May 31, 1960 V. H. BLACKMAN 2,939,049

APPARATUS FOR GENERATING HIGH TEMPERATURES

Filed May 29, 1958

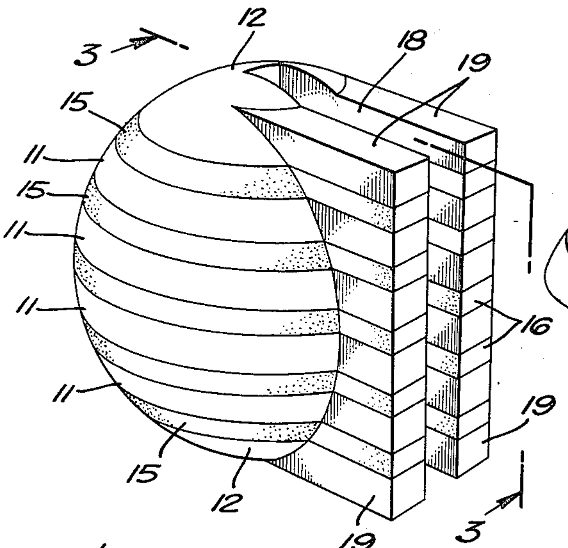

FIG. 1.

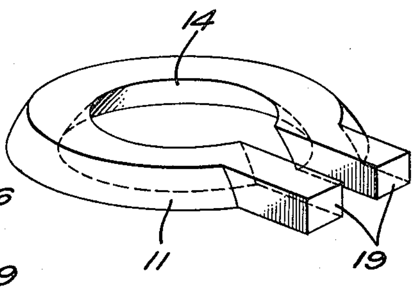

FIG. 2.

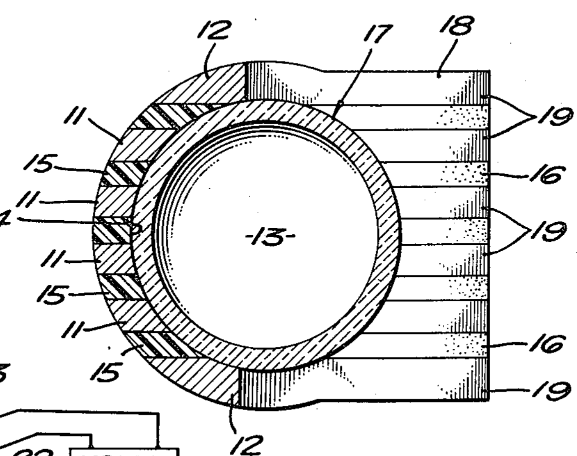

FIG. 3.

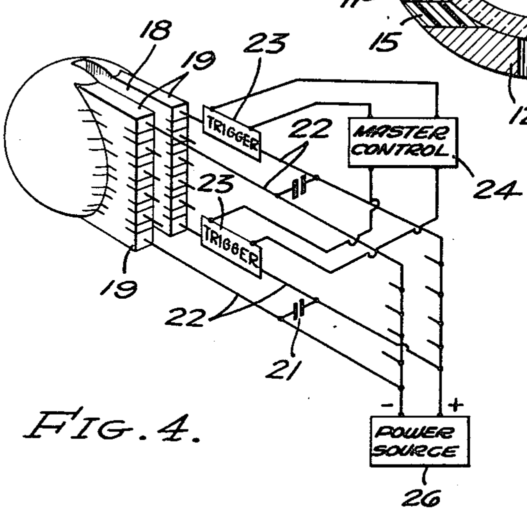

FIG. 4.

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United States Patent Office

2,939,049

Patented May 31, 1960

2,939,049

APPARATUS FOR GENERATING HIGH TEMPERATURES

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Filed May 29, 1958, Ser. No. 738,855

8 Claims. (Cl. 315—236)

This invention relates to apparatus for generating high temperatures, and high-intensity light. The invention pertains to the general field of discharge-type devices for creating momentarily temperatures measured in millions of degrees.

