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## (54) Tear gas generating device

(57) The present invention relates to a tear gas generator (1) comprising at least one container (2, 12) which contains an amount of a tear gas generating chemical compound (5) in the solid state, the chemical compound causing irritation of at least one part of an eye upon contact. The container contains a heating (4, 14) for causing evaporation of the chemical compound (5) from the solid state to the gas phase, the heating being in direct and/or indirect thermal contact with the tear gas generating compound (5), and an outlet for expelling the gas from the container and the tear gas generator; the tear gas generating compound in the gas phase causing irritation of at least one part of the eye and/or human soft membranes upon contact.

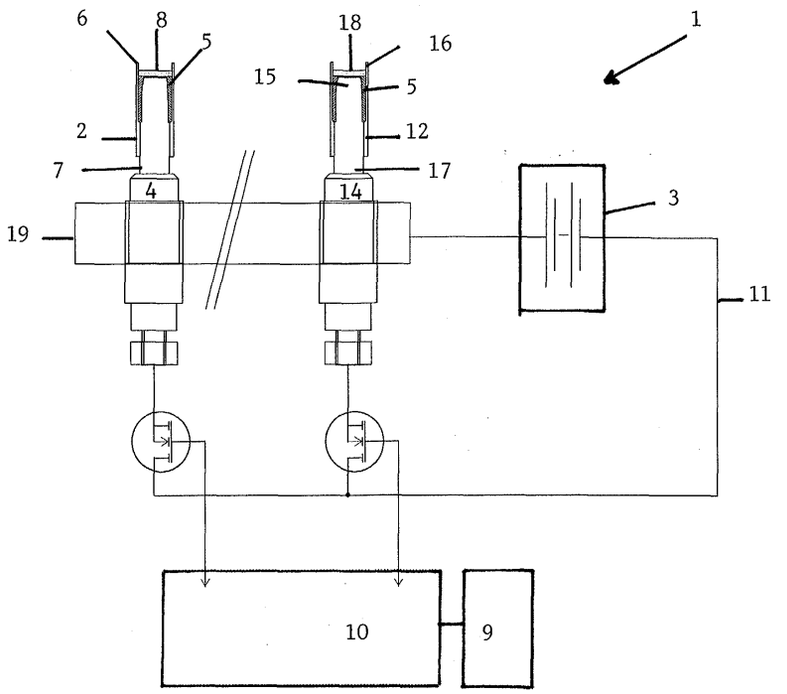


FIG. 1

EP 1 480 002 A1

## Description

**[0001]** The present invention relates to a tear gas generator comprising at least one container which contains an amount of a tear gas generating chemical compound in the solid state, the chemical compound causing irritation of at least one part of an eye upon contact, as disclosed in the preamble of the first claim.

**[0002]** Tear gas is a term which in general is used to designate chemical compounds which even at small concentrations cause irritation of eye lids, tear-ducts and mucous membranes, in particular with human beings. Known products used to generate tear gas include chloro-acetophenone, ortho-chlorobenylidene malontril, dibenz(b,f)-1,4-oxazepin, oleoresin, capsaicin or pepper spray. The latter is not considered as a tear gas, but is rather an irritant product capable of inducing infections.

**[0003]** The afore-mentioned chemical compounds know various practical applications, for example in tear gas grenades used to e.g. suppress demonstrations and in protective safety devices for the interior of buildings. The known safety device comprises a capillary containing an amount of one or more of the afore-mentioned products, and an ignition mechanism. When activating the safety device, an ignation current for the pyrotechnical powder is produced, which induces an instant melting of the powder followed by evaporation. As the capillary explodes, tear gas escapes.

**[0004]** This known tear generator however presents the disadvantage that the tear gas yield based on the amount of powder present in the tear gas generating device is too low.

**[0005]** There is thus a need to a tear gas generator, with which the tear gas yield may be improved.

**[0006]** It is therefore the object of the present invention to provide a tear gas generator showing an improved tear gas yield.

**[0007]** This object is achieved with the present invention with a tear gas generator, which comprises at least one container, the container containing

- an amount of a tear gas generating chemical compound in the solid state
- a heating for causing evaporation of the tear gas generating compound from the solid state to the gas phase, the heating being in direct and/or indirect thermal contact with the tear gas generating compound
- an outlet for expelling the gas;

the tear gas generating compound in the gas phase causing irritation of at least one part of an eye and / or human soft membranes upon contact.

