Dec. 21, 1965 F. L. WATTENDORF ET AL 3,225,225

HIGH VOLTAGE ELECTROSTATIC GENERATOR

Filed July 18, 1963 4 Sheets-Sheet 1

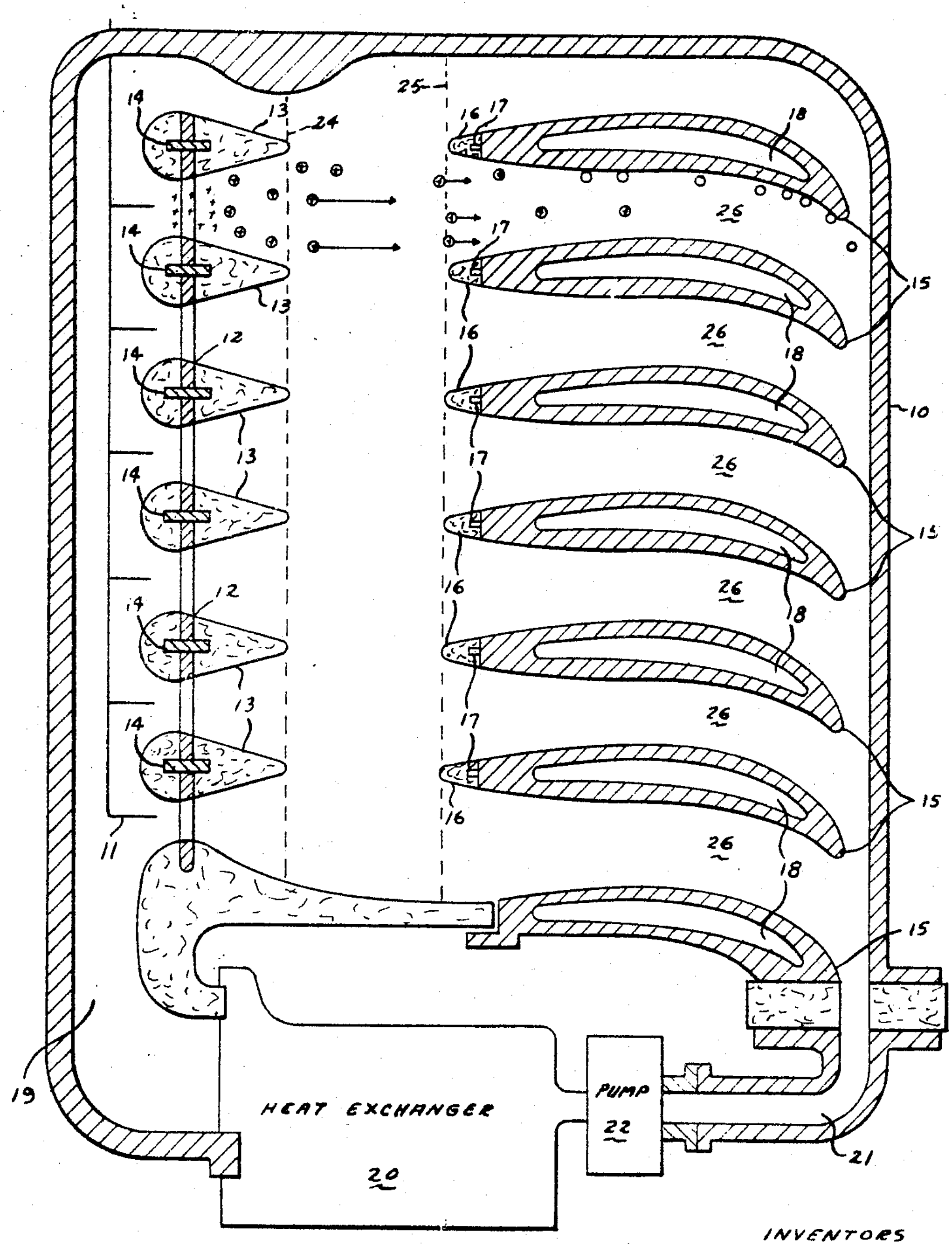

Fig-1

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HIGH VOLTAGE ELECTROSTATIC GENERATOR

