Dec. 6, 1966 R. GINELL 3,290,522

NUCLEAR EMISSION ELECTRICAL GENERATOR

Original Filed Aug. 28, 1956

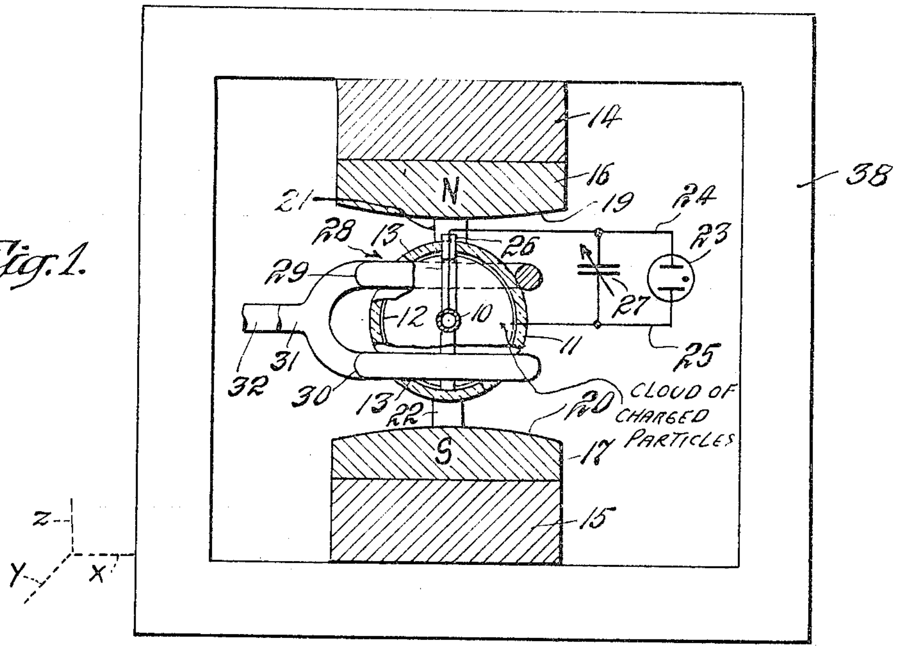

Fig. 1.

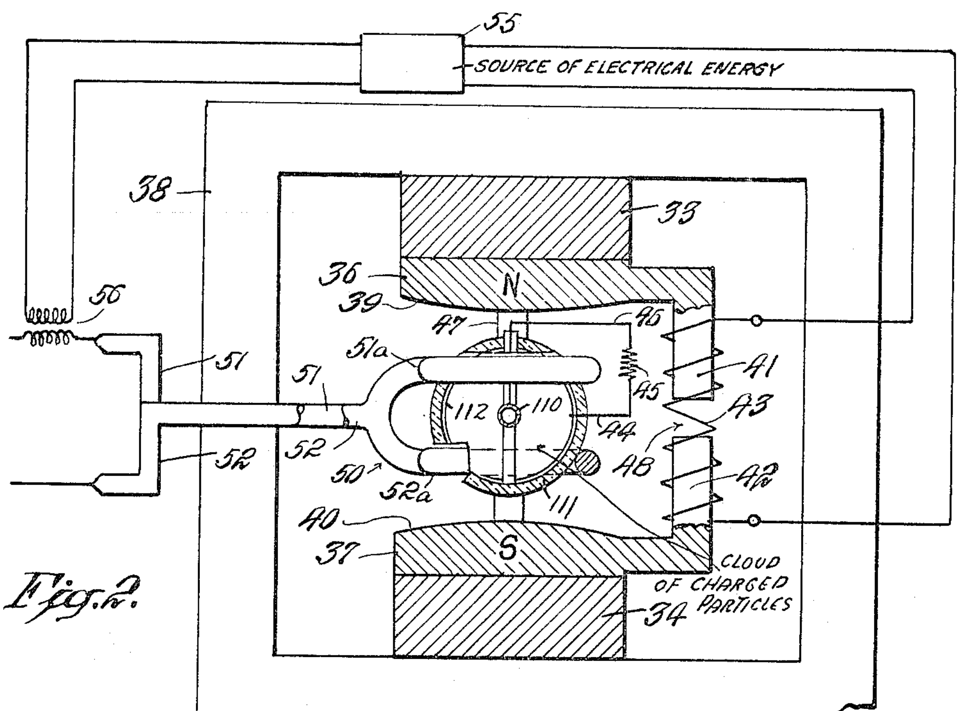

Fig. 2.