Discharge-type devices of the class indicated may be divided into those employing electrodes, and those effecting a discharge in space. Devices employing electrodes present substantial problems of contamination due to the vaporization of electrode material. This produces, particularly in the case of repetitive operation, detrimental effects because of the fact that the radiation capabilities of vapors of impurities are very high. It follows that a large amount of the energy stored in the discharge is dissipated in the form of radiation, thereby reducing the effective temperature of the gas.

With relation to devices which effect discharges in space, that is to say without electrodes, these conventionally consist of a toroidal chamber which produces, in conjunction with magnet means and by virtue of a pinch effect, a toroidal plasma concentration of filamentlike dimensions. The energy stored in this pinch of plasma, which is at least 100 times as long as it is thick, is readily radiated because of the geometry of the apparatus. For this and other important reasons, such apparatus has been characterized by limitations as to the maximum temperature which may be achieved, it being difficult to supply energy at a rate sufficiently fast to permit the attaining of ultra high temperatures. Other limitations and defects of such toroidal-type plasma devices have included a relative instability of the plasma.

In view of the above factors characteristic of discharge-type devices for obtaining extremely high temperatures, and intense sources of light, it is an object of the present invention to provide an improved apparatus for generating a very high temperature, and in a highly efficient manner.

A further object is to provide an improved apparatus for generating an extremely high temperature in a small volume approximating a point, through the use of a plurality of elements shaped as segments of a hollow spheroid and electrically insulated from each other, such segments each being continuous except for a single gap or split therein.

These and other objects and advantages of the invention will be more fully set forth in the following specification and claims, considered in connection with the attached drawing to which they relate.

In the drawing:

Figure 1 is a perspective view illustrating an apparatus constructed in accordance with the present invention;

Figure 2 is a fragmentary perspective view showing a segment of the apparatus of Figure 1;

Figure 3 is a transverse section taken on line 3—3 of Figure 1; and

Figure 4 is a schematic illustration, in fragmentary form, of electrical circuit means associated with the apparatus of Figure 1.

Stated generally, the apparatus of the invention comprises a plurality of continuous, hoop-like electrical conductors disposed in generally parallel relationship and encompassing a cavity having the general shape of a sphere or spheroid. The electrical conductors between the poles of the sphere have been given the reference numeral **11**, and the conductors at the poles have been given the reference numeral **12**. The cavity, numbered **13**, has a generally spherical or spheroidal wall **14** formed by the conductors **11** and **12** and by insulation **15** which separates the conductors. In order to maintain a substantial vacuum in the cavity **13**, a spherical envelope **17** is provided and preferably has its outer wall closely adjacent to cavity wall **14**. The envelope is formed of quartz or other insulator.

Each of the conductors **11** and **12** forms part of a single-turn electrical circuit which extends from one side of a single gap or split **18** in each conductor **11** and **12**, and thence around the conductor to the other side of the gap or split. In order to conduct current to and from the electrical conductors on opposite sides of the gaps **18**, electrical conductor bars **19** are provided.

Stated more definitely, the conductors **11** and **12** comprise spherical segments of a single hollow sphere or spheroid, and the insulators **15** also comprise segments of said hollow sphere or spheroid except at the gaps or splits **18**. The end caps **12** constitute the polar spherical segments of the spheroid, and the conductors **11** constitute the intermediate spherical segments. In the illustrated embodiment, the outer surfaces of the elements **11**, **12** and **15** comprise zones of a first sphere, and the inner surfaces thereof comprise zones of a second sphere having a smaller diameter but a common center. The last-mentioned sphere is the one which comprises the wall **14** of cavity **13**.

The bars or conductors **19** are preferably integral with the conductors **11** and **12**, and all are formed of a good electrical conductor such as copper. Correspondingly, the insulators **16** separating the bars **19** are illustrated as being integral with the insulators **15** between the conductors **11** and **12**.