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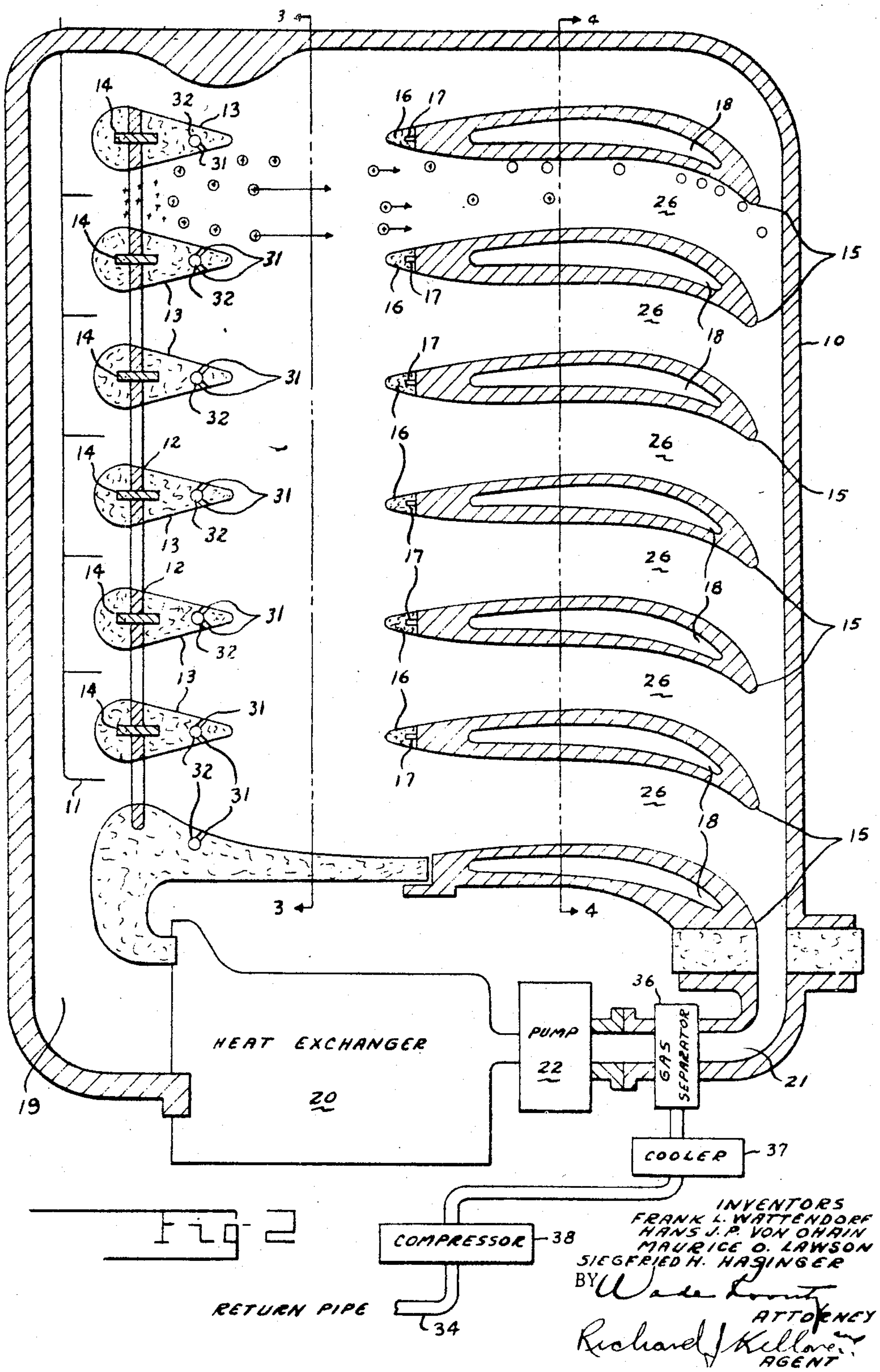