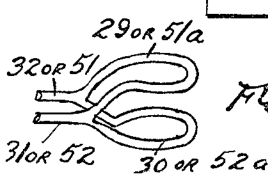

Fig. 3

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NUCLEAR EMISSION ELECTRICAL GENERATOR
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8 Claims. (Cl. 310—3)

This application is a continuation of my copending application Serial No. 606,708 filed August 28, 1956, now abandoned, which was copending with and a continuation-in-part of my application Serial No. 413,068 filed March 1, 1954, now abandoned, and each entitled Nuclear Emission Electrical Generator.

This invention relates to the derivation of electrical energy from the energy of charged particles derived from the alteration of the nucleus of an atom.

An object of this invention is to provide an apparatus that develops useful electrical energy from the energy of charged particles derived from the fission of radioactive material.

Another object of the invention is to provide an apparatus that utilizes the electric field developed by the kinetic energy of charged particles to produce electrical energy.

Other and further objects and advantages will be apparent from the following description taken in connection with the drawings in which

FIG. 1 is a schematic sectional view of an apparatus according to the invention;

FIG. 2 is a schematic sectional view of another embodiment of the invention; and

FIG. 3 illustrates the current loops.

In general, the embodiment of the invention provides electrical power by modulating the density of a cloud of charged particles confined within an enclosed space by a magnetic field. The variation in the density of the cloud of charged particles causes a variation in the magnetic field created by the cloud. This variation cuts an electrically conductive means to create an electric potential and current therein according to Faraday's Law of Induction. The density of the cloud of charged particles may be varied by impressing a periodically varying electrostatic field or a periodically varying electromagnetic field on the confined cloud of charged particles. The electrical energy is derived from the kinetic energy imparted to the charged particles on the occurrence of a fission of a radioactive material.

According to an embodiment of this invention, a radioactive source which emits charged particles, such as beta particles or electrons, is placed in a magnetic field so that when the particles are emitted they are captured within the electromagnetic field and travel in a helical path having an axis generally in the same direction as the axis of the magnet. The pole pieces have a configuration such that the lines of force are convex outwardly between the poles, the magnetic flux density being greater near the poles than at a midpoint between the poles. Also, at the midpoint between the poles the lines of force are parallel to the Z axis while departing more and more from the parallelism as the poles are approached. Thus, near the midpoint particles will tend to travel in helical paths upward and downward towards the poles. However, when they approach the poles, due to the change in the direction of the lines of force, their Z component will be reversed so that the charged particles will travel in a helical path back and forth between the poles, reversing in direction of travel when they approach the pole pieces. Thus, the charged particles of the cloud are in constant motion between the pole pieces. The size and density of the cloud of charged particles may be varied by altering the fields of force acting upon and confining the particles.

Referring specifically to FIG. 1, radioactive material as a thin layer in the form of a hollow sphere **10** is positioned at the center of a larger enclosing hollow sphere **11**, preferably made of glass. The inner surface of the glass sphere is coated with a thin layer of silver **12**. Sphere **10** may be supported by columns **13** secured to the glass sphere **11**. The sphere **11** is centrally positioned between the permanent magnet pieces **14** and **15** with pole pieces **16** and **17**, respectively. The magnet pieces are connected by a yoke **38**. The permanent magnet pieces are preferably made of Alnico and the pole pieces are made of ferrite and have convex surfaces **19** and **20**. The magnetic field extending between the pole pieces **16** and **17** has a curved shape with the lines of force concentrating at the surfaces **19**, **20** and bows outwardly so that the flux density is least in the plane midway between the surfaces **19** and **20**. The sphere **11** may be supported by insulating blocks **21** and **22** fitting between the sphere and the surfaces **19** and **20**.

