

OZONE GENERATOR AND A METHOD FOR GENERATION OF OZONE

Field of the invention

The present invention relates to an ozone generator and a method for generating ozone by exposing oxygen to a high frequency alternating current with high voltage over a dielectric.

Background of the invention

Ozone has strongly oxidizing features and is used, preferably diluted, to sterilize water. For example may waste water be treated for purpose of breaking down or eliminating substances dangerous for the environment or the health as well as unpleasant smells from the water, and the drinking-water may be pre-treated for purpose of improving the water quality. Other fields of application are e. g. as bleaching agent in the paper industry, for air purification purposes, and to perform certain oxidizing reaction in organic chemistry.

Ozone mixed with oxygen is produced by passing oxygen gas or gas rich in oxygen through an electric discharge. Oxygen gas or gas rich in oxygen is thereby made to flow through a chamber in an ozone generator or ozonizer, which chamber either is delimited by two tubes having the same axis or by plates in series, between which an electric discharge occurs. In this description the expressions space and chamber are used as representing the same, i.e. the place in the ozone generator where existing oxygen gas or gas rich in oxygen is converted to ozone.

The first mentioned type of ozone generator is for industrial purpose very large and space demanding and also difficult and expensive to produce and maintain. The second type of ozone generator is more economic and less space demanding, but has still certain sealing and strength problems and does not operate optimally.

A problem related to ozone generators is connected to that the chamber in which the oxygen in the form of oxygen gas or gas rich in oxygen is converted to ozone at least has one delimiting surface constituted of a dielectric material, a di-

electric. This dielectric is utilized for the purpose of generating a corona at the discharge between a high voltage electrode and earth, and is generally composed of a ceramic or a glass material. High gas pressures and not the least pressure variations in the gas supplied to the chamber, for example caused by pressure shocks in the
5 system when the gas supply is engaged or disengaged, generates high stresses on the ceramic with the consequence of the ceramic risking to crack.

Another problem is related to the sealing required between said dielectric and the opposite delimiting surface of the chamber, which opposite surface generally constitutes electric earth. This sealing is exposed to the influence of high gas
10 pressure and pressure shocks. In addition the sealing is a problem for the useful life and the reliability of the ozone generator since ozone is particularly reactive, whereby common rubber gaskets tend to break down and cause leakage.

Concrete exemplary embodiments of ozone generators have been described in a manifold of publications, i. a. in the following:

15 In US, A1, 5,354,541 is thus a tubular ozone generator described comprising i. a. a helical spring electrode 12, a tube 14 of dielectric material surrounding the electrode 12 and also a tubular, earthed and cooled second electrode 15. Between the second electrode 15 and the tube 14 is an annular chamber 16 for ozone generation delimited. Supply of oxygen to the only annular chamber 16 for ozone genera-
20 tion occurs one-sided, whereby in the beginning also the pressure influence is one-sided. During operation a pressure influence is continuously present from the outside against the tube 14, and this pressure influence varies instantaneously by pressure shocks which may occur during the operation. Altogether this causes major stresses on the construction and major risk for damages and leakage.

25 In US, A1, 4,960,570 a complex and material demanding ozone generator is described with i. a. tubes 3, 8 of a dielectric material, alternatively tubes having an outer coating of dielectric material. The tubes 3, 8 have internally a metallic film 4 constituting one electrode, alternatively show a separate electrode 10 inside the tubes 3. The tubes 3 are located between two flat external electrodes 1, 2, which are
30 cooled. Spaces or chambers 6 and 11, respectively, for ozone generation are found

between the tubes 3 and the plate electrodes 1, 2, and possibly also in the tubes 3 between the inside of the tubes and the electrode 10 therein. It is not evident from the publication how the spaces 6, between the details 3, 8 of dielectric material and the cooled electrodes 1, 2, are supplied with oxygen for ozone generation, and consequently nor how these details are affected by the pressure from the supplied oxygen or by pressure shocks arising during operation.

Through WO, A1 9701507 an ozone generator is known, which comprises two plates 2 of a dielectric material, and between them is a thread or net shaped electrode 3 located, over which electrode 3 is a high frequency alternating current with high voltage is applied and, on the outside of the plates 2, earthed and cooled electrodes 4. A space for ozone generation is delimited between the plates 2 and a frame 3'. The ozone generator is, from the inside of the space for ozone generation, exposed to pressure influence, whereby the plates 2 tend to separate. Instantaneously, at pressure shocks, this pressure influence may increase. Major risks for damages and sealing problems for the ozone generator exists. There are no spaces for ozone generation outside the plates 2.

In US, A, 5,435,978 is finally also a flat ozone generator with two electrodes 1 described, which intermediately form a space 2 for ozone generation. On the respective electrode 1 a layer of dielectric material is applied. In order to compensate the pressure in the internal space 2 for ozone generation, an external pressure is applied on the ozone generator by locating it in a pressure vessel, in which a gas under pressure is supplied. Instantaneous pressure differences due to pressure shocks, which occur during operation of the ozone generator, are however hard to handle. The risk for damages is large at these occasions.

Yet another ozone generator design is shown in "High Density Ozone Generation In a Very Narrow Gap By Silent Discharge" by M. Kuzumoto, Y. Tabata and S. Yagi, Mitsubishi Electric Corporation. The proposed design discloses a thin circular one-sided discharge chamber between a ceramic plate and an earth electrode. Gas inlets to the chamber are arranged in the periphery of the chamber, while an outlet is arranged in the center of the chamber through a hole in the earth



electrode. The ceramic plate rests, on the opposite side of the chamber, against a stress buffering plate of unknown kind, which in its turn is adjacent to a metal plate. Towards the stress buffering plate the ceramic plate is coated with a metal layer, which forms a high voltage electrode. The depth of the chamber is defined by a
5 metal spacer located therein and comprises radially extending support element.

