

VACUUM TUBE

TECHNICAL FIELD

5 The present invention relates to devices that provide with operating of emitted electrons in a vacuum space and more particularly, to a vacuum tube.

BACKGROUND OF THE INVENTION

10 Vacuum tubes are used for operating of emitted electrons in a vacuum space, one type of which is known as Vacuum Tube Diode. A typical Vacuum Tube Diode for operating of emitted electrons in a vacuum space characterizes by the applied method of transformation of the electron stream in the vacuum space into the electrical current.

15 A conventional Vacuum Tube Diode has a housing with a cathode that has an electron-generating element known as emitter, and an anode located at the opposite side of the housing. At the moment the Vacuum Tube Diode's emitter is activated, there is generated an electron emission between the cathode and
20 anode. The cathode begins generating free electrons that form a stream of emitted electrons directed towards the anode. The result of the said process is the current of electrical energy streaming from the anode of Vacuum Tube Diode.

25 Vacuum Tube Diode that is currently known has a low ability of accumulation of electric charge, because its capacity depends on the mass of streaming emitted electrodes, and because the Vacuum Tube Diode normally has no mechanism for keeping the electrons from falling onto the anode. As such, presently known Vacuum Tube Diodes can only keep electrons inside the housing for a very short time.

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SUMMARY OF THE INVENTION

Embodiments of the present invention provide a device that would be able to store significantly more electrical energy than existing vacuum tubes, and to keep the energy for a relatively long time. With these abilities, vacuum tubes formed according to embodiments of the present invention can provide a large variety of industrial applications.

According to one aspect, the present invention provides a vacuum tube with a housing that provides a vacuum space therein. A cathode and an anode are installed in the housing. When an external power is supplied to the cathode and the anode, an emitter formed on the cathode is activated to generate electrons into the housing. Magnetic elements are provided adjacent to the housing, and the magnetic elements generate a magnetic field to form a three dimensional barrier in the housing. With proper configurations of the vectors of magnetizing of the magnetic elements and the external power supplied to the anode and cathode, the magnetic field acts against the electrons to cause the surrounding three dimensional magnetic barrier trapping the electrons therein, hence to prevent the electrons from contacting the cathode, the anode, internal surfaces of the housing, and other internal elements of the device. Discharging of the electrons from the housing can then be controlled and / or prevented, to achieve the expected accumulation of free electrons in the housing.

In one embodiment, the magnetic elements include multiple dispersed permanent magnets aligned in radial orientation, and made as the elements of the housing. These permanent magnets may be attached to the external surface and/or the internal surface of the housing. Alternatively, the housing itself may be a permanent magnet. Since the magnets are placed surrounding the vacuum space including the area between the cathode and the anode, and since the magnetic field changes the vector of motion of the electron stream generated by the cathode, the electrons are kept in confinement, without touching the walls of the housing and without reaching or touching the cathode, and the anode. The

said magnetic field keeps the electrons away from the housing, the cathode and the anode at a distance sufficient to prevent the electrons from being caught by the housing, the cathode and / or the anode. Accordingly, the electrons accumulated inside the housing form a dense electron cloud of slow electrons.

5 The maximum density and pressure of the electron cloud are proportional to the power of the multiple magnetic elements and to the potential between the anode and the cathode during the charging process. After the charge, the electron cloud can be kept inside the vacuum space for a relatively long time, and without making an output current, due to the power of the magnetic field of the multiple
10 magnetic elements.

In another embodiment, the magnetic elements include a flexible sheet of magnetic material wrapped around, and covering an external surface of the housing. In yet another embodiment, the magnetic elements include particles of
15 magnetic material formed within a wall of the housing. In a further embodiment, the magnetic elements include a layer of magnetic material coated on an external and/or internal surface of the housing.

BRIEF DESCRIPTION OF THE DRAWINGS

These and other aspects and advantages of the present invention will be described in detail with reference to the accompanying drawings, in which:

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Fig. 1A is a schematic cross sectional front view of a vacuum tube according to one embodiment of the present invention;

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Fig. 1B is a schematic front view of a magnet used in the vacuum tube shown in Fig. 1A;

Fig. 1C is a schematic cross sectional front view of a vacuum tube which is an alternative of that shown in Fig. 1A;

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Fig. 2A is a schematic cross sectional front view of a vacuum tube according to another embodiment of the present invention, when in an electron accumulation state;

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Fig. 2B is a schematic cross sectional front view of Fig. 2A, when in an electron discharge state;

Fig. 3A is a schematic cross sectional front view of yet another embodiment of the present invention;

