherical conducting shells.

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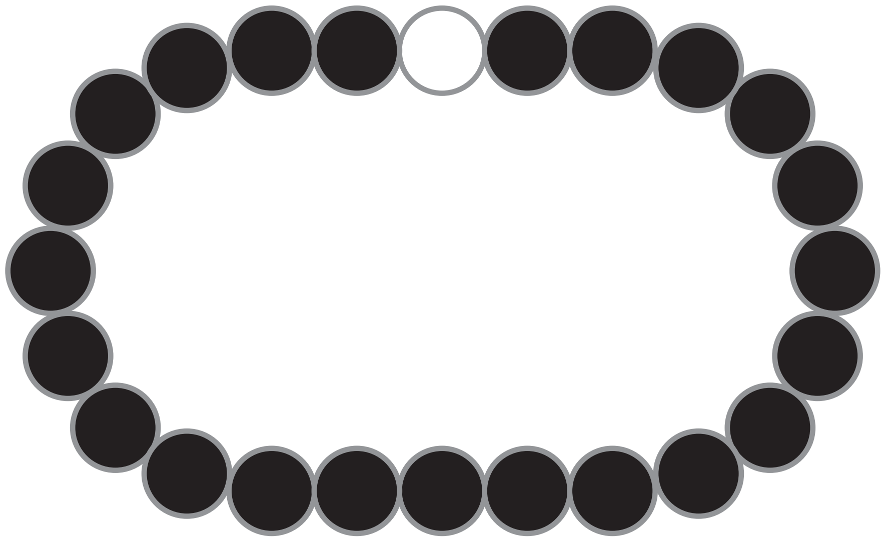

Figure 77

With this approach, the emphasis is not on inducing a current around the circuit. Large-scale flow of electrons around the circuit is not really desired—rather, local, short-distanced but very fast flow of electrons is desired. The emphasis of this approach is creating massive standing, spherical waves of electromagnetic fields that result in a massive voltage across the containment sphere and massive containing fields—i.e., high voltage, high resistance, low current. (Or, massive magnetic differentials if the reactor is operating in the Magnetic Mode.)

7) Another possible concept for the electrical conducting circuit—the main concept that is emphasized in this document—would be to create an electrical circuit using conducting spheres as previously described, laid out in an oval track, and to place coils around one or both of the hemispheres of one or more of the conducting spheres. The coils will be used to induce the electromagnetic pulses and to tap excess energy.

Using this overall concept, there are hundreds of possible wiring schemes where the coils are connected in series, in parallel, on separate circuits, or in combinations of these.

This overall concept has many common advantages. They are in stark contrast to the disadvantages of the circuit described in 3 above. Advantages include:

- The conducting spheres would be relatively cheap and easy to manufacture.
- It would not be a problem to lengthen or shorten the circuit—new or old spheres could be added or removed.
- While the harmonics of the heated circuit would change, it would change uniformly over the entire circuit because, by actively monitoring and equalizing coolant temperatures, the amount expanding and contracting of the spheres could be controlled.
- While localized eddy-currents from secondary currents still could melt or explode small areas of spheres, the danger of the exploding wire phenomena

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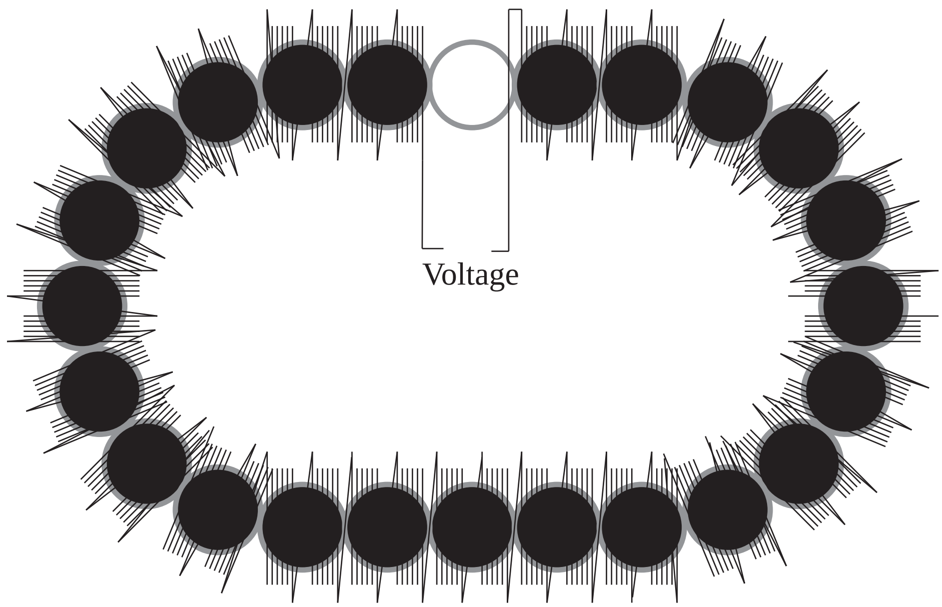
would be minimized since the main electromagnetic wave would not explode huge sections of a conductor.