The thin layer of radioactive material in sphere **10** may be made of the element strontium 90 which emits charged particles at any angle to the X, Y and Z ordinates illustrated in dotted lines in FIG. 1. The charged particles having a component of velocity along the X or the Y ordinate cut the lines of force of the magnetic field and due to the high flux density and the charge on the particle, the particle curves and circles to travel in a helical path having its axis generally parallel to the Z ordinate. As the particle moves towards either the pole **16** or **17**, the converging lines of force of the magnetic field cause the radius of the helical path of the particle to contract and the change in direction of the magnetic lines of force cause the charged particle to reverse its direction along the Z axis so that it travels towards the opposite pole. This focusing action causes the charged particle to oscillate back and forth between the pole pieces. The radioactive source provides a vast quantity of these charged particles which forms a dense cloud within the hollow sphere **11**.

The charged particles emitted by the radioactive source that travels along the Z ordinate (having no X or Y velocity component) are not affected by the magnetic field, since they are traveling parallel to the lines of force. These particles and other particles, the major portion of whose velocity is in the Z direction, are collected by the silver lining **12** and accumulate thereon to create an electrostatic charge between the silver lining **12** and the hollow sphere **10**. Since the charged particles on the silver lining are of the same polarity as the charged particles of the cloud within the hollow sphere, the electrostatic charge on the silver lining **12** causes the cloud to be compressed or increased in density.

The hollow sphere **10** and the silver lining **12** are connected to a gas discharge tube **23** by means of leads **24** and **25**, respectively. The lead **24** extends through an insulator **26** in the wall of the hollow sphere **11**. Thus, the silver lining **12** and the sphere **10** are connected across the discharge tube **23** to place the electrostatic charge across the elements of the tube. When the electrostatic charge reaches a given value the gaseous discharge tube fires, equalizing the potentials of the sphere **10** and the lining **12** so that there is little or no electrostatic charge on the sphere **11**. As the charge is removed, the cloud of charged particles expands. When the voltage falls to a predetermined low value, the gas discharge tube is extinguished and the potential on sphere **11** is again increased. This action is repetitive and is essentially a relaxation oscillator. An external variable condenser **27** may be connected across the gaseous discharge tube **23** to vary the capacity of the circuit and hence the rapidity of discharge of the gaseous discharge tube, and thereby the frequency of the pulsations of the charged cloud.

An electrical conductive means 28 may comprise two electrically conductive loops 29 and 30 with spaced ends connected to line conductors 31 and 32. The charged cloud, on contracting and expanding, induces in the loops an electric current and potential which is removed by conductors 31 and 32.

In a specific embodiment of the aforementioned described unit, the radioactive material may be one gram of strontium 90 formed as a hollow sphere with an inside diameter of 9 mm. and an outside diameter of 11.36 mm., resulting in a thickness of 1.18 mm. Strontium 90 decomposes with a half life of 20 years to yield yttrium 90 and a beta particle. Yttrium 90 is also radioactive and has a half life of 61 hours. Yttrium 90 yields zirconium 90 and a beta particle. Zirconium 90 is stable.

The amperage from one gram of strontium 90 and yttrium 90 in equilibrium amount is 2.36×10^{-6} amperes. When the magnet provides a field of 4,400 gauss, the beta particles of maximum energy will circle in an orbit having a diameter of approximately 4 cm. Since beta particles revolve in an orbit on both sides of the inner sphere, the inside diameter of the outer sphere should be at least 9.5 cm. The inner sphere 10 and the outer shell 11 have a capacity of 0.730 micromicrofarad. If the gas is discharged at a breakdown voltage of 1,000 volts, the frequency of discharge will be 540 cycles per second. The external variable condenser 27 may have a maximum capacity of 10 micromicrofarads, making the total capacity of the circuit 10.730 micromicrofarads. With this total capacity in the circuit, the frequency of discharge is 36.60 cycles per second. Thus, a range from 540 to 36.60 cycles per second may be provided with a discharge tube having a breakdown voltage of 1,000 volts and a 10 micromicrofarad variable condenser. Further variation of the frequency may be obtained by varying the discharge voltage of the tube 23.

The value 2.36×10^{-6} amperes is derived as follows: The specific rate constant of strontium 90 is

$$k=\frac{\ln 2}{\text{half life}}=3.96\times10^{-6}\ \text{hr.}^{-1}$$

The amount decomposing in unit time, t, will be

$$x=A_o(1-e^{-kt})$$

where

x is the amount decomposed at time, t,
k=specific rate constant
A_o=starting amount (amount at $t=0$)
e=base of natural longarithms=2.71828+
t=time.