Fig. 2

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HIGH VOLTAGE ELECTROSTATIC GENERATOR

Filed July 18, 1963 4 Sheets-Sheet 3

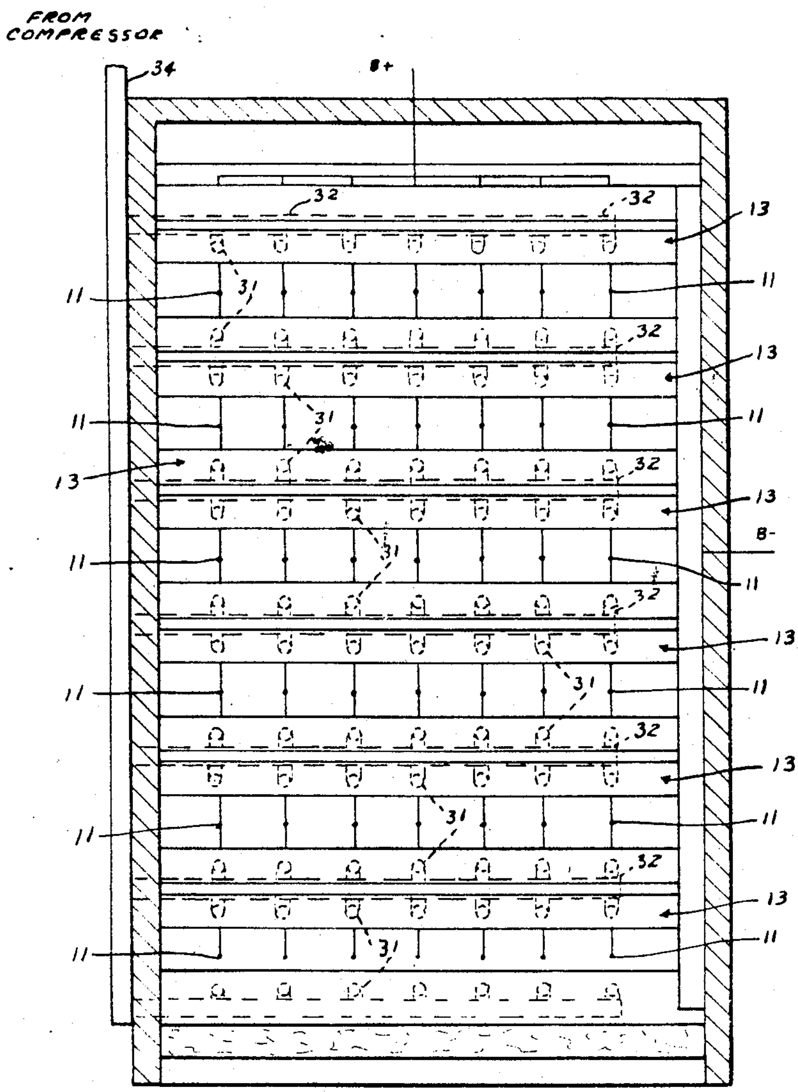

Fig-3

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HIGH VOLTAGE ELECTROSTATIC GENERATOR