- Finally, the modular design would allow easy repair or replacement of conductors or coils.

Wiring Pattern for Coils

How the coils are wired to each other around the conducting circuit is a key consideration. Each coil could be treated as a separate circuit. The coils could be wired in parallel, or in series. Or they could be wired in various combinations.

Examples of these reactor circuits include:



Coils Wired in Series
Figure 78

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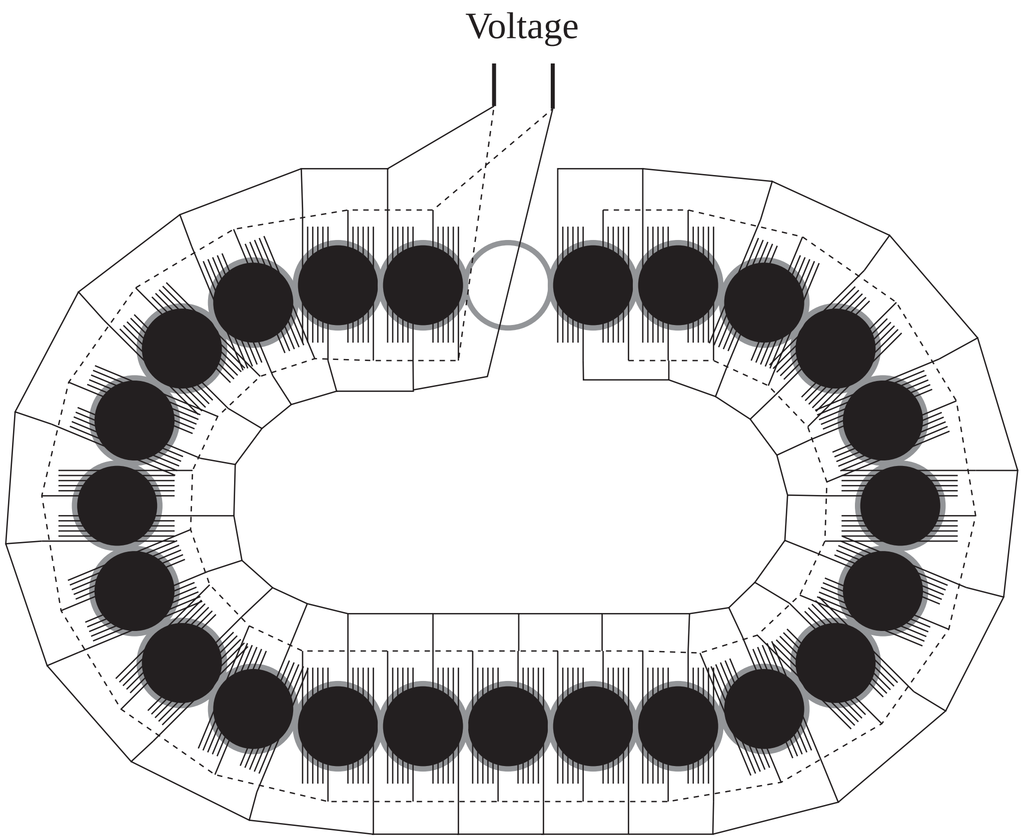

Coils Wired in Parallel
Figure 79

Graphic not yet completed
Coils Wired as Separate Circuits

Graphic not yet completed
Coils Wired in Combinations of Series, Parallel, and Separate Circuits

No particular example appears as the clear winner. Each example could work. However, it seems that simplest circuit would have advantages for maintaining harmonic current flows and lower costs.