For the first hour of operation at equilibrium let

$A_o=1$ gm. strontium 90
$t=1$ hour
$x=1[1-e^{-3.96\times10^{-6}(1)}]=4\times10^{-6}$ gm./hr. per gm. Sr^{90}
$x=0.044\times10^{-6}$ atomic wts./hr. (decomposed per gm. Sr^{90})
$x=2.65\times10^{+16}$ atoms decomposed/hr.
$x=2.65\times10^{+16}$ beta rays produced/hr. per gm. Sr^{90}
$x=7.36\times10^{12}$ beta rays/sec. per gm. Sr^{90}

since 96,500 amperes$=6.02\times10^{23}$ electrons/sec. hence

$$x=1.8\times10^{-6}\ \text{amperes}$$

This is the amperage obtained from one gram of strontium 90 over the first hour of its life. Since one beta is obtained from yttrium 90 for each beta from strontium 90, the total amperage obtained from this system is twice this figure or

$$\text{Total amperage}=2.36\times10^{-6}\ \text{amperes}$$

In deriving the value of 4,400 gauss the motion of the charged particle is taken into consideration. For a moving electron

$$HR=\frac{mv}{e}$$

where

H is the strength of the magnetic field in gauss
R is the radius of the path
m is the mass of the particle (here an electron)
v is the velocity of the particle (here an electron)
e is the charge of the electron (this is multiplied by a factor for a charged particle having a charge greater than one electron charge).

m which is the mass of the particle is a variable factor which, according to the Einstein Theory of Relativity, varies with the velocity of the particle. This theory has been verified in this respect. According to this theory

$$m=\frac{m_o}{[1-(v^2/c^2)]^{1/2}}=m_o(1-b^2)^{-1/2}$$

where

$b=v/c$
m_o=rest mass of particle (here the electron)
v=velocity of the particle
c=velocity of light.

Since the velocity of the electron from Sr^{90} and Y^{90} is so great, this relativity correction must be taken into account. Inserting this equation and the equation $v=bc$ into the previous equation, we have

$$HR=\frac{m_oc}{e}b(1-b^2)^{-1/2}$$

in calculating the value of HR. The terms on the right, m_o, c, and e are known constants leaving only b to be determined. The velocity of a particle is a function of its energy and the relationship is given by Einstein's law as

$$E=(m-m_o)c^2$$

where E=the energy of the particle

Inserting the value of m from

$$m=m_o(1-b^2)^{-1/2}$$

and factoring, we have

$$E=m_oc^2(n-1)$$

where

$$n=\frac{1}{(1-b^2)^{1/2}}$$

i.e.,

$$m=nm_o$$

or

$$n=1+\frac{E}{m_oc^2}$$

and

$$b=\left(1-\frac{1}{n^2}\right)^{1/2}$$

From these equations if we use the known energy of the particles from the Sr^{90}–Y^{90} system we can calculate HR. For the Sr^{90}–Y^{90} system the maximum energy contained in any emitted particle is 2.2 m.e.v. Hence, using $E=2.2$ m.e.v.

$$n=5.31$$

and

$$b=0.982$$

Using the previous equation

$$HR=1704\ bn$$
$$HR=8885\ \text{gauss cm.}$$

With the magnetic field of 4,400 gauss, the radius of revolution of the orbit of the charged particle is calculated by dividing 8885 gauss cm. by 4400 gauss. This results in an orbital radius of 2.02 cm. or an orbital diameter of 4.04 cm. Since space for two orbits is required along with space for the radioactive sphere, the inner diameter of the outer sphere should be at least of the order of 9.5 cm.

The capacity between the inner shell and outer sphere is 0.730 micromicrofarad and is determined as follows:

$$C=\frac{Kr_1r_2}{(r_1-r_2)m}$$

where

C=capacity of the condenser in farads
r_1=radius of the external shield
r_2=radius of the internal spheres
K=dielectric constant of the internal space, in this case =1.
$m=9\times10^{11}$ statfarads/farad

and

$$Q=EC$$

where

E=EMF of charge in volts
Q=Quantity of electricity in coulombs.