**[0008]** With the device of the present invention, the tear forming product is released in the form of gas, which allows optimizing tear generation upon contact with the eyes and /or human soft membranes, at a tear gas concentration below the acute toxicity of the product. An analysis of the problems associated with powdery tear forming products which contact the eye as a solid/liquefied particle, has shown that these products only produce an effect when there is a direct contact between the solid and the at least one part of the eye. With solid tear generating products the extent of the irritation has been found to be mainly determined by the area of the contact surface between the solid/liquefied particle and the eye part and/or human soft membranes contacted by it, and to a lesser extent by the amount of the product contacting the eyes. The total amount of product contacting the eyes and / or human soft membranes rather determines the acute toxicity of the product.

**[0009]** The thermal contact between the tear gas generating compound and the heating ensures maximum tear gas formation. An analysis of the problems associated with the known tear gas generating device has shown that evaporation of the powder following ignition is usually incomplete. Following ignition only part of the powder has been found to evaporate. The remainder of the powder is entrained as the tear gas leaves the device, powder having the lower tear inducing capacity.

**[0010]** The present invention offers the advantage that the risk to spreading of powder or solidified liquid particles in the environment may be minimized. This allows minimizing the risk to a belated evaporation of the powder as room temperature is raised for example following heating or sun rays, which would render the room unsuitable for human use for a too long period of time.

**[0011]** A preferred embodiment of this invention is characterized in that as a tear gas generating chemical compound, use is made of an amount of at least one aromatic ketone.

**[0012]** Preferred aromatic ketones are acetophenones, in particular chloroacetophenon as with the latter there is a significant difference between (a) the concentration of the product causing detrimental irritation and (b) the lethal product concentration. Because of this difference the risk to undesired abuse may be minimised.

**[0013]** Chloroacetophenon, in particular omega chloroacetophenon, is a particularly useful compound as it combines a relatively low boiling point of only 247°C, with a significantly higher decomposition temperature of 350°C. Because of the low boiling point, little energy is needed to achieve the desired evaporation to the gas phase. The higher decomposition temperature minimizes the risk to decomposition following a controlled temperature shot. The inventor has further observed that chloroacetophenon has a poor water solubility, which hampers removal through washing

with water and that the irritation effect is enhanced upon contact with water and soap.

**[0014]** Another aromatic ketone suitable for use with the present invention is ortho-chlorbenzalmalononitrile, however this compound has a slightly higher melting and boiling point (respectively 93 and 317°C), and is water soluble. A further aromatic ketone suitable for use with the present invention is dibenz (b,f)-1,4 oxazepine.

**[0015]** A preferred embodiment of the tear gas generator of this invention which facilitates product storage, is characterised in that the chemical compound is present in the device in the form of a solid as in the powdery state corrosive properties of the product with respect to the container are the lowest.

**[0016]** Further preferred embodiments of the invention are disclosed in the dependent claims.

**[0017]** The present invention also relates to a container containing an amount of the tear gas generating compound in the solid state.

**[0018]** The present invention further relates to a kit containing a plurality of containers containing an amount of the tear gas generating chemical compound in the solid state, the chemical compound causing irritation of at least one part of an eye upon contact; a heating for causing evaporation of the chemical compound from the solid state to the gas phase; and an outlet for expelling the gas from the container, the kit being removably attachable to the tear gas generator. Thereby, the containers may be received into a housing.

**[0019]** The present invention additionally relates to an alarm device comprising the above described tear gas generator.

**[0020]** The present invention also relates to a method of generating a tear gas as described below in the figure description.

**[0021]** The invention is further illustrated in the appending figures and figure description.

**[0022]** Figure 1 is a schematic representation of the device of the present invention.

**[0023]** Figure 2 is a schematic representation of the container of the present invention.

**[0024]** As can be seen from figure 1, the tear gas generator 1 of the present invention comprises one or more containers or cartridges 2, 12 in which an amount of at least one tear generating product 5 is stored. However, if so desired to improve the irritation produced upon contact, a mixture of two or more tear generating compounds may be used. The tear generating compound is preferably present in the container as a solid powder. To achieve a dense packing, quick heating and high evaporation yield, the particle size of the powder is preferably as small as possible.