One technique would be to use Rowland Ring coils placed around an electrical circuit composed of conducting spheres, as previously described. A coil could be placed at one point along the electrical circuit, or multiple coils could be placed around one or both of the hemispheres of one or more of the conducting spheres. Again, there are hundreds of possible wiring schemes where the coils are connected in series, in parallel, on separate circuits, or in combinations of these. The Rowland Ring coils may or may not have a soft iron core. Examples include:

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Graphic not yet completed
Wired in series

Graphic not yet completed
Wired in parallel

Graphic not yet completed
Wired as separate circuit

Graphic not yet completed
Wired using combination of above

Each example could work. However, it seems that simplest circuit would have advantages for maintaining harmonic current flows and lower costs. I prefer the coils in series because their inductance will add thus creating a powerful voltage across the core that would be very difficult for the MHD effect to reverse direction.

Power Source

Depending on the reactor dimensions and materials, and depending on the designed yield for the D-T plasma or pellet, there would be a characteristic electric voltage or magnetic differential required across the conducting sphere just prior to the ignition of the fusion process. Obviously, an external power source is needed for providing power to the coils that provide the electromagnetic pulse that sweeps over the conducting layer of the core in order to provide initial confinement and ignition—in the case of a purely inductive compressive technique—and the confining fields for the MHD effect. Also, in the case of using inertial techniques for initial ignition of a D-T pellet, a power source would be needed for the lasers, or other beam devices.

Possible power sources could include:

1) Coal powered AC generators
2) Hydro powered AC generators
3) Nuclear fission powered AC generators
4) Coal powered DC generators
5) Hydro powered DC generators

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6) Nuclear fission powered DC generators

7) Banks of capacitors charged by any of the above devices or: the commercial power grid; liquid fuel generators; solar panels; geothermal energy capture devices; or a variety of other energy sources.

For the purposes of this example, a coal powered DC generator will be used.

Removing power form the conducting circuit

Again, depending on the reactor dimensions and materials, and depending on the designed yield for the D-T plasma or pellet, there would be a characteristic voltage required across the conducting sphere just prior to the ignition of the fusion process.

Once the fusion process starts, the MHD process will induce a higher electric voltage or magnetic differential across the reactor core. All that is needed is the electrical circuitry to monitor this electric voltage or magnetic differential, and to use the excess to induce current in the coils and to move the current to the power grid.

One possible technique for tapping the correct amount of energy from the circuit might be to attach a set number of coils to the circuit and have about 60% of the coils maintaining the required containing voltage and about 40% of the coils tapping off excess voltage. For example, in an early design of one type of reactor, it had:

- 2 reactor cores—it is a 2 cycle engine
- 30 conducting spheres—15 per each half of an oval
- 48 total coils
- 32 coils for creating and maintaining the confining voltage—16 per each half of the oval
- 16 coils for tapping off excess voltage—induced by the MHD effect from the fusion reaction

Since 66% of the coils are for maintain voltage, and 33% of the coils are designed for tapping off excess voltage, the yield of the fusion burn should not exceed 29% of the total capacity of the circuit. This value of 29% would allow up to 2 of the tap coils to burn out and still be able to draw off the MHD energy.

This example gives insight on the best wiring techniques. What should happen if coils burn out? If one containment coil burns out, then the whole containment circuit should shut down. This would allow the fusion plasma to expand, cool, and stop the fusion burn. However, if a tap coil burns out, then an opposite coil in the circuit should go down to keep a symmetric voltage. But to insure the ability of the circuit to keep drawing off excess MHD power, the tapping coils should not all be wired in series. If all of the tapping coils went down, the MHD fields might be powerful enough to flip the polarity of the entire conducting circuit—with the resulting danger of the rapid voltage flip-flop.

DC versus AC

There are possible designs—that use 1 or more cores—that would, for these types of fusion reactors, create DC currents. In such cases an AC inverter would be required. There are possible designs—that use 2 or more cores—that would create AC currents. In such cases, if the frequency is appropriate, the current could go directly to the power grid. If the frequency is not correct, then additional circuitry would be required for changing the frequency.