In this system the radioactive sphere is emitting a fixed current of beta rays (coulombs/sec.) hence,

$$Q=\frac{A}{f}$$

where

A=Amperage of source
f=Frequency of discharge in cycles/sec.

combining the equations

$$f=\frac{A(r_1-r_2)m}{Er_1r_2}$$

$A=2.36\times10^{-6}$ amperes not considering self-absorption. If a 50% loss for self-absorption is allowed, the emitting amperage is 1.18×10^{-6} amperes. One third of these electrons will be captured by the spherical shell so that the charging current will be $\frac{1}{3}(1.18\times10^{-6})$ amperes.

Since the magnet strength is 4,400 gauss, then as previously calculated the radius of revolution of the electrons of maximum energy will be approximately 2 cm., and the outer spherical shell will be 9.5 cm. in diameter. $r_1=4.75$ cm.; $r_2=0.57$ cm. so that

$$f=\frac{1.18\times10^{-6}}{3}\cdot\frac{(4.75-0.57)9\times10^{11}}{4.75(0.57)}\cdot\frac{1}{E}$$

$$f\cong\frac{5.4\times10^5}{E}$$

Since the discharge voltage of the cell is equal to 1,000 volts, the frequency of discharge will be ~540 cycles/sec. The frequency and voltage can be varied by the external condenser **27** connected in parallel across the discharge tube. Using the above equations, the capacity of the concentric shell condenser is

$$C=\frac{r_1r_2}{(r_1-r_2)m}=\frac{(4.75\times0.57)}{(4.75-0.57)9\times10^{11}}\text{ farad}$$

$$C=0.730\times10^{-12}\text{ farad}$$

Since the externally connected condenser in parallel has a maximum capacity of 10 $\mu\mu$farad, the total capacity is

$$C=10.730\times10^{-12}\text{ farad}$$

The frequency of discharge is

$$f=\frac{A}{CE}=\frac{1.18\times10^{-6}}{3(10.730\times10^{-12})}\cdot\frac{1}{E}$$

$$f=0.3660\times10^5/E$$

When the discharge voltage is at 1,000 volts, then the frequency is 36.60 cycle/sec. When the discharge voltage is reduced to 500 volts, then the frequency is 73.20 cycles/sec. Since the external condenser is variable, the voltage can be adjusted to the characteristics of the discharge tube or to any other desired value.

In FIG. 2 an embodiment is shown in which a radioactive source is in the form of a thin hollow sphere **110** with an inside diameter of 0.9 cm. and an outside diameter of 1.136 cm. providing a wall thickness of 0.118 cm. The sphere is made of strontium 90 which emits charged particles. The sphere **110** is positioned at the center of a larger enclosing hollow sphere **111**, preferably made of glass and having an inside diameter of 9.5 cm. The inner surface of the glass sphere is coated with a thin layer of silver **112**. The sphere **111** is centrally positioned between the Alnico permanent magnet pieces **33, 34** with pole pieces **36, 37** preferably made of ferrite and having surfaces **39, 40**. A yoke **38**, preferably made of soft iron, connects the Alnico magnet pieces **33** and **34** to provide a flux therebetween and the Alnico magnet pieces are arranged so that the pole piece **36** is a north pole and the pole piece **37** is a south pole. The convex surfaces **39** and **40** shape the magnetic field between the pole pieces with a slight curvature so that the field has the general shape of a barrel or staves of a barrel. The pole pieces **36** and **37** have extensions **41** and **42** with an electrical coil **43** wound around the extensions **41** and **42** to provide a variable flux to the pole pieces **36** and **37** to modulate the magnetic field extending between the pole pieces.

The spheres **110** and **111** are centrally positioned in the field. As indicated in FIG. 2, the magnetic flux is symmetric around the Z ordinate. The pole pieces are preferably 9.5 cm. in diameter and the Alnico magnets provide a field strength in the order of 4,400 gauss. The pole pieces **36** and **37** are spaced preferably 9.5 cm. apart. The glass sphere **111** is centrally positioned between the pole pieces **36** and **37** so that the inner sphere **110** is at the center of the magnetic field.