**[0025]** Each container or cartridge contains a heating 4, 14 for heating and causing evaporation of the tear generating compound 5, although embodiments may exist in which one single heating functions to heat two or more cartridges. The heating 4, 14 is preferably mounted into the container or cartridge 2, 12 as in that case optimum heat transfer to the tear generating compound may be guaranteed. To ensure optimum heat transfer, the heating is in direct thermal contact or in radiation contact with the tear gas generating powder. This may for example be achieved by means of a heating pin which protrudes into the container, the top 15 of the pin being coated with the tear generating compound 5. Thereby the powder is heated using conduction heating, which may be supplemented by heating through IR radiation. It is however also possible to use any heating ought suitable by the person skilled in the art, for example a heating wire or a resistor or a mantle heating or any other heating known to the person skilled in the art, for example microwave heating, induction heating or convection by means of a flowing hot gas. According to the present invention it is further possible to mix the tear gas generating powder with metal particles, following which the heating rat may be improved. In the embodiment shown in figure 2, the heating pin 4, 14 simultaneously functions as a cover or sealing for one end 7, 17 of the container 2, 12.

**[0026]** The opposite first end 6, 16 of the container 2, 12 is closed off by a removably mounted closure or sealing 8, 18. The container may take the form of a casing or envelope enveloping the heating 4, 14 and the tear gas generating compound, to improve thermal contact between the tear gas generating compound and the heating. The casing or envelope is further sealed by a cover or sealing 8, 18, with the purpose of (i) minimizing the risk to intrusion of dirt or any other unwanted contamination; (ii) maximizing vapour pressure within the cartridge. A practical embodiment of the sealing is for example a heat sensitive fleece, which is broken as the heating reaches a certain temperature, thus providing a direct outlet for the tear gas. The nature of the material of which the removable closure or sealing 8, 18 is made is not critical to the invention. The sealing 8, 18 will however usually be made of a material having a melting point or a decomposition temperature which is sufficiently below the evaporation temperature of the solid tear gas forming product. This ensures that the container 2, 12 is opened at a temperature below the evaporation temperature of the tear gas generating compound 5, thus optimizing production and expelling of tear gas from the container 2, 12.

**[0027]** The tear gas generator 1 may further contain an air or gas supply for supplying air or gas to the cartridge. The gas/air functions to dilute and entrain the tear gas into the room which is to be filled with it.

**[0028]** The device further contains an electric power generator for supplying energy to the heating 4, 14, for evaporating the tear gas forming powder.

**[0029]** When built into a safety device, either the safety device or the tear gas generator 1, may comprises a detector 9 for detecting any unwanted activity in its vicinity. As is schematically shown in figure 1, the detector 9 is coupled to a power control unit 10, for example an electric power control 10, for example an MCU. However any other power

control device ought suitable by the person skilled in the art may be used. The detector 9 is provided to generate a signal when detecting any unwanted activity in the vicinity of the tear gas generator 1, which signal activates the power control 10. It is however also possible to provide means which allow direct activation of the power control 10. The power control 10 in turn is coupled to the electric power supply, which in turn is coupled to the heating 4, 14. The power control unit 10 functions to ensure that the energy supply rate is sufficiently high upon activation of the device, but also to limit the energy supply to the heating in view of minimizing the risk that the temperature of the heating exceeds a pre-set maximum temperature and of minimising the risk to decomposition of the powder.

**[0030]** The MCU may be designed to register the container or containers that have already been used, to select a particular container or to activate the containers in a particular order upon consecutive activations. The MCU is also designed to activate the heating 4, 14 of a particular container upon receiving a signal from the detector. The use of a time-controlled MCU, which de-activates the heating after a pre-set heating time has expired, allows minimizing the risk to over-heating the device or the tear gas generating compound.

**[0031]** The electric power control is preferably done using Pulse Width Modulation, in combination with a Power FET-transistor, as this provides optimum temperature control of the heating pin.

**[0032]** The shape of the container 2, 12 is not critical to the invention and will usually be chosen by the person skilled in the art taking into account the shape of the housing 11 into which it is to be mounted. The container 2, 12 may for example take the form of a substantially cylindrical container, one end of which is closed off by means of a closure 8, 18. The nature of the material of which the container 2, 12 is made is not critical to the invention. The container may for example be made of a plastic material, glass, metal, steel, stainless steel. It is however preferred to have the container made of stainless steel or nickel plated brass as this is the more inert and rigid material.