Major Nuclear Fusion Reactor Types

To recap: the major types of nuclear fusion reactors in these designs all use a spherically shaped electromagnetic field for the purposes of confining the fusion burn and for MHD conversion of energy, and use spherical conducting spheres to create a harmonic pulse that sweeps over the core. Within these overall parameters, there are many possible nuclear reactor design variations possible, using various combinations of components available. Some of the variables in the reactor design include:

1) Fusion Fuel: D-T, D-D, and D-He, and other elements
2) Fusion Fuel Type: Plasma, or Pellet
3) Reactor Core confinement field alignment: Magnetic Mode, Electrical Mode
4) Ignition technique: electromagnetic induction; laser beam inertial; ion beam inertial, implosion cage
5) Reactor confinement material: solid conductor, solid superconductor, plasma, liquid, gas, “No Core”
6) Various reactor core wall material choices, or “No-Core” design
7) Confinement circuit shape: oval, circular, straight
8) Confinement coil type: normal cylindrical coil; normal concentric cylindrical coils; normal (single) helical coils; normal (multiple) parallel helical coils; Rowland Ring coils with soft iron cores; Rowland Ring coils without soft iron cores; individual hemispherical coils; grouped hemispherical coils
9) Conducting Sphere type: hollow with vacuum; solid filled
10) Conducting Sphere fill material
11) AC or DC output design
12) One, two, three, four, or more cores
13) Burn length: pulsed, quasi-continuous, or continuous operation
14) Cooling technique: pulsed, quasi-continuous, or continuous operation

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Some major design choices

One Core, Plasma fuel designs:

1) One core, ignition by induced compression, plasma fuel (D-D, D-He, D-T), confinement by circuit using spherical conducting coils arranged in a circular or oval pattern, confinement fields induced by Rowland Ring coils **with** a soft iron core, pulsed or quasi-continuous DC operation
2) One core, ignition by induced compression, plasma fuel (D-D, D-He, D-T), confinement by circuit using spherical conducting coils arranged in a circular or oval pattern, confinement fields induced by Rowland Ring coils **without** a soft iron core, pulsed or quasi-continuous DC operation
3) One core, ignition by induced compression, plasma fuel (D-D, D-He, D-T), confinement by circuit using spherical conducting coils arranged in a circular or oval pattern, confinement fields induced by **traditional coils,** pulsed or quasi-continuous DC operation
4) One core, ignition by induced compression, plasma fuel (D-D, D-He, D-T), confinement by circuit using spherical conducting coils arranged in a circular or oval pattern, confinement fields induced by **hemispheric coils,** pulsed, quasi-continuous, or continuous DC operation

Two or more Core, Plasma fuel designs:

5) Two or more cores, ignition by induced compression, plasma fuel (D-D, D-He, D-T), confinement by circuit using spherical conducting coils arranged in a circular or oval pattern, confinement fields induced by Rowland Ring coils **with** a soft iron core, pulsed or quasi-continuous AC operation
6) Two or more cores, ignition by induced compression, plasma fuel (D-D, D-He, D-T), confinement by circuit using spherical conducting coils arranged in a circular or oval pattern, confinement fields induced by Rowland Ring coils **without** a soft iron core, pulsed or quasi-continuous AC operation
7) Two or more cores, ignition by induced compression, plasma fuel (D-D, D-He, D-T), confinement by circuit using spherical conducting coils arranged in a circular or oval pattern, confinement fields induced by **traditional coils**, pulsed or quasi-continuous AC operation
8) Two or more cores, ignition by induced compression, plasma fuel (D-D, D-He, D-T), confinement by circuit using spherical conducting coils arranged in a circular or oval pattern, confinement fields induced by **hemispheric coils,** pulsed or quasi-continuous AC operation

One Core, Pellet fuel designs:

9) One core, ignition by inertial beam technique, pellet fuel (D-D, D-He, D-T), confinement by circuit using spherical conducting coils arranged in a circular or

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oval pattern, confinement fields induced by Rowland Ring coils **with** a soft iron core, pulsed DC operation

10) One core, ignition by inertial beam technique, pellet fuel (D-D, D-He, D-T), confinement by circuit using spherical conducting coils arranged in a circular or oval pattern, confinement fields induced by Rowland Ring coils **without** a soft iron core, pulsed DC operation

11) One core, ignition by inertial beam technique, pellet fuel (D-D, D-He, D-T), confinement by circuit using spherical conducting coils arranged in a circular or oval pattern, confinement fields induced by **traditional coils**, pulsed DC operation