The cloud of charged particles is formed in a manner similar to the embodiment of FIG. 1. However, the cloud is modulated by varying the magnetic field rather than the electrostatic field. The charge of the particles collected by the silver lining **112** is returned to the inner sphere **110** by means of electrically conducting lead **44**, resistor **45** and electrically conducting lead **46** passing through the outer sphere **111** and the silver lining **112** by means of an insulator **47** electrically isolating lead **46** from the lining **112**. Thus, a charge is prevented from accumulating on the lining **112** in relation to the inner sphere **110** that would influence the charged cloud within the sphere **111**.

The extensions **41, 42** are positioned so as not to materially affect the symmetry of the flux between the pole pieces **36** and **37** and may be provided with an air gap **48** to increase the reluctance of the magnetic path but still permit a magnetic coupling through the winding **43**. The coil **43** and the extensions **41** and **42** are formed so that when the proper current is passed through the winding **43**, a magnetic flux is formed in the extensions **41** and **42** that passes therethrough to the pole piece **36** across the space between the pole pieces **36** and **37** to vary the permanent flux created by the Alnico magnet pieces **33** and **34**. This variation causes the charged cloud to be compressed on an increase of the flux density and to expand on a decrease of the flux density. The variation in the sizes of the charged cloud within the sphere **110** causes the variation in the magnetic field produced by the charged cloud.

The cloud comprises a large number of charged particles all rotating in the same direction about their respective axes. Since the cloud is within a confined space, the particles are moving in the same direction at the periphery of the cloud to provide a magnetic field coupled with the conductive loops. The modulated magnetic field of the magnets acts on the individual particles causing their orbits to contract and expand. The particles forming the cloud cause the field of the cloud to contract and expand delivering the energy of the circulating particles to the conductive means as electrical energy.

This current is circulated through the electrical conductive means **50** by the conductors **51** and **52**. These conductors may be connected to a load for the utilization of this electrical energy. The electrical conductive means **50** may comprise an upper loop **51***a* and a lower loop **52***a*, each formed with a split so that the ends of the loops are connected to the conductors **51, 52** in parallel. As with loops **29** and **30**, loops **51***a*, **52***a* each has a small cross section in a plane containing the magnet axis in comparison to the conductive path (FIG. 3).

To initially modulate the main magnetic flux, the coil **43** may be connected to an independent alternating source of electrical energy **55**. However, when sufficient current passes through the conductors **51, 52**, a portion of the current may be tapped by a transformer means **56** to stop the operation of the alternating source **55** and supply the current to the coil **43**.

Thus, it is seen that in the foregoing embodiment the electrons which strike the silver lining or shield **112** are electrically connected to the radioactive source **110** through the resistance **45** and are not utilized to modulate the charged cloud. The modulation is achieved by passing an initial alternating current from the source **55** to the coil **43**. This alternating current alters the lines of force which flow through the auxiliary pole pieces **41, 42** and varies the flux density of the main flux. The main magnetic flux is thereby cyclically changed and the charged cloud cyclically contracts and expands further changing the magnetic field in passing through the loops **51***a* and **52***a*. When the conductors are carrying sufficient alternating current the source **55** is cut out and the device is self-exciting.

The two above-described methods for varying the cloud of charged particles set forth in connection with FIGS. 1 and 2 can be combined. The condenser-discharged current could be fed to the gas-discharged cell by means of a winding around the auxiliary gap. This combination will increase the efficiency of the device.

Calculations as to power derivable from the above-mentioned source are as follows:

The maximum energy of beta from yttrium 90 is 2.2 mev. The average energy as measured recently is 0.895 mev. This is 40.7% of the maximum value. The corresponding value for strontium 90 has not been experimentally determined, but a likely assumption is that

$$E_{\text{aver}}=0.4\ E_{\text{max}}$$

hence, for strontium 90

$$E_{\text{av}}=0.4\ (0.53)=.212\ \text{mev.}$$

$$1\ \text{mev.}=1.6\times10^{-6}\ \text{ergs}$$

for Sr^{90}

$$1.6\times10^{-6}\ \frac{\text{ergs}}{\text{mev.}}\times.212\ \frac{\text{mev.}}{\text{beta}}\times7.36\times10^{12}\ \frac{\text{beta}}{\text{sec.}}=$$

$$0.25\times10^{7}\ \text{ergs/sec.}=0.25\ \text{joule/sec.}=0.25\ \text{watt}$$

similarly for Y^{90}

$$0.895\ \text{mev./beta}\cong1.055\ \text{watts}$$

Total power=1.305 watts/gm. Sr^{90} average for 1st hour of operation.