As previously indicated, each conductor **11** or **12**, together with the associated bars **19** on opposite sides of gap **18**, comprises a single-turn electrical circuit about the common axis of the spherical segments **11** and **12**. When a very high current is passed substantially simultaneously through each conductor **11** and **12**, during a very short period of time, a strong magnetic field is formed to result in acceleration of ionized particles in cavity **13**, toward the center portion thereof. This effect, which may be characterized as a radially-inwardly directed blast or implosion, generates a high temperature in a small volume approximating a point. In order to maintain the conductors and insulators in assembled condition despite the strong magnetic forces involved, it is within the scope of the invention to suitably reinforce the apparatus such as by embedding the same in a large block of strong insulating material, which may be jacketed and reinforced at a location remote from the sphere.

Proceeding next to Figure 4, a capacitor means **21**, of a low-inductance type, is connected by means of leads **22** across the bars **19** for each conductor **11** and **12**. The dishcarge of each capacitor **21** is effected by a suitable trigger or switch means **23**, under the control of a master control **24**. The capacitors **21** are charged from a suitable D.C. power source, indicated at **26**. It is to be understood that a capacitor, trigger, etc. is provided for each pair of bars **19**, although some have been omitted in Figure 4 for purposes of simplicity of illustration.

In the operation of the apparatus, the capacitors **21** are charged to a suitable voltage, and corresponding polarities, from the power source **26**. The charge may be very great, since the capacitors **21** should have extremely large capacitance, it being understood that the showing at Figure 4 is highly schematic as to these elements. After the capacitors **21** have been charged, and after the power source has been disconnected therefrom by suitable means, not shown, the master control **24** is operated to effect closing of the circuits through trigger means **23**. Each capacitor **21** thus discharges through a single-turn circuit comprising leads **22**, bars **19**, and the associated single conductor **11** or **12**. The discharges of the capacitors **21** may be simultaneous, or at slightly different times, normally overlapping, within a very short time interval. The discharge currents flow in the same direction about the axis of the sphere.

With the described apparatus, the magnetic fields generated by the electrical currents may be accurately controlled by varying the amount of flow through each conductor **11** and **12**, the charges on the respective capacitors **21**, the times of discharge, etc. This provides the optimum field strength conditions within the cavity **13**. The capacitors may, if desired, be charged from separate sources. It is within the scope of the invention to provide various numbers of conductors, various spacings therebetween, etc.

To amplify upon the previously-stated theory relative to the present invention, it is pointed out that the flow of current is in a given direction through the conductor means and circumferentially about the axis of the spheroidal cavity. This results in the formation of an induced current sheet flowing in the opposite direction and through the gas. The induced current sheet is located within the evacuated cavity and is initially relatively close to the cavity wall formed by the conductor means. Thus, in the situation in which there is an envelope within the cavity, the induced current initially flows through the gas adjacent the inner wall of the envelope, it being remembered that the envelope is formed of non-conductive material.

The sheet of induced current, composed of ions and electrons, acts as a barricade through which the lines of magnetic force may not pass in quantity. This is particularly true when the rate of change of magnetic field strength is great. This being the case, at least the majority of lines of magnetic force initially pass (in a spheroidal configuration) between the conductor metal and the current sheet—or largely through the envelope in cases where there is an envelope.

The generally spheroidal magnetic field acts as a piston to drive (implode) the current sheet, that is to say the ions and electrons, radially inwardly toward the center of the cavity. As the current sheet collapses toward the center, in a shock wave, the lines of magnetic force collapse toward the center (in the above-indicated piston action) to compress the gas, and greatly elevate its temperature because of the speed and collision of the particles. The inward movement continues until the external magnetic pressure is counterbalanced by the internal pressure resulting from compression and temperature increase.

Since the lines of magnetic force may not pass through the electrical conductor metal, the conductor is provided with openings (or non-conductors) at the poles of the cavity. The lines of force thus flow through the poles and externally of the spheroid to form continuous loops. As previously indicated, the reinforcing material in which the apparatus is embedded is non-conductive (except possibly in a casing remote from the sphere) and thus does not interfere with the external portions of the lines of force.

To aid in the above-described action, the gas within the cavity should be ionized before the capacitors commence to discharge. This may be done in any suitable manner, such as by passing radio-frequency waves through the cavity. For example, electrodes may be located near (but outside) the opening at each pole, and energized by a radio-frequency oscillator.