**[0033]** The container 2, 12 may be used as such. It is however also possible to provide a housing 11 comprising two or more containers 2, 12, the housing being removably connectable to the tear gas generator 1.

**[0034]** The tear gas generator 1 of this invention may further contain a fan or preferably a propellant gas to optimize spreading. It is however also possible to use a propellant gas, a compressed gas or a liquefied gas, for example HFC's or carbondioxide. Carbondioxide is preferred as it has a higher density as compared to air, following which the tear gas/ CO2 mixture forms a thick fog layer above the floor. Carbondioxide has been found to show good miscibility with the tear gas, and a high vapour pressure (approximately 50 Bar at 20°C), thus ensuring fast spreading of the tear gas - carbondioxide mixture over the room to be protected. In that way a single container may suffice to fill an entire room with tear gas in an even concentration.

**[0035]** In the table below, a comparison is made of the effect generated by three different solid tear generating compounds of this invention.

| | (1) | (2) | (3) |
|---|---|---|---|
| TC50 eyes | 0.3 | 0.004 | 0.004 |
| TC50 respiratory tract | 0.4 | 0.023 | 0.002 |
| LC50 | 20-80 | 3.6-20 | 0.7 |
| LCT50 | 14000 | 25000 | no information |

(1): chloroacetophenon

(2) : ortho-chlorobenzylidene malonitril

(3) dibenz(b,f)-1,4-oxazepine

all amounts are given as $mg/m^3$

TC 50 eyes : the minimum amount sensed by 50% of the test persons as a tear generating amount

TC50 respiratory tract: the minimum amount sensed by 50% of the test person in the respiratory tract an mucous membranes

LC50: the minimum amount sensed by 50% of the test persons as unbearable

LCT50: the amount at which there is a 50% risk to a lethal dosis ($mg/m^3$ and per minute).

**[0036]** The invention further relates to a kit of two or more containers 2, 12 containing an amount of a tear gas generating chemical compound 5 in the solid state, the chemical compound causing irritation of at least one part of an eye upon contact; and an outlet for expelling the gas from the container 2, 12, the kit being removably attachable to the heating and the tear gas generator. Thereby, the containers 2, 12 may be received into a housing 19 to facilitate mounting.

## Claims

1. A tear gas generator (1) comprising at least one container (2, 12) which contains an amount of a tear gas generating chemical compound (5) in the solid state, the chemical compound causing irritation of at least one part of an eye upon contact, **characterised in that** the container contains a heating (4, 14) for causing evaporation of the chemical compound (5) from the solid state to the gas phase, the heating being in direct and/or indirect thermal contact with the tear gas generating compound (5); and an outlet for expelling the gas from the container and the tear gas generator; the tear gas generating compound in the gas phase causing irritation of at least one part of the eye and/or human soft membranes upon contact.

2. A tear gas generator as claimed in claim 1, **characterised in that** as the tear gas generating compound (5) use is made of at least one aromatic ketone or a mixture of two or more of those.

3. A tear gas generator as claimed in claim 1 or 2, **characterised in that** as the tear gas generating compound (5) use is made of at least one acetophenon or a mixture of two or more of those.

4. A tear gas generator as claimed in any one of claims 1-3, **characterised in that** as the tear gas generating compound (5) use is made of chloroacetophenon.

5. A tear gas generator as claimed in any one of claims 1-4, **characterised in that** the tear gas generating compound (5) is present in the form of a solid.

6. A tear gas generator as claimed in any one of claims 1-5, **characterised in that** the container (2, 12) comprises a first end (6, 16) made of a material having a melting point below the evaporation temperature of the tear gas generating compound (5), and a second end (7, 17) comprising the heating (4, 14).

7. A tear gas generator as claimed in claim 6, **characterised in that** the heating (4, 14) comprises a top (15) which protrudes into the container (2, 12), at least part of the top being coated with the tear gas generating compound (5).

8. A tear gas generator as claimed in any one of claims 1-7, **characterised in that** the tear gas generator comprises a detector (9), which is coupled to a power control (10), the power control (10) in turn being coupled to the heating (4, 14), the detector being provided to detect any unwanted activity in the vicinity of the tear gas generator (1), to generate a signal upon detecting such unwanted activity which activates the power control (10), the power control (10) being provided to generate a signal to activate the heating (4, 14) upon activation by the detector (9).

9. A tear gas generator (1) as claimed in any one of claims 1-8, **characterised in that** the tear gas generator (1) comprises a housing (11), the at least one container (2, 12) being removably attachable to the housing (11).