Purpose with the invention

A purpose with the present invention is to provide an ozone generator and a method for ozone generation, which overcome the problems with the prior art. An
10 aspect of this purpose is to use a simple, compact and less costly design to increase the power and improve the conversion efficiency compared to known ozone generators, and moreover to prevent components of the apparatus to be damaged or to deteriorate in efficiency due to the overpressure of supplied gas and due to pressure shocks arising during the operation of the apparatus.

15 A further aspect of this purpose is to provide a design, which gives a uniform pressure distribution over the delimiting surfaces of the gas chamber.

Another aspect of this purpose is to provide a design that is adapted to protect a sealing, arranged between a dielectric and an opposite delimiting surface, from wear as a consequence of the reactive action of the ozone.

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Summary of the invention

According to a first aspect of the present invention an ozone generator B referred to, for these purposes comprising a unit, in which unit a high voltage electrode and an electrically isolating element, preferably a dielectric element, are
25 joined, and a chamber which is delimited by said dielectric element and by an earth electrode. The invention is, according to the first aspect, characterized by the ozone generator being arranged to operate with pressure equilibrium, whereby a pressure change in said chamber is arranged to act with equal force on opposite sides of said unit.

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According to a second aspect of the invention an ozone generator is referred

to, comprising a high voltage electrode, and also a first and a second dielectric element, arranged on opposite sides of said high voltage electrode. These dielectric elements are on opposite sides of said high voltage electrode arranged in sealed connection with a first and a second earth electrode, respectively, whereby the
5 respective earth electrodes are arranged to delimit a first and a second sealed chamber, respectively, towards said first and second dielectric element, respectively. More specifically according to a third aspect of the invention, an ozone generator is thus referred to, wherein a high voltage electrode is located centrally between two uniform sealed chambers, and wherein each one of the chambers on one side is
10 delimited from said high voltage electrode by a dielectric, and on another side by an earth electrode. With this arrangement the for ozone generators sensitive dielectric element is exposed to equal gas pressure and gas pressure variations from opposite sides, whereby the pressure is equalized.

According to a fourth aspect an ozone generator is referred to, comprising a
15 high voltage electrode and a dielectric, which dielectric delimits a sealed chamber to an opposite wall with an intermediate endless sealing. According to the fourth aspect, the invention is characterized by a recess being formed in an outer part of the chamber, endlessly extending adjacent said sealing, in which recess an inlet to said chamber emerges, whereby the chamber presents a larger depth in said recess than
20 in its central part. Preferably an outlet from said chamber, intended for output of ozone, is arranged with an orifice at the central part of the chamber. With this arrangement the supplied oxygen gas or gas rich in oxygen is made to first fill said recess, in which the smallest resistance for the gas to diffuse is provided, and thereafter to diffuse towards the central parts of the chamber. With a uniform gas flow,
25 which flow due to the locations of the inlet and outlet is directed from the periphery of the chamber to its center, oxygen which first fills the chamber close to the sealing will protect the same from the ozone generated in the chamber.

According to a preferred embodiment of the present invention the ozone generator comprises a pressure compensation admitting unit, which has been joined
30 together with at least two plates of a dielectric material and an electrode present

between said plates, on which electrode a high frequency alternating current with high voltage is applicable, and two sealed spaces for ozone generation on opposite sides of said unit, whereby the respective sealed space, on the side opposite the plate of dielectric material, is delimited by an earthed and cooled electrode, via which
5 oxygen gas or gas rich in oxygen is supplied to the space and ozone is conducted away from the same.

By this arrangement a compact design with minor space requirements is obtained, still having high efficiency without damage or sealing problems at e.g. the unit comprising the plates of dielectric material and the electrode on which a high
10 frequency alternating current with high voltage is applicable, since this unit at the same time is influenced by an overpressure and pressure shocks from two opposite sides, respectively, and by its form moreover forces these overpressures and pressure shocks, respectively, to compensate, i.e. equalize, each other. The compensation of said overpressure and pressure shocks, respectively, which may originate
15 during operation of the apparatus gives stability to the apparatus and thereby an increased conversion efficiency for the same.

The present invention also refers, according to a fifth aspect, to a method for ozone generation comprising the steps of supplying oxygen or gas rich in oxygen to a first chamber, and applying a high frequency alternating current with high voltage
20 to a high voltage electrode for the purpose of causing a discharge in the first chamber over a dielectric to an earth electrode. The method is characterized by pressure changes in the supplied gas being compensated by the gas pressure being forced to operate to the same extent on opposite sides of a compact unit comprising said dielectric. By compact is here meant that the included components in the unit
25 between themselves are in mechanical connection without any intermediate spaces, whereby the unit substantially constitutes a non-compressable body.

More exactly, according to a sixth aspect of the present invention, a method for ozone generation is referred to comprising the steps of oxygen gas or gas rich in oxygen under pressure being conducted from a common source into two uniform
30 sealed chambers, which chambers are delimited from each other by a unit, which

unit comprises two dielectric elements and between them a high voltage electrode, a high frequency alternating current with high voltage being applied on said high voltage electrode, existing oxygen in the chambers thereby being converted to ozone by electric discharges between said high voltage electrode and separate earth electrodes, where each earth electrode respectively delimits one chamber, respectively, on opposite side of the respective dielectric element.