It is emphasized that the present invention produces a relatively stable concentration of high-temperature plasma near the center of the cavity. The plasma is stable because the magnetic field is generated by the flow of current through the metal conductor. This is to be contrasted with pinch-type devices, in which the constricting magnetic field results from flow of current through the gas. In such pinch devices, instability resulting from variation in current flow is compounded by simultaneous variation in the magnetic field.

The present apparatus may be pulsed, for example at a relatively high frequency, instead of being employed as a single-operation apparatus. This may be accomplished by rapidly charging and discharging the capacitors.

A feature of the present invention is that all of the lines of magnetic force need not pass through the openings (at the bases of the splits or gaps) in polar conductors **12**. Instead, some of the lines of force pass through intermediate layers of insulation **15**. This reduces the concentration of magnetic field in the polar openings, and thereby lessens the strength requirements of the apparatus.

The conductors **11** and **12** may be made very wide, or plate-like, in order to increase the strength thereof. They are not necessarily externally spheroidal, or shaped externally as segments of spheres. The conductors may be segments of bodies generally shaped as spheroids, such as prolate or oblate spheroids. Throughout this specification and claims, the use of the term "spheroid" includes not only elements which approach spheres, but also perfect spheres.

It is to be understood that the terms "point," "approximating a point," etc., do not mean that the high-temperature occurs only at a geometrical point. What is meant is that the highest concentration of plasma is in a small volume, as close to a point as possible. There may, however, be plasma concentrations of lesser density at regions other than the center of the cavity.

Various embodiments of the present invention, in addition to what has been illustrated and described in detail, may be employed without departing from the scope of the accompanying claims.

I claim:

1. Apparatus for generating a very high temperature, comprising a plurality of continuous hoop-like electrical conductors disposed in generally parallel relationship and each having a split or gap at only one point therein, said conductors being provided around a cavity, said conductors being electrically separate from each other whereby each defines a single turn of conductive material about said cavity.

2. Apparatus for generating extremely high temperatures and intense light, comprising a plurality of generally parallel electrical conductors having openings shaped to form a spheroidal cavity, each of said conductors being formed with a gap or split at only one point therein to provide single-turn electric circuits around said cavity, and conductor means to conduct current to and from each of said conductors at opposite sides of the gap or split therein.

3. The invention as claimed in claim 2, in which means are provided to insulate said conductors from each other, and to maintain said cavity in a substantially evacuated condition.

4. The invention as claimed in claim 2, in which a source of current is connected separately to the conductor means for each of said conductors.

5. The invention as claimed in claim 4, in which said current source comprises a capacitor means connected across the conductor means for each of said conductors, and trigger means to effect discharge of said capacitor

means in a single-turn circuit through said conductor means and the associated conductor.

6. Apparatus for creating a very high temperature in a small volume approximating a point, which comprises a plurality of electrical conductors and a plurality of insulators disposed in alternate, parallel relationship and shaped generally as spherical segments of a single hollow sphere, said segments each having a single split or gap therein and creating a single split or gap throughout substantially an entire great semi-circle of said hollow sphere, means to maintain the cavity within said hollow sphere in a substantially evacuated condition, and electrically-conductive bars connected to said segments at points on opposite sides of the splits or gaps therein, said bars extending outwardly from said segments in generally parallel relationship, each of said segments being continuous except at said gap to provide a single-turn electrical circuit around said cavity through which large amounts of current may be passed instantaneously to effect acceleration of ionized particles in said cavity toward the center portion thereof.

7. The invention as claimed in claim 6, in which means are provided to supply large amounts of current to each of said segments through the bars therefor and in a substantially instantaneous manner, said means comprising separate capacitor means connected across the bars for each of said conductive segments, trigger means to control discharge of said capacitor means through said segments, control means to operate said trigger means and to time the discharge of the capacitor means, and means to charge said capacitor means.

8. The invention as claimed in claim 7, in which said current supply means is adapted upon discharge of the capacitor means to effect current flow through all of said segments in the same direction about the axis thereof.

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