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Fig. 3B is a partial schematic cross sectional top view of Fig. 3A;

Fig. 4A is a schematic cross sectional front view of still another embodiment of the present invention;

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Fig. 4B is a flow chart showing a method of making a vacuum tube shown in Fig. 4A;

Fig. 5A is a schematic cross sectional view of a further embodiment of the present invention;

5 Fig. 5B is a flow chart showing a method of making a vacuum tube shown in Fig. 5A;

Fig. 5C is a schematic cross sectional view of a vacuum tube which is an alternative of that shown in Fig. 5A.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

For the purpose of illustration, embodiments of the present invention will be described to a device or apparatus suitable for storing electrical energy, which
5 may be described as vacuum tubes suitable for accumulating electrons.

Embodiments of the present invention will also be described to a method of utilizing electrical energy and a method of making vacuum tubes for utilizing electrical energy. Nevertheless, it will be understood by one skilled in the art that
10 embodiments of the present invention are applicable to cases where vacuum tubes with the capabilities of accumulating electrons may be used in other applications, such as electrical power supplies.

As shown in Fig. 1A, a vacuum tube 100 according to one embodiment of the present invention has a cylindrical glass housing 110, a cathode 112, an
15 emitter 114 and an anode 116 disposed in the housing 110. When the cathode 112 and anode 116 are connected to external power source (not shown), the emitter 114 will be activated, and generate electrons 118 in the housing 110.

It should be appreciated that although the emitter is described here as a
20 separate element, the emitter may also be in the form of an integrated part of the cathode. A vacuum tube may not necessarily include an emitter as a separate element, but the cathode itself may serve as the emitter. It should also be appreciated that vacuum tubes according to embodiments of the present invention may be formed with a housing of shapes other than cylindrical described here.
25 For example, the housing may be a spherical shape, an irregular shape or a combination of different shapes.

Magnetic elements 102, including multiple dispersed permanent magnets 120, are attached to and surrounding the housing 110, with similar magnetic
30 polarities orientated surrounding the housing. One example of the multiple permanent magnets 120 is shown in Fig. 1B. As an alternative of the vacuum tube shown in Fig. 1A, Fig. 1C shows a vacuum tube 101 configured with part or

all multiple permanent magnets 120 attached to the internal surface of the housing 110. Each one of the magnets 120 has an individual magnetic field, represented by magnetic lines 122. When the magnets are attached to the housing 110, the magnetic fields of the multiple permanent magnets are combined together, forming a three-dimensional barrier 124 inside the housing 110. Facing the repulsive forces from the barrier 124, the electrons 118 are trapped inside the barrier 124, without contacting the housing 110. With the emitter 114 remains activated, more electrons are generated, and accumulated in the housing 110.

When the accumulation of the electrons reaches a predetermined level, the emitter 114 may be deactivated, and the cathode 112 and anode 116 may be disconnected from the external power source. The vacuum tube 100 now has the accumulated electrons kept inside and by virtue of the barrier 124, the electrons can be kept for a relatively long time.

The accumulated electrons can be converted into a current by applying a higher potential to the anode 116, by using an external magnetic force, or by other appropriate methods of discharge, as illustrated below.

Fig. 2A is a schematic cross sectional front view of a vacuum tube 200 according to another embodiment of the present invention. According to the present embodiment, a vacuum tube may be used as a power supply device.

As shown in Fig. 2A, a vacuum tube 200 has a housing 210, a cathode 212, an emitter 214 and an anode 216 installed in the housing 210. Multiple permanent magnets 220 are attached to and surround the housing 210. It should be noted that for the purpose of easy illustration, magnetic lines of the multiple permanent magnets are not shown in Fig. 2A. A barrier 224 is formed by the combined magnetic field of the multiple permanent magnets 220. When the emitter 214 is activated, electrons 218 are generated in the housing, and are trapped inside the barrier 224.

One or more of the multiple permanent magnets 220, for example 220a, 220b, 220c and 220d attached to the bottom side of the housing 210, are configured to be movable relative the housing 210, between a first position shown in Fig. 2A, and a second position shown in Fig. 2B.

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When at the first position, the magnets 220a, 220b, 220c and 220d are attached to the housing 210 and the magnetic fields of magnets 220a, 220b, 220c and 220d together with those of other magnets form the barrier 224, to trap the electrons 218 inside. When magnets 220a, 220b, 220c and 220d are at the first position, the electrons are repulsed away from contacting the cathode, the emitter, the anode as well as the housing 210. Electrons 218 can then be accumulated in the housing 210, in a manner similar to that illustrated above in conjunction with Figs. 1A and 1B.