Brief description of the drawings

Further advantages with and characterising features of the apparatus for ozone generation according to the present invention are described thoroughly below with references to the accompanying drawings, in which

figure 1 shows a schematic perspective view of a first preferred embodiment of an ozone generator according to the present invention;

figure 2 shows a schematic longitudinal sectional view of an ozone generator according to figure 1;

figure 3 shows a schematic cross-sectional view of a second preferred embodiment of an ozone generator according to the present invention; and

figure 4 shows schematically a part of the ozone generator according to figure 3, as seen from the inside of its chamber.

Detailed description of preferred embodiments

With reference to the figures 1 and 2 an apparatus for ozone generation, an ozone generator or ozonizer, is thus schematically shown in a first preferred embodiment.

As is evident from especially figure 2 a sealed space or a chamber 1 for ozone generation in said apparatus for ozone generation is on one side delimited by a plate 2 of dielectric material, preferably a ceramic, glass or similar, and on the opposite side by an earthed and cooled electrode 3 of e.g. aluminum, stainless steel or the like, preferably aluminum due to its good thermal conductivity. An electrode

4 of e.g. aluminum, copper or another electric conductive material and on which a high frequency alternating current with high voltage is applicable, is arranged on the opposite side of the plate 2 of dielectric material as said sealed space/chamber 1.

The plate 2 of dielectric material and the respective electrodes 3, 4 all present
5 suitable size and shape for the referred purpose. The mentioned details of the presented embodiment are e.g. shaped as four-sided, almost quadratic plates, but the plates, or the like, may also be rectangular, circular, three-sided, five-sided, six-sided and so on.

In order to design an ozone generator in a simple and cost-effective way, in
10 accordance with the invention, having double effect, a second plate 2' of dielectric material is arranged on the opposite side of the electrode 4, on which electrode 4 a high frequency alternating current with high voltage is applicable, as the first plate 2 of dielectric material. The electrode 4, preferably in the form of a foil or a metal sheet, is suitably clamped between the plates 2, 2' of dielectric material, or e.g.
15 screen printed on one or both plates 2, 2' forming a kind of coating thereon, but may also be of another suitable design, for example having the shape of a plate as in the drawings in figures 1 and 2. Required couplings for connection to an alternating current source are not shown. Irrespective of the embodiment of the electrode 4 a compact unit requiring little space, a "packet", is provided according to the inven-
20 tion, composed of the electrode 4 and the two plates 2, 2' of dielectric material, with the capability to resist, absorb two external pressures acting counter-directed thereupon, and to force these pressures to compensate, equalize, each other. The second plate 2' of dielectric material delimits, together with a second earthed and a cooled electrode 3', located opposite said second plate 2', a second sealed space 1' for ozone
25 generation.

Each earthed and cooled electrode 3, 3' is constituted by an earthed block, preferably of one of the above-mentioned metals, and includes a cooling medium or shows ducts (not shown) for a cooling medium in order to achieve required cooling thereof during operation. In each earthed and cooled electrode 3, 3', i.e. in said metal
30 block are further inlet and outlet means formed, preferably inlet passages 5, 5' for

supply of oxygen gas or gas rich in oxygen to respective sealed spaces 1, 1', and respective outlet passages 6 and 6' to conduct ozone away from the respective space 1 and 1'. These passages 5, 5' and 6, 6', respectively, for oxygen gas or gas rich in oxygen and ozone are formed in said metal block 3, 3' in such a way, that when the metal blocks are assembled with the rest of the components to an ozone generator, the passages 5 and 5' extend essentially opposite to each other and the passages 6 and 6' opposite to each other, i. e. extending mirror-inverted to each other, whereby oxygen gas or gas rich in oxygen flows into the sealed spaces 1, 1' of the ozone generator at mainly the same position in the respective space, and equally from the respective space at mainly the same position.

In some of the known embodiments of ozone generators in which oxygen gas or gas rich in oxygen is conducted into a sealed space centrally located in an ozone generator (see e.g. above-mentioned WO, A1 9701507), the ceramic material, often used as the dielectric material, tends for example to crack due to the overpressure generated between the plates of ceramic material, pressing the plates outwardly against the earthed and cooled electrodes (metal blocks), or the sealings to the sealed space brakes down; glue lines give in etc.

The embodiment according to the present invention of an apparatus for ozone generation with double sealed spaces or chambers 1, 1' which are supplied with oxygen gas or gas rich in oxygen from different directions, eliminates the risk for damage on the plates 2, 2' of dielectric material due to the pressure differences arising by the pressurized oxygen gas or gas rich in oxygen and pressure shocks, respectively. This is obtained by applying pressure on the plates 2, 2' from two directions simultaneously and by that the plates together with the intermediate electrode 4 being formed pressure compensating so that applied pressure from said different directions compensate, equalize, each other even when they vary for example due to pressure shocks. The plates 2, 2' of dielectric material and the intermediate electrode 4 should herewith achieve required support from for example one in a pressure compensation admitting unit further included component which co-operates to said pressure compensation. The plates 2, 2' and the intermediate

electrode 4 may also give necessary support to each other, e.g. by being joined according to the above to a pressure compensation admitting unit having no inter-space between said components, and wherein the electrode 4, when having the shape of a plate, may be formed solid as in the figures 1 and 2, or alternatively as
5 e.g. a more or less perforated plate. When oxygen gas or gas rich in oxygen is supplied to the spaces 1, 1' the plates 2, 2' are pressed towards each other. Said embodiment of the apparatus for ozone generation permits supply of oxygen gas or gas rich in oxygen at an overpressure close to 15 bar, resulting in increased efficiency and larger yield. The pressure compensation admitting unit also contrib-
10 utes to the apparatus obtaining a more stabile operation with improved conversion efficiency.