Filed July 18, 1963 4 Sheets-Sheet 4

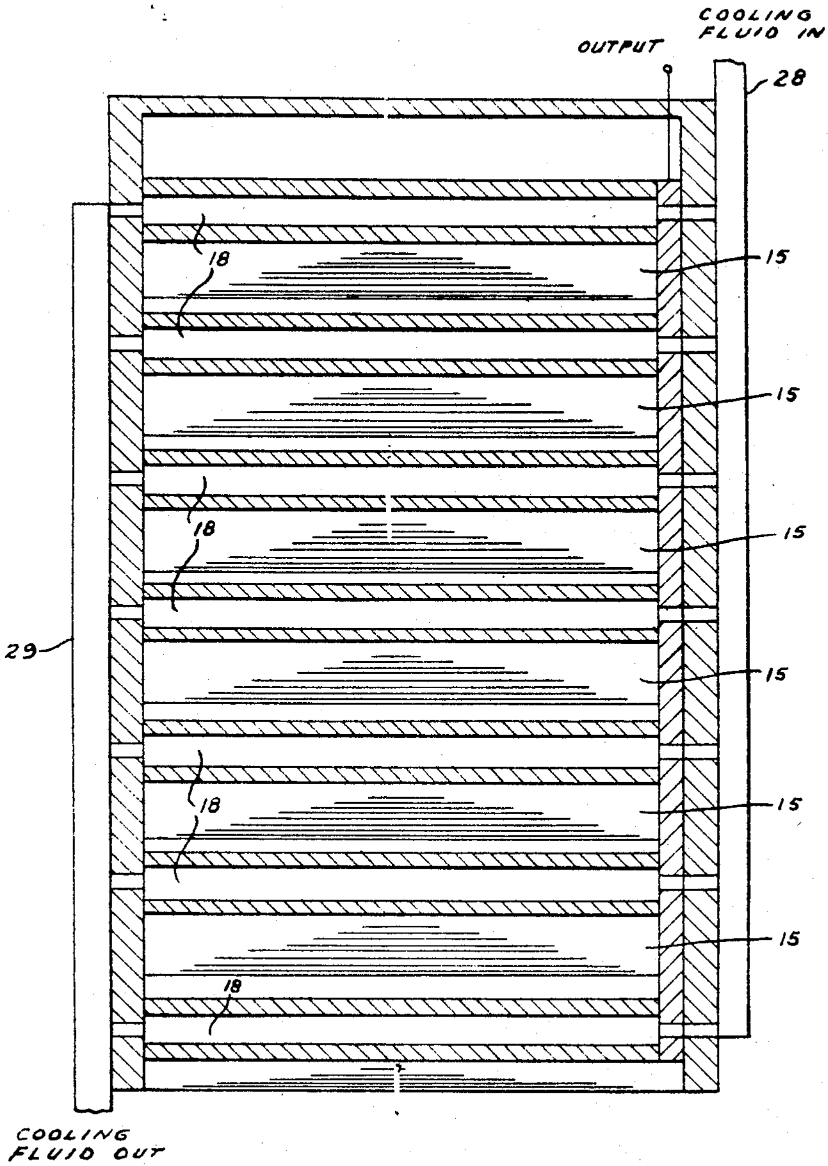

Fig-4

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3,225,225

HIGH VOLTAGE ELECTROSTATIC GENERATOR

Frank L. Wattendorf, New York, N.Y., and Hans J. P. von Ohain, Brookville, and Maurice O. Lawson and Siegfried H. Hasinger, Dayton, Ohio; said Von Ohain, Lawson, and Hasinger assignors to the United States of America as represented by the Secretary of the Air Force

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7 Claims. (Cl. 310—6)
(Granted under Title 35, U.S. Code (1952), sec. 266)

The invention described herein may be manufactured and used by or for the United States Government for governmental purposes without payment to us of any royalty thereon.

This invention relates to a device for directly converting thermodynamic energy into electrical energy.

One object of the invention is to provide an electrostatic generator wherein the mass to charge ratio of the working substance can be varied over a wide range.

Another object of the invention is to provide an electrostatic generator wherein the mass to charge ratio is substantially uniform.

These and other objects will be more fully understood from the following detailed description taken with the drawing wherein:

FIG. 1 is a sectional view of an electrostatic generator according to the invention;

FIG. 2 is a sectional view of a modification of the device of FIG. 1;

FIG. 3 is a partial sectional view of the device of FIG. 2 along the line 3—3; and

FIG. 4 is a sectional view of the device of FIG. 2 along the line 4—4.

Direct electrostatic-fluid dynamic energy conversion processes can be grouped into two large families, namely:

(a) Processes in which charged colloids or ions of one sign are transported against an electrostatic field by viscosity interactions with a gaseous or dielectric liquid working substance such Gourdine's electric wind generator.

(b) Processes in which a major portion of the working substance is first transformed into kinetic energy of charged particles, which then transport the electric charges against an electrostatic field along a ballistic path. In this process the kinetic energy of the particles decreases as their electrical potential energy increases. The device of this invention relates to the use of the second process.