12) One core, ignition by inertial beam technique, pellet fuel (D-D, D-He, D-T), confinement by circuit using spherical conducting coils arranged in a circular or oval pattern, confinement fields induced by **hemispheric coils**, pulsed DC operation

Two or more Cores, Pellet fuel designs:

13) Two or more cores, ignition by inertial beam technique, pellet fuel (D-D, D-He, D-T), confinement by circuit using spherical conducting coils arranged in a circular or oval pattern, confinement fields induced by Rowland Ring coils **with** a soft iron core, pulsed AC operation

14) Two or more cores, ignition by inertial beam technique, pellet fuel (D-D, D-He, D-T), confinement by circuit using spherical conducting coils arranged in a circular or oval pattern, confinement fields induced by Rowland Ring coils **without** a soft iron core, pulsed AC operation

15) Two or more cores, ignition by inertial beam technique, pellet fuel (D-D, D-He, D-T), confinement by circuit using spherical conducting coils arranged in a circular or oval pattern, confinement fields induced by **traditional coils**, pulsed AC operation

16) Two or more cores, ignition by inertial beam technique, pellet fuel (D-D, D-He, D-T), confinement by circuit using spherical conducting coils arranged in a circular or oval pattern, confinement fields induced by **hemispheric coils**, pulsed AC operation

1 No-Core core Plasma fuel designs in Electric Mode:

17) 1 No-Core core, plasma fuel gradually added to chamber by injection, ignition by induced compression, continuous voltage provided by circuit using spherical conducting coils arranged in a circular or oval pattern, confinement field voltage provided by Rowland Ring coils with soft iron core, continuous DC operation.

18) 1 No-Core core, plasma fuel gradually added to chamber by injection, ignition by induced compression, continuous voltage provided by circuit using spherical conducting coils arranged in a circular or oval pattern, confinement field voltage provided by Rowland Ring coils without soft iron core, continuous DC operation.

19) 1 No-Core core, plasma fuel gradually added to chamber by injection, ignition by induced compression, continuous voltage provided by circuit using spherical conducting coils arranged in a circular or oval pattern, confinement field voltage provided by traditional coils, continuous DC operation.

1 No-Core core Plasma fuel designs in Magnetic Mode:

20) 1 No-Core core, plasma fuel gradually added to chamber by injection, ignition by induced compression, continuous magnetic differential provided by circuit using spherical conducting coils arranged in a circular or oval pattern, confinement field voltage provided by traditional coils, continuous DC operation.

21) 1 No-Core core, plasma fuel gradually added to chamber by injection, ignition by induced compression, continuous magnetic differential provided by circuit using spherical conducting coils arranged in a circular or oval pattern, confinement field voltage provided by hemispheric coils, continuous DC operation.

2 No-Core cores Plasma fuel designs in Magnetic Mode:

22) 2 No-Core cores, plasma fuel gradually added to chambers by injection, ignition by induced compression, continuous magnetic differential provided by circuit using spherical conducting coils arranged in a circular or oval pattern, confinement field voltage provided by traditional coils, continuous AC operation.

23) 2 No-Core cores, plasma fuel gradually added to chambers by injection, ignition by induced compression, continuous magnetic differential provided by circuit using spherical conducting coils arranged in a circular or oval pattern, confinement field voltage provided by hemispheric coils, continuous AC operation.

1 No-Core core Plasma fuel Straight-Line designs:

24) 1 No-Core core, plasma fuel gradually added to chamber by injection, ignition by induced compression, continuous magnetic differential provided by circuit using spherical conducting coils arranged in a straight-line pattern, confinement field voltage provided by traditional coils, continuous DC operation.

25) 1 No-Core core, plasma fuel gradually added to chamber by injection, ignition by induced compression, continuous magnetic differential provided by circuit using spherical conducting coils arranged in a straight-line pattern, confinement field voltage provided by hemispheric coils, continuous DC operation.

I believe that the best design, for short-term testing and production, is reactor design 12 using D-T fusion fuel pellets and laser inertial beams—as shown in the preferred embodiment. There currently is a facility being built called the National Ignition Facility. The confinement circuit described here could, potentially be added to that facility. Or, a similar facility, using the same type of laser inertial confinement could be built, but with the added confinement circuit. The benefits of this design are: the simplicity of one core; the lower magnetic fields required due to inertial ignition techniques; and the smooth harmonics of the Hemispheric Coils.