The respective sealed space 1, 1' being delimited by a plate 2 and 2', respectively, of dielectric material and by an earthed and cooled electrode 3 and 3', respectively, is also delimited by at least one endless sealing 7, extending between
15 the plates 2 and 2', respectively, and the electrode 3 and 3', respectively, (see figure 2). In order to achieve optimal sealing effect, the sealing preferably consists of an O-ring 7 of an elastic material proportionately resistant to ozone, e.g. silicone rubber. The plate 2 and 2', respectively, of dielectric material and the earthed and cooled electrode 3 and 3', respectively, are only by pressure in contact with the
20 sealing and are to a certain extent movable in relation to each other in their longitudinal direction. Suitable arrangements for this are probably known and are therefore not described or shown in more detail here. Alternatively may the sealing 7 be formed in or arranged on any of the respective sealed space 1, 1' delimiting parts 2, 3 and 2', 3', respectively. External of respective sealing 7 is suitably at least
25 one ring 10 of electric non-conducting material, preferably teflon or a teflon-like material, arranged to prevent the sealing from moving outwardly due to the pressure in the sealed spaces 1, 1' and to prevent a spark-over directing between the electrodes 3 and 3', respectively, and 4 along their edge sections.

As is evident from the above the plates 2, 2' function as a dielectric. When
30 the electrode 4 is connected to an alternating current source and the electrodes 3, 3'

to earth an electric discharge occurs through the plates 2, 2'. Suitable voltage on the alternating current is preferably in the interval 6.000-30.000 V, while the frequency of the alternating current preferably is in the interval 2-100 kHz. As a result of the discharge a part of the oxygen in the sealed spaces 1, 1' is converted into ozone. The
5 yield may reach about 20 per cent by volume of the gas flowing out through the passages 6 from the ozone generator.

The oxygen gas or gas rich in oxygen which is conducted into the sealed spaces 1, 1' of the ozone generator at high pressure via the passages 5,5' may be made to flow randomly through the sealed spaces 1, 1' towards the outlet passage 6
10 for ozone (see shown dashed and dotted arrows in figure 1) or be directed in winding paths through the spaces. Passages (not shown) for oxygen gas or gas rich in oxygen and ozone may for this purpose be formed in respective sealed space 1, 1' and may each be given desired shape for optimal generation of ozone. In the embodiment shown on the drawings in the figures 1 and 2 with two sealed spaces
15 1, 1' these passages are preferably arranged to extend mainly opposite to each other, i.e. mirror-inverted. The pressure on the plates 2, 2' of dielectric material from the inflow of oxygen gas or gas rich in oxygen is thereby distributed analogously in the both sealed spaces 1, 1' and counteracts itself.

Suitable operating temperature for the plates 2, 2' of dielectric material is
20 about 20°C, though higher temperatures are admitted. However about 80% of the supplied electric energy which is converted to heat, must be cooled, which preferably occurs via the earthed and cooled electrodes 3, 3', i.e. the metal block with cooling medium or with passages with cooling medium.

With the above described sealed spaces 1, 1' for ozone generation, delimited
25 by plates 2, 2' of dielectric material, earthed and cooled electrodes 3, 3' having smooth surfaces, and also by least one endless sealing 7, the thickness of said spaces may primarily be dependent on the thickness of the sealing around the spaces. If, for some reason, a larger volume of said sealed spaces 1,1' is desired, this may easily be achieved by e.g. providing respective earthed and cooled electrode 3, 3' with a
30 recess 8 on the side thereof which delimits such a sealed space. Thus is in the

drawings in the figures 1 and 2 shown preferred embodiment of the ozone generating apparatus according to the present invention, respective sealed space 1, 1' formed mainly of, and the size thereof is by said recess 8 established to that extent that the main part of the space is delimited by the recess and the main part of the size (thickness) of the space is defined by the depth of the recess.

In order to optimize the generation of ozone it is required that the so called corona-effect which is achieved at the electrical discharge between the electrodes is as uniform as possible, i.e. uniformly distributed over the whole surface where the discharge may occur via a dielectric and in presence of oxygen. For this, in turn, an even distance is required between said dielectric and the earth electrode.

To achieve optimal ozone generation, but also to improve the cooling, one embodiment of the present invention is therefore provided with a corona-effect promoting structure 9, being devised to promote a discharge between the electrodes 3, 3' and 4, respectively, and being arranged or formed in the drawn embodiment of figures 1 and 2 in both sealed spaces 1, 1' (see preferably figure 2). In one embodiment said structure is mainly formed as a net 9. In order to achieve the desired uniform distance the net 9, which preferably is made of stainless steel, is constituted of a separate part located in respective sealed space 1, 1' adjacent to the earthed and cooled electrode 3, 3', i.e. in the shown embodiment in the recess 8 thereof. Alternatively the net may however be formed directly in the surface (e.g. the bottom of the recess 8) on respective earthed and cooled electrode 3, 3', which faces and delimits the sealed space 1 and 1, respectively. The net structure may be formed e.g. by stamping, milling, etching or cutting by means of laser in said surface. An embodiment in which the structure is formed in the surface of the earth electrode implies a simpler construction with less comprising parts in the ozone generator, compared to an embodiment with a separate structure 9.