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The magnets 220a, 220b, 220c and 220d may be detached from housing 210 and moved to the second position, as shown in Fig. 2B. Moving magnets 220a, 220b, 220c and 220d to the second position will bring the magnetic fields of the magnets 220a, 220b, 220c and 220d away from the housing 210, causing a change in the strength, shape and/or size of the barrier 224. Fig. 2B shows one of the situations of the change in the strength, shape and/or size of the barrier 224.

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As shown in Fig. 2B, movement of magnets 220a, 220b, 220c and 220d away from the housing 210 increases the size of the barrier 224 by which, an end portion 212a of the cathode 212 is included inside the barrier 224. It follows that, the electrons 218 can contact cathode 212 through the end portion 212a and accordingly, the electrons 218 can be discharged from the cathode 212. The electrical energy possessed by the accumulated electrons 218 can then be released or discharged from the vacuum tube 200.

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A person skilled in the art would appreciate that, by appropriate electrical circuits and connections, a vacuum tube according to the present embodiment may be used as an electrical power supply, such as a rechargeable battery.

5 Figs. 3A and 3B show a vacuum tube according to yet another embodiment of the present invention.

In the present embodiment, a vacuum tube 300 has magnetic elements 302 surrounding a cylindrical housing 310. The magnetic elements 302 include a
10 flexible sheet 320 made of magnetizable material, wrapped around the housing 310. The flexible sheet 320 is then magnetized, with polarities 320a oriented surrounding the housing 310, as shown in Fig. 3B. Flexible sheet 320 now has a combined magnetic field generated in the housing 310. On the top and bottom sides of the cylindrical housing 310, there are attached permanent magnets 322a
15 and 322b.

Similar to the magnets illustrated above, the magnetic fields of the flexible sheet 320 and the permanent magnets 322a and 322b form a barrier 324 in the housing 310. When electrons 318 are generated in the housing 310, the barrier
20 324 traps the electrons 318 therein, and prevents the electrons 318 from contacting cathode 312, emitter 314 and anode 316 installed in the housing 310. Electrons 318 can then be accumulated in the housing 310, making the vacuum tube 300 an energy storage device.

25 Fig. 4A is a schematic cross sectional front view of still another embodiment of the present invention. As shown in Fig. 4A, a vacuum tube 400 has a housing 410 formed of silicon glass material. A partial enlarged view of housing 410 is also shown in Fig. 4A. During forming the glass housing 410, magnetizable particles 420, such as magnetizable sand particles, are mixed with
30 liquid-form glass material, and together form the glass housing 410.

Once the liquid-form glass material is cold and solidified, the magnetizable particles 420 are enveloped in a wall of the housing 410. Thereafter, the housing 410 is placed into an electro-magnetizing device, such as an open-core electromagnet, for a predetermined period of time. The magnetizable particles 420 inside the wall of the housing 410 can then be magnetized, and generates a magnetic field inside the housing 410. The magnetic field forms a barrier 424 to trap electrons 418 generated in the housing 410, in a manner similar to the embodiments illustrated above.

The present embodiment is advantageous in that, since there is no operation of mounting or attaching magnets onto the housing, as required according to previous embodiments, the overall cost of making the vacuum tube will be much lower and further, the assembling process of the vacuum tube will be much faster. Besides, the magnetizable sands particles are much cheaper than the shaped magnets. Moreover, the present embodiment enables the housing to be made with other shapes, such as spherical or irregular shapes. The present embodiment also enables the integration of the vacuum tube manufacturing process into the productions lines of making other glass wares or articles.

Fig. 4B is a flow chart showing a method 450 for making a vacuum tube shown in Fig. 4A. According to the method, firstly, as shown in block 452, particles of magnetizable material are added into, and mixed with liquid-form glass material. Thereafter, as shown in block 454, the liquid glass is solidified, to form the shaped glass housing, with the magnetizable particles enveloped in the wall of the glass housing. The glass housing is then placed under an external magnetic field, so that the particles of magnetizable material can be magnetized, as shown in block 456.

Fig. 5A is a schematic cross sectional front view of a further embodiment of the present invention. As shown in Fig. 5A, a vacuum tube 500 has a housing 510 and magnetic elements 502 formed surrounding the housing 510. The magnetic elements 502 provide a magnetic field to form a barrier 524 in the housing 510.

In the present embodiment, the magnetic elements 502 include a layer of magnetizable material coated on the housing 510. In one example, the layer of magnetizable material is formed of a multi-component mixture of magnetizable
5 powders and non-organic materials, including a mixture of different types of silicates and liquid conductors. Prior to be coated on the housing, the mixture is in the liquid state or a paste form under room temperature.