The major problems in the use of this second process lies in the production of high-speed charged particles having a suitable or uniform mass to charge ratio.

According to this invention energy for producing high-speed particles is taken from a pressurized gas employing an energy exchange process from the internal energy of the gas to kinetic energy of droplets, from the pressure head of gas from which the particles are produced. In prior art devices the charge is added to the working substance after the expansion process. According to this invention the charge particles are seeded into the working medium prior to the expansion process so that the charge particles in the vapor flow serve as condensation nuclei around which the water vapor condenses during during the expansion process. This provides a substantially uniform mass to charge ratio. The mass to charge ratio can be varied over a wide range by controlling the rate of ion production for a given rate of condensation by varying the potential difference bewteen the needle electrodes and the grid electrode.

Referring now to FIG. 1 of the drawing, the drawing reference number **10** refers to an electrostatic generator

having a plurality of rows of needle electrodes **11** as shown in FIG. 3 adjacent a grid electrode **12**. Expansion nozzles **13** of insulating material are formed adjacent the grid electrode **12** such as by molding around support members **14**.

Spaced from the nozzles **13** are a plurality of receiving electrodes **15**. The tip of the receiving electrodes adjacent nozzles **13** are coated with insulating material **16** around support members **17**. Ducts **18** are provided in the receiver electrdoes through which a cooling liquid such as water may run. A high pressure gas such as steam is supplied to the electrostatic generator through a flow duct **19** from a heat exchanger **20**. The condensed gas is returned to the heat exchanger by means of a return pipe **21** and a pump **22**.

In the operation of the device of the invention the high temperature gas from the heat exchanger **20** passes through flow duct **19**. Ions are seeded into the gas by the effect of the field between the grid **12** and needle electrodes **11**. The gas is expanded in nozzles **13** so that a major portion of the gas is condensed to form small droplets of uniform size around the ions. At the exit of the nozzles **13** the major portion of the energy available in the working medium is transformed into kinetic energy of the charged droplets. As the particles pass between planes **24** and **25** they are decelerated by the electric field effect between these planes. The charged droplets are further decelerated in the passages **26** between the receiver electrodes **15**. The cooling liquid from inlet tubes **28** in channels **18** cools any remaining gas, as shown in FIG. 4. The liquid passes out through tube **29** also shown in FIG. 4. The condensed liquid is returned to the heat exchanger **20** through return pipe **21** and pump **22** after it has given up its charge to the receiver electrodes **15**. The sign of the potential applied to grid **12** and needle electrodes **11** is determined by whether negative or positive ions are to be seeded into the working medium. Also other working medium besides water can be used, for example, mercury or rubidium.

The gas which does not condense in the nozzle and which is condensed by the cooling liquid in channels **18** is lost energy. A greater portion of the working medium can be converted into useful working substance by modifying the device of FIG. 1 in the manner shown in FIG. 2 wherein a gas such as hydrogen, which does not condense in the expansion process, is added to the working substance through ducts **31** and channels **32** and inlet tube **34**, shown in FIG. 3. The gas may be removed in a liquid gas separator **36** in any well known manner such as by gravity separation. The gas is then cooled in a standard type cooler **37** and supplied to tube **34** through a standard type gas compressor **38**. Since hydrogen has a much higher heat capacity than the usual gases which are used as the working substance only a small amount of hydrogen is needed for cooling. The structure of FIG. 2 is otherwise the same as FIG. 1.

While the ducts **31** and channels **32** are shown as being located within nozzle members **13**, it is obvious that separate tubes and ducts could be provided either upstream or adjacent the nozzle members **13**.

There is thus provided a device for direct conversion of thermodynamic energy into electric energy.

While certain specific embodiments have been described in detail it is obvious that numerous changes may be made without departing from the general principles and scope of the invention.