The above described apparatus for generation of ozone may, if so is desired for further enhanced ozone production, be attached to one or more other apparatuses of the same sort to devices with a manifold of stacks of such apparatus. In order to facilitate such an attachment, but also to admit an alternative embodiment according

to the invention, it is with certain modifications of the embodiment shown in the figures 1 and 2 possible e.g. to form one or more of the earthed and cooled electrodes 3, 3' with recesses 8 on two opposite sides thereof, and with the corresponding arrangement as the above described of the plates 2, 2' of dielectric material and also the electrodes 4 for connection to an alternating current source, on both sides of said earthed and cooled electrodes. When needed or desired, a further plate of dielectric material may thus be arranged on the side of the earthed and cooled electrode 3 or, in the embodiment shown on the drawings in figure 1 and 2, on the other side of it or the earthed and cooled electrodes 3, 3', opposing the side(s) which delimit(s) a sealed space 1, 1', such that a further sealed space is delimited between respective further plate and the earthed and cooled electrode(s), and as well may a second electrode on which a high frequency alternating current with high voltage is applicable, be arranged on the opposite side of respective further plate of dielectric material as said further sealed space or spaces.

Supports for the plate 2 of dielectric material and the electrode 4 may be required if no further expansion is made.

Furthermore, it should also be noted that the last mentioned further embodiment of the apparatus according to the present invention for ozone generation of course also is possible even without said recesses on both sides of one or more earthed and cooled electrodes.

In figures 3 and 4 a second preferred embodiment of the invention is shown, which second embodiment in many aspects resembles the first embodiment shown in the figures 1 and 2. Therewith are the reference notations used in figures 3 and 4 the same as those used in figures 1 and 2, where the same or corresponding parts are referred to.

Thus, in figure 3, an ozone generator is shown having a high voltage electrode 4 on which a high frequency alternating current with high voltage is applicable. This high voltage electrode is arranged between a first and a second dielectric element 2 and 2', respectively, which dielectric elements 2, 2' preferably are mounted directly on said high voltage electrode 4 on opposite sides thereof. In

figure 3 the respective dielectric element 2 and 2', respectively, is shown at a distance from the high voltage electrode 4 only for the purpose of clearly showing the position of the high voltage electrode 4. The first dielectric element 2 delimits, on its opposite side of the high voltage electrode 4, a chamber 1 adapted for ozone generation from oxygen gas or gas rich in oxygen. A first earthed electrode 3 delimits the first chamber 1 on the opposite side of the chamber 1 of the first dielectric element 2. Correspondingly, the second dielectric element 2' delimits on its opposite side of the high voltage electrode 4, a second chamber 1', which second chamber 1' is uniform with the first chamber 1. A second earth electrode 3' delimits said second chamber 1' on the opposite side of the chamber 1' of said second dielectric element 2'. In the earth electrodes 3 and 3', respectively, inlet passages 5 and 5', respectively, are arranged, adapted for connection to a common source for oxygen gas or gas rich in oxygen. Further, outlet passages 6 and 6', respectively, are arranged in the earth electrodes 3 and 3', respectively, which outlet passages are adapted for outlet of ozone. Each chamber 1 and 1', respectively, is between its delimiting dielectric element 2 and 2', respectively, and earth electrode 3 and 3', respectively, sealed off with an endlessly extending sealing 7 and 7', respectively. For each sealing 7, 7' a sealing recess 11 and 11', respectively, is therefor arranged in earth electrode 3 and 3', respectively. Furthermore, a support ring 10 is arranged between said earth electrodes 3, 3' outside said sealing 7, 7', for which support ring 10 respective earth electrode 3, 3' is arranged with an outer recess 12 and 12', respectively.

Said second embodiment shown in figures 3 and 4 differ in a couple of aspects from the first embodiment shown in the figures 1 and 2. For example, the second embodiment is characterized by that internal recesses 13 and 13', respectively, are arranged in respective earth electrode 3, 3', endlessly extending immediately inside respective sealing recess 11, 11'. These internal recesses 13 and 13', respectively, are thus situated inside the respective chamber 1, 1', defining in the respective chamber a periphery section having a larger depth than in the respective central section of the chamber.

As is clearly evident from the figures 3 and 4 said inlet passages 5 and 5', respectively, emerge in the respective chamber 1, 1' in these internal recesses 13 and 13', respectively. With this arrangement the gas, preferably oxygen gas, which is supplied to the chambers 1, 1' is brought to first fill said internal recesses 13 and 13', respectively, as the flow resistance is less in the relatively deeper recesses 13, 13' than inwardly the relatively more shallow central section of the respective chamber 1, 1'. Since the gas not until thereafter will flow inwardly towards the respective outlet passage 6, 6' arranged in the center of respective chamber 1, 1', more or less from the entire periphery of the chamber, a uniform pressure distribution over the chamber is achieved. Moreover, fresh gas will continuously be supplied into respective recess 13, 13' and thereby form a barrier between the respective sealing 7, 7' and ozone generated in respective chamber 1, 1', which ozone tends to flow towards the respective outlet passage 6, 6' of the chamber. This barrier effect is particularly advantageous since the highly reactive features of the ozone otherwise means a risk for the sealings 7, 7' to break down. The arrangement with the adjacent to the sealing extending internal recess, and with the inlet passage emerging in said recess and the outlet passage emerging in the center of the chamber, thus guarantees an increased resistance and useful life for the product.