In the mid-term, I believe design number 8 with: 2 cores; using D-D plasma fuel; using hemispheric coils; and optimized for 60 MHz pulsed (AC) operation would be best. The benefits of this design are: efficient use of one reactor core's MHD fields for creating the other reactor core's confinement fields (like a two cylinder gasoline engine); quasi-continuous operation (i.e., requiring periodic replacement of cores and other components) using injected plasma; and optimization for 60 MHz AC power for direct commercial electrical grid utilization.

In the long range, I believe design number 23 using 2 cores based on the adjustable wavelength “No-Core” design may be best. This design has many advantages: the ability to operate almost nonstop since there are no cores to wear out; the magnetic circuit does not entail large-scale movements of electrons that could burn out conducting spheres; the hemispheric coils should provide smooth confining fields; the conducting spheres and hemispheric coils could be continuously cooled; the use of pulse injected D-D plasma fuel into the confining fields allows the central burning mini-stars to continuously burn; the mini-stars would pulse with opposite beats (i.e., as one star expands, inducing a MHD field, this induced MHD field will induce confining fields that compress the other star, then the cycle reverses); and the induced current that is tapped off will be AC.. And finally, the wavelength of the core area can be adjusted to take into account thermal heating and cooling. All that would be needed would be periodic replacement of conducting spheres; shield materials; miscellaneous electrical components, and cooling system components.

Summary of Invention

The primary of goal of the preferred embodiment of these designs is to create commercial electric energy using the nuclear fusion process of converting the mass of light elements into electrical energy. I believe the key to successfully doing this, in an economical manner, is to place the fusion burn inside a spherical electromagnetic containment field. By doing so, this external spherical electromagnetic field provides many benefits: it controls and contains the physical location of the fusion burn; it inhibits instabilities; it uses instabilities in a MHD fashion to extract electrical energy; it lengthens the burn; it allows a more controlled release of energy rather than an explosive release of energy; and it can be used to ignite the fuel. A secondary goal of some of these reactor designs is to produce diamond crystals. The key to creating and maintaining the spherical electromagnetic containment field is the use of spherical reactor cores and conductors. A key in creating harmonic fields is the careful design of electromagnetic induction coils that can be used to transfer energy to and from the containment circuit. In particular, the new and unique design of hemispheric coils promises to provide very clean harmonics at a relatively low cost. While there are many material and design variations possible in these designs, they all are intended to create powerful spherical electromagnetic fields around the fusion burn. In the past there has been no design for fusion reactors that places spherical electromagnetic fields around the fusion burn in order to impart energy to the fuel to contain and ignite the fuel, and to extract energy from the fusion burn using MHD. These designs are the first in history to offer humanity inexpensive, practically unlimited, almost totally clean energy.

The foregoing description of the preferred embodiment of the invention has been presented for the purposes of illustration and description. It is not intended to be exhaustive or to limit the invention to the precise form disclosed. Many modifications and variations are possible in light of the above teaching. Any person schooled in the art of nuclear reactor design should be able to use this schooling to design and build nuclear fusion reactors that provide more energy than they consume from thermal losses and from the energy required to start the fusion burn.

Claims

As a reward for my contributions, I claim rights to nuclear fusion reactor designs comprising:

spherical electromagnetic fields to contain, to transfer energy into, and transfer energy out of nuclear fusion reactions

comprising electromagnetic fields that surround a fusion process of converting matter into energy using the MagnetoHydroDynamic interaction of the fusion reaction with the spherical electromagnetic confinement fields

comprising an electromagnetic containment circuit

comprising spherical conductors forming a closed loop

comprising coils for transferring energy between the closed loop and the electrical energy grid

comprising coils that provide a means for applying voltage or current to the containment circuit

comprising compression, heating, and electromagnetic fields to carbon in order to convert carbon into diamond.

Oath

This document describing nuclear fusion reactor designs utilizing spherical electromagnetic fields to compress, contain, and extract energy was created by me. I did not create the original drawings of the high voltage cabling in Figure 50. I did not create the original image of the planetary nebula in Figure 67. With these two exceptions, all graphics and figures were created by myself.

John Thomas Nordberg

5/17/99

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