The magnetizable powder may be made of one or more types of magnetic
10 materials. Before mixing with the liquid components, the magnetizable powders are undergoing a demagnetizing process.

When the magnetizable powders are properly mixed with the liquid conductors, the mixture is coated on the housing by, for example, painting,
15 spraying or the like. The coated mixture is then dried to form a layer of magnetizable material 520 on the external surface of the housing 510. As an alternative of the vacuum tube shown in Fig. 5A, Fig. 5C shows a vacuum tube 501 configured with a magnetizable material 520 coated at the internal surface of the housing 510.

Thereafter, the housing 510 is placed into an electro-magnetizing device, such as an open-core electromagnet for a predetermined period of time. The layer 520 coated on the housing 510 can then be magnetized, and generates a magnetic field inside the housing 510. The magnetic field form a barrier 524 to
25 trap electrons 518 generated in the housing 510, in a manner similar to the embodiments illustrated above.

Fig. 5B is a flow chart showing a method 550 of making a vacuum tube shown in Fig. 5A. According to the method, firstly, as shown in block 552,
30 powders of magnetizable material are mixed with liquid conductors to form a paste of magnetizable powders. Thereafter, as shown in block 554, the paste is coated on a housing, and dried to form a layer of magnetizable material on a surface of

the housing. The housing is then placed under an external magnetic field, so that the layer of magnetic powders can be magnetized, as shown in block 556.

5 The present embodiment provides an alternative yet convenient and efficient solution to form a vacuum tube, to provide a housing with magnetic elements. The overall cost of making the vacuum tube is much lower. Further, the assembling process of the vacuum tube will be much faster.

10 The vacuum tube according to embodiments of the present invention can be used as a vacuum tube device for accumulating emitted electrons and store the electrons for a relatively long time, and to convert the accumulated electrons into electrical current by adding a discharging system.

15 Although embodiments of the present invention have been illustrated in conjunction with the accompanying drawings and described in the foregoing detailed description, it should be appreciated that the invention is not limited to the embodiments disclosed, and is capable of numerous rearrangements, modifications, alternatives and substitutions without departing from the spirit of the invention as set forth and recited by the following claims.

CLAIMS

1. A vacuum tube comprising:
 - a housing providing a vacuum space therein;
 - 5 an anode and a cathode disposed in the housing for generating electrons in the vacuum space, and
 - magnetic elements disposed adjacent to the housing,
 - wherein a magnetic field generated by the magnetic elements forms a three dimensional barrier in the vacuum space, and
 - 10 wherein the barrier is to trap the electrons therein.
2. The vacuum tube as recited in claim 1, wherein the magnetic elements comprise a plurality of magnets attached to the housing.
- 15 3. The vacuum tube as recited in claim 2, wherein the plurality of magnets are attached to an external surface of the housing.
4. The vacuum tube as recited in claim 2, wherein the plurality of magnets are attached to an internal surface of the housing.
- 20 5. The vacuum tube as recited in claim 1, wherein the magnetic elements comprise a flexible sheet of magnetizable material covering the housing.
6. The vacuum tube as recited in claim 1, wherein the magnetic elements
- 25 comprise particles of magnetic material enveloped in a wall of the housing.
7. The vacuum tube as recited in claim 1, wherein the magnetic elements comprise a layer of magnetic material coated on a surface of the housing.
- 30 8. The vacuum tube as recited in claim 7, wherein the layer of magnetic material is coated on an external surface of the housing.

9. The vacuum tube as recited in claim 7, wherein the layer of magnetic material is coated on an internal surface of the housing.
- 5 10. The vacuum tube as recited in claim 1, wherein at least a part of the magnetic elements is movable relative to the housing between a first position and a second position to vary the magnetic field in the housing, wherein when at the first position the electrons are prevented from contacting the anode and the cathode, and when at the second position the electrons are allowed to contact at least one of the anode and the cathode.
- 10 11. A vacuum tube comprising:
a housing providing a vacuum space therein;
an anode and a cathode disposed in the housing for generating
electrons in the vacuum space, and
15 wherein the housing generates a magnetic field forming a three dimensional barrier in the vacuum space, and
wherein the barrier is to trap the electrons therein.
- 20 12. The vacuum tube as recited in claim 11, further comprising a permanent magnet attached to the housing, wherein the permanent magnet is movable relative to the housing between a first position and a second position to vary the magnetic field in the housing, wherein when the at the first position the electrons are prevented from contacting the anode and the cathode, and when at the second position the electrons are allowed to
25 contact at least one of the anode and the cathode.