Another feature characterizing the embodiment shown in the figures 3 and 4 is the circular shape, which is illustrated in figure 4. In this figure the earth electrode 3 is shown from the side facing the chamber 1. It is clearly evident where the inlet passage 5 and the outlet passage 6 emerge, and that the different recesses 11, 12, 13 of the earth electrode 3 form a manifold of concentric circles in the periphery of the earth electrode. The circular shape is advantageous since the supplied gas, which first fills the internal recess 13, afterwards has an equally long distance to flow to the outlet passage 6, which further results in a uniform pressure distribution over the chamber 1. The lack of corners following the circular shape is also advantageous at high gas pressure.

The recesses 13, 13' which are adapted to protect the sealings 7, 7' against the ozone may of course be realized in ozone generators with a different shape than

circular, for example as the one shown in figure 1.

In agreement with the embodiment shown in the figures 1 and 2 the earth electrodes 3, 3' may be arranged with a corona-effect promoting structures, for example net patterns arranged in the surfaces of the earth electrodes 3, 3' facing the
5 respective chamber 1, 1'. Also other earlier discussed features of the first embodiment are of course applicable also on the second embodiment. This applies for example to the design of the high voltage electrode 4 and the dielectric elements 2, 2', the cooling of the earth electrodes 3, 3', and also for the embodiment with double-sided earth electrodes 3, 3', which are arranged to delimit further gas
10 chambers.

The embodiment in figure 3 of the invention is, as the one in figure 2, designed to decrease stresses on the dielectric elements 2, stresses that primarily are due to gas pressure variations in a gas supply system which is connected to the ozone generator to supply oxygen gas or gas rich in oxygen to the inlet passages
15 5, 5'. The solution is based on one of the basic principles in physics, namely that such stresses may be decreased or eliminated by a construction allowing pressure compensation. According to the embodiments shown in the figures is this pressure compensation realized by letting oxygen gas or gas rich in oxygen under pressure be conducted from a common source into two uniform sealed chambers 1, 1', and that
20 these chambers in between themselves are delimited by a unit comprising two dielectric elements 2, 2' and between them a high voltage electrode 4. Pressure variations originating from the gas supply system will thus generate equal pressure changes in the two opposite chambers 1, 1', whereby no resulting force arises, acting on the unit located between the chambers.

25 Due to the opposite chambers being arranged with their respective inlet passages 5, 5' and outlet passages 6, 6' on corresponding position on opposites sides of said unit, an ozone generator which is comparatively insensitive to high supplied pressure is also obtained.

For a suitable connection of the ozone generator to a gas supply system the
30 inlet passages 5, 5' are preferably arranged on the same side, as is shown in figure 3.

A larger ozone generator system may easily be built of a stack of ozone generators according to the second embodiment mounted in a pile, since both inlet passages and outlet passages are accessible from the sides of the earth electrodes 3, 3'.

In an alternative embodiment, not shown in the figures, the ozone generator
5 comprises a unit with a first and a second side, and which at least partly is perforated and thereby permeable for gas from said first side to said second side. The unit comprises a high voltage electrode, which is coated with a dielectric material. Preferably comprises the unit a net structure including a high voltage electrode coated with a dielectric material. In the ozone generator the unit is
10 arranged in a chamber, which chamber at least partly is delimited by an earth electrode. The dielectric material delimits the high voltage electrode from the chamber, but due to the permeability for gas of the unit gas pressure variation arising in said chamber are able to propagate to both sides of said unit, whereby no resulting force acting on the sides of the unit arises. The chamber may be arranged
15 with two opposite earth electrodes with the unit located in the chamber between said earth electrodes. The chamber is arranged with an inlet passage for gas, preferably oxygen gas or gas rich in oxygen, and an outlet passage, preferably ozone bearing gas. In an embodiment two inlet passages to the chamber may be arranged, one on each side of said unit, as well as two outlet passages on each side of said unit.

20 In a further embodiment of the invention, comprising a chamber for conversion of oxygen gas or gas rich in oxygen to ozone, the delimiting surfaces of the chamber are constituted of concentric tubes with a common axis instead of plates, whereby the chamber also is tubular. The internal tubular delimiting surface of the chamber comprises a first tubular dielectric material according to the teachings of
25 the prior art. A high voltage electrode is arranged adjacent to the first dielectric element on the opposite side of said chamber, i.e. arranged at the inside of the dielectric tube.

In a first variant of this embodiment the high voltage electrode engages, on the opposite side of the first dielectric tube, a second tubular dielectric element. This
30 second tubular dielectric element delimits in its turn, on its inside, a second

chamber. The respective chamber is, on the opposite side of the respective delimiting dielectric tube, delimited by an earthed metal tube. Furthermore, the ozone generator is arranged with each one inlet passage to the respective chamber, which inlet passages are arranged to be connected to a common gas supply system for
5 supply of oxygen gas or gas rich in oxygen to the respective chamber. The ozone generator thus comprises a series of concentric tubes, in which the two dielectric elements and the electrode located between them constitutes a unit. With the described arrangement pressure variations originating from the gas supply system connected to the ozone generator will influence said unit both from its inside and
10 outside.