The losses can be calculated by subtracting a 50% self-absorption loss from 1.305 watts/gm. to give .6525 watt/gm. From this is subtracted one-third modulating current loss (Z component current loss) and miscellaneous losses such as striking gas molecules and reflection off supports, etc., to give .3915 watt/gm. or 30% of the original power available for coupling.

In the above description it has been assumed that the source of radioactivity was a hollow sphere of a radioactive metal. However, the sphere may have other forms to cut down on self-absorption. Wire-mesh or coated wire-mesh in the shape of disks or stars would be excellent.

The shape of the external condenser shell was chosen as a hollow sphere for illustrative purposes because of the ease of computation. Other shapes could be used and the shape will be determined by the shape of the pole pieces and the shape of the radioactive source.

The outer shell should probably be made of a nonconductor lined with a very thin layer of a conductor or metal. This is necessary because if an unsupported metal shell is used, it would, of necessity, have to be relatively thick and in a thick shell parasitic currents would be induced which would cut down on the usable power derived.

The source used in the above example is one made of strontium 90 metal. While there are a number of advantages in using this material, any convenient beta emitter can be used. Further, for positively charged particles any alpha emitter can be used. Moreover, the substance producing beta rays may be created in the apparatus. A device of this sort would be a neutron-producing source surrounded by a substance which would produce beta rays by decomposition after being struck by and absorbing a neutron. Most natural elements will absorb neutrons and then spontaneously decompose giving off beta rays. An example of such a combination would be a polonium-beryllium source surrounded by a shell of natural, non-radioactive, yttrium metal, yttrium 89. The polonium yields alpha particles which impinge on the beryllium yielding neutrons. The neutrons would strike the yttrium 89 yielding yttrium 90 plus gamma radiation. The yttrium 90 would then decompose with a half life of 61 hours to give a beta ray and zirconium 90. The advantage of this latter type of source is that it is not tied to the half life of the original isotope. There are only a few isotopes known of median half life like strontium 90.

Various other embodiments and changes may be made in the above apparatus without departing from the scope of the invention as set forth in the appended claims.

I claim:

1. Apparatus for producing electric voltage and current comprising means spaced along an axis for producing flux increasing in density in opposite directions from an intermediate plane therebetween transverse to the axis for confining charged particles within the flux, enclosing means forming an evacuated space between said spaced means, means for producing charged particles mounted in said evacuated space of said enclosing means and positioned in a plane from which the flux produced by said spaced means increases in density on opposite sides thereof for confining charged particles created by said means producing charged particles as a cloud of charged particles with an external field, means for periodically varying the density of the flux confining the charged particles to vary the cloud of charged particles and the external field thereof, electrical conductive means for delivery of current to a circuit and being electrically separate from said means for periodically varying the density of the flux confining the charged particles as a cloud of charged particles, said electrical conductive means substantially surrounding said evacuated space formed by said enclosing means and extending transverse to the axis and the flux produced by said spaced means and positioned within said external field of said cloud of charged particles confined by the flux for creating a voltage within said electrical conductive means on variation of the external field of the cloud of charged particles.

2. Apparatus for producing electric voltage and current comprising a pair of magnetic pole pieces spaced along a central axis for producing flux increasing in density in opposite directions from an intermediate plane therebetween transverse to the axis for confining charged particles within the flux, enclosing means forming an evacuated space between said spaced pole pieces, means for

producing charged particles mounted in said evacuated space of said enclosing means and positioned between said pole pieces to create charged particles deflected by the flux to orbit within the flux as a charged cloud having an external field, means for periodically varying the density of the flux confining the charged particles to vary the cloud of charged particles and the external field thereof, electrical conductive means for delivery of current to a circuit and being electrically separate from said means for periodically varying the density of the flux, said electrical conductive means extending transverse to the central axis and having a radial width to the central axis substantially less than the length of the conductive means and substantially surrounding said evacuated space formed by said enclosing means to be positioned within said external field of said cloud of charged particles confined by the flux for creating a voltage within said electrical conductive means on variation of the external field of the cloud of charged particles.