We claim:

1. An electrostatic generator comprising a plurality of needle discharge electrodes, a plurality of receiver electrodes, a grid electrode located between said discharge

electrodes and said receiving electrodes, a plurality of expansion nozzle means attached to said grid electrode, means for applying a first potential to said discharge electrodes, means for applying a second potential to said grid electrode, means for directing a stream of high pressure high temperature gas past said discharge electrodes through said nozzle means toward said receiving electrodes, to thereby condense said gas around charge particles leaving said discharge electrodes, means within the gas stream for cooling said gas and output means connected to said receiver electrodes.

2. An electrostatic generator comprising a plurality of needle discharge electrodes, a plurality of receiver electrodes, means for cooling said receiver electrodes, a grid electrode located between said discharge electrodes and said receiving electrodes, a plurality of expansion nozzle means attached to said grid electrode, means for applying a first potential to said discharge electrodes, means for applying a second potential to said grid electrode, means for directing a high pressure high temperature gas past said discharge electrodes through said nozzle means to thereby condense said gas around charge particles leaving said discharge electrodes and an output means connected to said receiving electrodes.

3. An electrostatic generator comprising a plurality of needle discharge electrodes, a plurality of receiver electrodes, means for cooling said receiver electrodes, a grid electrode located between said discharge electrodes and said receiving electrodes, a plurality of expansion nozzle means attached to said grid electrode, means for applying a first potential to said discharge electrodes, means for applying a second potential to said grid electrode, a heat exchanger, means for directing a high pressure high temperature gas from said heat exchanger past said discharge electrodes through said nozzle means to thereby condense said gas around charge particles leaving said discharge electrodes and means for returning the condensed gas to said heat exchanger and an output means connected to said receiving electrodes.

4. An electrostatic generator comprising a plurality of needle discharge electrodes, a plurality of receiver electrodes, means for cooling said receiver electrodes, a grid electrode located between said discharge electrodes and said receiving electrodes, a plurality of expansion nozzle means attached to said grid electrode, means for applying a first potential to said discharge electrodes, means for applying a second potential to said grid electrode, a heat exchanger, means for directing high pressure high temperature steam from said heat exchanger past said discharge electrodes through said nozzle means to thereby condense said steam around charge particles leaving said discharge electrodes,, means for returning the condensed steam to said heat exchanger and an output means connected to said receiving electrodes.

5. An electrostatic generator comprising a plurality of needle discharge electrodes, a plurality of receiver electrodes, means for cooling said receiver electrodes, a grid electrode located between said discharge electrodes and said receiving electrodes, a plurality of expansion nozzle means attached to said grid electrode, means for applying a first potential to said discharge electrodes, means for applying a second potential to said grid electrode, a heat exchanger, means for directing high pressure high temperature mercury vapor from said heat exchanger past said discharge electrodes through said nozzle means to thereby condense said mercury vapor around charge particles leaving said discharge electrodes, means for returning the condensed mercury vapor to said heat exchanger and an output means connected to said receiving electrodes.

6. An electrostatic generator comprising a plurality of needle discharge electrodes, a plurality of receiver electrodes, means for cooling said receiver electrodes, a grid electrode located between said discharge electrodes and said receiving electrodes, a plurality of expansion nozzle means attached to said grid electrode, means for applying a first potential to said discharge electrodes, means for applying a second potential to said grid electrode, a heat exchanger, means for directing a high pressure high temperature working gas past said discharge electrodes through said nozzle means to thereby condense said gas around charge particles leaving said discharge electrodes, means for supplying a cooling gas to said working gas adjacent said nozzles, means for returning the condensed gas to said heat exchanger and an output means connected to said receiving electrodes.

7. An electrostatic generator comprising a plurality of needle discharge electrodes, a plurality of receiver electrodes, means for cooling said receiver electrodes, a grid electrode located between said discharge electrodes and said receiving electrodes, a plurality of expansion nozzle means attached to said grid electrode, means for applying a first potential to said discharge electrodes, means for applying a second potential to said grid electrode, a heat exchanger, means for directing a high pressure high temperature working gas past said discharge electrodes through said nozzle means to thereby condense said gas around charge particles leaving said discharge electrodes, means for supplying hydrogen gas to said working gas adjacent said nozzles, means for returning the condensed gas to said heat exchanger and an output means connected to said receiving electrodes.

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