In a second variant of the tubular embodiment the tubular unit is constituted of a gas permeable high voltage electrode which is coated with a dielectric material, whereby the unit preferably forms a tubular net structure with an outside and an inside. The unit is arranged in the tubular chamber, and the permeable features of
15 the net structure brings about that a generated pressure change on one side of the unit generates a corresponding pressure change on its opposite side.

In the tubular embodiment of the invention said unit is, in each end of the ozone generator, preferably sealed towards the earthed metal tubes with interposed O-rings. In each end of the respective earthed metal tube a recess is preferably
20 formed, extending in the chamber adjacent to the O-ring devised to seal off the chamber towards the opposing dielectric tube element. In this recess, which forms a deepened section of the chamber, said inlet passage preferably emerges, while said outlet passage preferably emerges centrally on the earthed metal tube. This arrangement causes supplied oxygen gas or gas rich in oxygen first to fill said
25 recess, thereby protecting the adjacent O-ring against ozone generated in the chamber.

For those skilled in the art it is obvious from above that the apparatus according to the present invention may be modified and changed within the frame of the following claims without departing from the idea and the purpose of the inven-
30 tion. Thus the embodiments of the different comprising details in the apparatus may



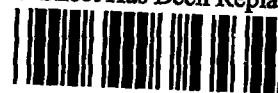
be different from that which have been shown in the drawings and described above. The choice of material may also be different to that proposed above. Mentioned operational parameters may also vary depending on the application and desired effect.

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CLAIMS

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1. An ozone generator comprising:
 - a high voltage electrode (4);
- 5 - a first (2) and second (2') dielectric element, arranged on both sides of said high voltage electrode (4), which dielectric elements (2, 2'), on opposite sides of said high voltage electrode (4) are arranged in sealed attachment to
 - a first (3) and a second (3') earth electrode, respectively, which earth electrodes are arranged to delimit a first (1) and a second (1') sealed chamber,
- 10 respectively, towards said first (2) and second (2') dielectric element, respectively.
2. The ozone generator according to claim 1, wherein said chambers are essentially uniform and arranged symmetrically on both sides of said high voltage electrode.
- 15 3. The ozone generator according to claim 1 or 2, wherein the high voltage electrode (4) is provided with couplings connectable to a power source for application of a high frequency alternating current with high voltage.
- 20 4. The ozone generator according to claim 3, wherein the high voltage electrode (4) is clamped up between the dielectric elements (2, 2').
5. The ozone generator according to claim 3, wherein the high voltage electrode (4) is formed or arranged as a metallic coating on one or both of the dielectric
- 25 elements (2, 2').
6. The ozone generator according to any of the preceding claims, wherein the high voltage electrode (4) is composed of a metal foil or metal sheet.
- 30 7. The ozone generator according to any of the preceding claims, wherein the



* C L M S *

dielectric elements (2, 2') are composed of mainly flat, parallelly arranged bodies.

8. The ozone generator according to any of the preceding claims, wherein each chamber is arranged with inlet means (5, 5') for supply of oxygen gas or gas rich in oxygen, and outlet means (6, 6') for outlet of ozone.

9. The ozone generator according to any of the preceding claims, wherein respective earth electrode (3, 3') is composed of an earthed metal block comprising a cooling medium or having ducts for a cooling medium.

10

10. The ozone generator according to claim 9 in combination with claim 8, wherein said inlet and outlet means for the respective chamber comprises an inlet passage (5, 5') and an outlet passage (6, 6') formed in said metal block (3, 3'), and wherein said inlet passages (5, 5') for said two chambers are adapted for connection to a common conduit for pressurized gas.

11. The ozone generator according to claim 10, wherein the passages (5 and 6, respectively) for oxygen gas or gas rich in oxygen and ozone in the two metal blocks (3, 3') are formed so as to after assemblage of the metal blocks (3, 3') in an ozone generator, extend essentially opposite to each other.

12. The ozone generator according to any of the preceding claims, wherein respective sealed chamber (1, 1') mainly is formed by a shaped recess (8) in the respective earth electrode (3, 3').

25

13. The ozone generator according to any of the preceding claims, wherein each respective sealed chambers (1, 1') is delimited by least one endlessly, between the dielectric element (2, 2') and the earth electrode (3, 3'), extending sealing (7, 7').

14. The ozone generator according to claim 13, wherein said sealing is constituted

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of an O-ring (7, 7').

15. The ozone generator according to any of the claims 13-14 in combination with claim 10, wherein a recess (13, 13') is arranged in the respective earth electrode (3, 3') adjacent within said sealing (7, 7'), endlessly extending close to the sealing, in which recess (13, 13') said inlet passages (5, 5') emerge.

16. The ozone generator according to any of the claims 13-15, wherein a ring (10) of an electrically isolating material is arranged externally of respective sealing (7, 7') to protect against spark-over external of respective chamber (1, 1').

17. The ozone generator according to any of the preceding claims, wherein flow control passages for oxygen gas or gas rich in oxygen and ozone are formed in the inside of respective sealed chamber (1, 1'), adapted to conduct the gas flow in pre-determined directions in said chamber.

18. The ozone generator according to claim 17, wherein flow control passages are arranged to extend mainly opposite to each other.

19. The ozone generator according to any of the preceding claims, comprising a structure (9) arranged or formed in the respective sealed chamber, which structure is formed to promote the forming of a corona-effect at discharge between the high voltage electrode (4), by the dielectric (2, 2'), to the earth electrode (3, 3') in respective chamber (1, 1').