3. An apparatus for producing an electric voltage comprising a pair of spaced magnetic pole pieces, means defining a medium of low permeability between said spaced pole pieces traversed by the magnetic flux of said pole pieces, a radioactive source located between said pole pieces within said medium to create between said pole pieces charged particles, said pole pieces forming a magnetic flux around said radioactive source and increasing in flux density from an intermediate plane traversing said medium to deflect the charged particles to orbit within said flux with a kinetic energy produced in the creation of said particles and creating a charged cloud having an external magnetic field and contained within said medium by the flux of said pole pieces, conductive means between said pole pieces and located within the external field of the charged particles, means for periodically varying the density of the flux confining the charged particles to vary the size of the cloud of charged particles and the external field thereof to create a voltage in the conductive means by the movement of the external field.

4. An apparatus for producing an electric voltage comprising a pair of spaced magnetic pole pieces, means defining a medium of low permeability between said spaced pole pieces traversed by the magnetic flux of said pole pieces, a radioactive source located between said pole pieces within said medium to create between said pole pieces charged particles, said pole pieces forming a magnetic flux around said radioactive source and increasing in flux density from an intermediate plane traversing said medium to deflect the charged particles to orbit within said flux with a kinetic energy produced in the creation of said particles and creating a charged cloud having an external magnetic field and contained within said medium by the flux of said pole pieces, conductive means between said pole pieces and located within the external field of the charged particles, a conductive shield surrounding said radioactive source and spaced therefrom to form a chamber for containing the cloud of charged particles and receive a potential to change the size of said cloud, and means for temporarily discharging said potential to return the size of the cloud of charged particles to noncharge size.

5. Apparatus as claimed in claim **4** in which said discharge means comprises a discharge tube connected to said shield.

6. An apparatus for producing an electric voltage comprising a pair of spaced magnetic pole pieces, means defining a medium of low permeability between said spaced pole pieces traversed by the magnetic flux of said pole pieces, a radioactive source located between said pole pieces within said medium to create between said pole pieces charged particles, said pole pieces forming a magnetic flux around said radioactive source and increasing in flux density from an intermediate plane traversing said medium to deflect the charged particles to orbit within said flux with a kinetic energy produced in the creation of said particles and creating a charged cloud having an external magnetic field and contained within said medium by the flux of said pole pieces, conductive means between said pole pieces and located within the external field of the charged particles, and means for varying the flux of said spaced magnetic pole pieces for varying the spatial orientation of the cloud of charged particles and the external field thereof to create a voltage in said conductive means.

7. An apparatus for producing an electric voltage comprising a pair of spaced magnetic pole pieces, means defining a medium of low permeability between said spaced pole pieces traversed by the magnetic flux of said pole pieces, a radioactive source located between said pole pieces within said medium to create between said pole pieces charged particles, said pole pieces forming a magnetic flux around said radioactive source and increasing in flux density from an intermediate plane traversing said medium to deflect the charged particles to orbit within said flux with a kinetic energy produced in the creation of said particles and creating a charged cloud having an external magnetic field and contained within said medium by the flux of said pole pieces, conductive means between said pole pieces and located within the external field of the charged particles, an auxiliary pair of pole pieces magnetically coupled to said spaced magnetic pole pieces, a coil around said auxiliary pole pieces, an external source of energy coupled with said coil for producing oscillations therein to vary the flux of said spaced magnetic pole pieces for varying the spatial orientation of the cloud of charged particles to alter the position of the external field to create a voltage in said conductive means.

8. A method for the conversion of the kinetic energy of a charged particles to useful energy comprising producing a magnetic field increasing in flux density on opposite sides of a transverse plane, producing charged particles having trajectories in planes transverse to the magnetic lines of force and curving the trajectories by the magnetic lines of force into complete orbits within the magnetic field and restricting the longitudinal movement of the charged particles by the increase in flux density to form a cloud of charged particles with the peripheral charged particles of a given charge moving in the same direction to create an electrical field in a given direction at the periphery of the cloud, modulating the magnetic field to vary the size of the cloud and the spatial orientation of the electrical field and creating current and voltage in wirelike means encompassing the cloud by the change in spatial orientation of the electrical field thus extracting the kinetic energy of the charged particles as current and voltage in the wirelike means.

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