20. The ozone generator according to claim 19, wherein said structure is formed mainly as a net (9).

21. The ozone generator according to claim 19 or 20, wherein the structure (9) is composed of a separate part arranged in respective sealed chamber (1, 1').

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22. The ozone generator according to claim 20 or 21, wherein the structure (9) in the respective sealed chamber (1, 1') is a pattern formed in the respective earth electrode (3, 3').
- 5 23. The ozone generator according to claim 1, wherein an annular sealing (7, 7') is arranged between the respective dielectric element (2, 2') and earth electrode (3, 3'), thereby delimiting said respective chamber to the shape of circular discs, and wherein the respective earth electrode shows an inlet passage (5, 5') adapted to supply oxygen gas or gas rich in oxygen, and an outlet passage (6, 6') adapted to
10 conduct ozone away from the respective chamber (1, 1').
24. The ozone generator according to claim 23, wherein for the respective chamber said inlet passage (5, 5') emerges in the periphery part of the chamber (1, 1'), close to said sealing (7, 7'), and wherein said outlet passage emerges centrally in
15 the chamber.
25. The ozone generator according to claim 24, wherein a recess (13, 13') is formed in said earth electrode in the periphery part of the chamber, extending in a ring concentrically inside said sealing, in which recess (13, 13') said inlet passage
20 emerges.
26. An ozone generator comprising a high voltage electrode (4), located centrally between two uniform sealed chambers (1, 1'), wherein each chamber on one side is delimited from said high voltage electrode by a dielectric (2, 2') and on another side
25 by an earth electrode (3, 3').
27. An ozone generator comprising a unit, in which unit a high voltage electrode (4) and a dielectric element (2, 2') are joined together, and a chamber (1, 1') which is delimited by said dielectric element and by an earth electrode (3, 3'), characterized
30 by that the ozone generator is arranged to work with pressure equilibrium, whereby





a pressure change in said chamber is arranged to operate with equal force on opposite sides of said unit.

28. The ozone generator according to claim 27, arranged to generate the same gas
5 pressure on said opposite sides of the unit.

29. The ozone generator according to claim 28, comprising two chambers (1, 1'),
and wherein said unit comprises two dielectric elements (2, 2') joined together with
said high voltage electrode (4) on both sides thereof, whereby the respective di-
10 electric element delimits a chamber towards an earth electrode (3, 3').

30. The ozone generator according to claim 29, wherein said chambers are mainly
uniform and arranged symmetrically on both sides of said unit.

15 31. The ozone generator according to claim 30, wherein said chambers on respec-
tive opposite sides of said unit are delimited by each one earth electrode, which
earth electrodes are connected to the respective dielectric material with an endlessly
extending sealing (7, 7').

20 32. The ozone generator according to claim 31, wherein said dielectric elements
are composed of mainly flat circular bodies.

33. An ozone generator comprising a high voltage electrode (4) and a dielectric
(2, 2'), which dielectric delimits a sealed chamber (1, 1') towards an opposite wall
25 (3, 3') with an interposed endless sealing (7, 7') characterized by that a recess (13,
13') is formed in an outer part of the chamber, endlessly extending close to said
sealing, in which recess (13, 13') an inlet (5, 5') to said chamber emerges, whereby
the chambers shows a larger depth in said recess (13, 13') than in its central part.

30 34. The ozone generator according to claim 33, wherein an outlet (6, 6') from the





chamber emerges in its central part.

35. A method for ozone generation, whereby:

- oxygen gas or gas rich in oxygen under pressure is conducted from a common
5 source into two uniform sealed chambers (1, 1'), which chambers between themselves are delimited by a unit, which unit comprises two dielectric element (2, 2') and between them a high voltage electrode (4);
- a high frequency alternating current with high voltage is applied on said high voltage electrode (4);
- 10 - oxygen gas present in the chambers (1, 1') is converted into ozone by electric discharges between said high voltage electrode (4) and separate earth electrodes (3, 3'), wherein the respective earth electrode delimits the respective chambers on opposite sides of the respective dielectric element.

15 36. The method according to claim 35, wherein respective dielectric element and earth electrode mainly are flat and joined together with an annular extending sealing, thereby delimiting respective chamber to a flat annular form, and wherein oxygen gas or gas rich in oxygen is conducted into respective chamber at its periphery part and ozone is conducted out from respective chamber at its central part.

20

37. The method according to claim 36, wherein gas conducted into respective chamber, first fills the periphery part of the chamber, due to an annular extending recess (13, 13') arranged in said earth element adjacent to the sealing (7, 7').

25 38. The method according to any of the claims 35-37, whereby oxygen gas or gas rich in oxygen is conducted into the sealed chambers (1, 1') at mainly the same position in the respective sealed chambers, and that ozone is conducted out from the respective sealed chambers at mainly the same position.

30 39. A method for ozone generation comprising the steps of:



- supplying oxygen or gas rich in oxygen to a first chamber;
 - applying a high frequency alternating current with high voltage on a high voltage electrode (4), for the purpose of causing a discharge (2, 2') over a dielectric in the first chamber to an earth electrode (3, 3'), characterized by that pressure
- 5 changes in the supplied gas are equalized by a pressure change in said chamber being arranged to operate with equal force on opposite sides of a compact unit comprising said dielectric.

40. The method according to claim 39, whereby oxygen gas or gas rich in oxygen is
10 supplied from the same source and at the same rate to said first chamber and to a second chamber, and wherein said compact unit forms a partition wall between said chambers.

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