10. A tear gas generator (1) as claimed in any one of claims 1-9, **characterised in that** the tear gas generator (1) comprises a plurality of containers (2, 12) which are mounted into a housing (19) the housing being removably attachable to the tear gas generator (1).

11. A tear gas generator as claimed in any one of claims 1-10, **characterised in that** as the power control (10) use is made of a MCU, which is provided to de-activates the heating after a pre-set heating time has expired.

12. A container (2, 12) containing an amount of a tear gas generating chemical compound (5) in the solid state, the chemical compound causing irritation of at least one part of an eye upon contact; a heating (4, 14) for causing evaporation of the chemical compound from the solid state to the gas phase; and an outlet for expelling the gas from the container (2, 12) for use with the tear gas generator of any one of claims 1-11.

13. A kit of two or more containers (2, 12) containing an amount of a tear gas generating chemical compound (5) in the solid state, the chemical compound causing irritation of at least one part of an eye upon contact; a heating (4, 14) for causing evaporation of the chemical compound from the solid state to the gas phase; and an outlet for expelling the gas from the container (2, 12), the kit being removably attachable to the tear gas generator as claimed in any one of claims 1-11.

14. A kit as claimed in claim 13, **characterised in that** the containers (2, 12) are received into a housing (19).

**15.** An alarm device comprising the tear gas generator as claimed in any one of claims 1-11.

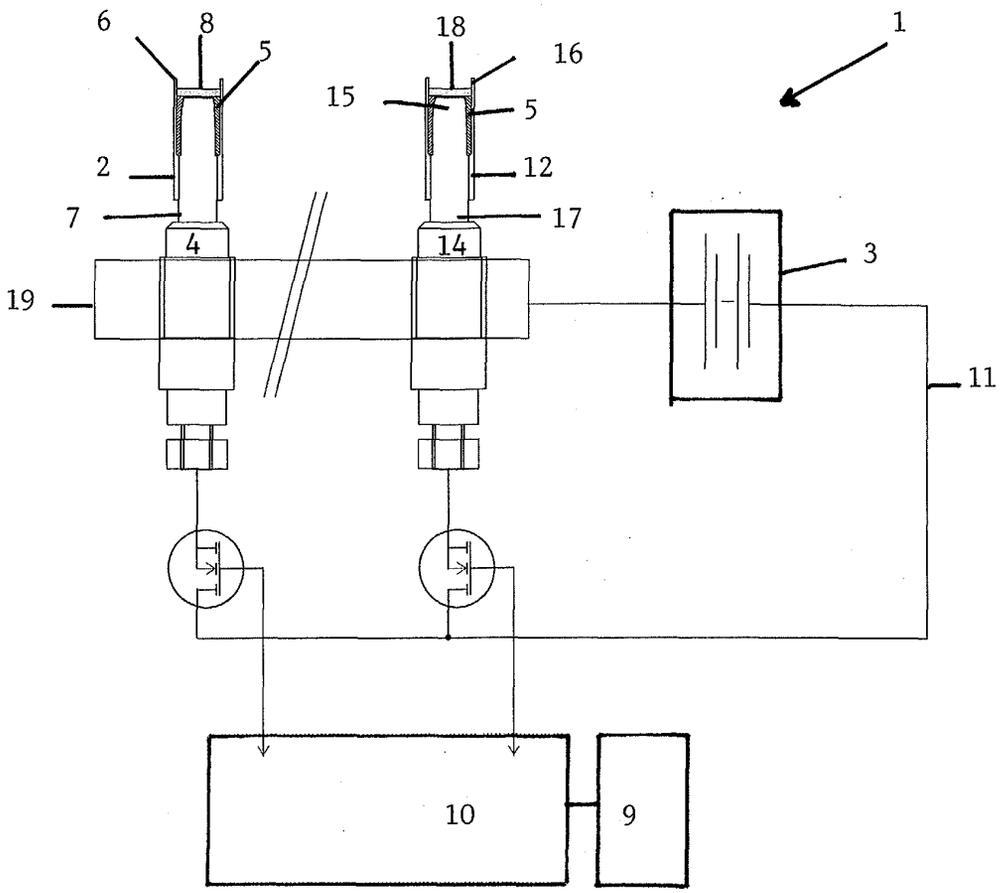


FIG. 1

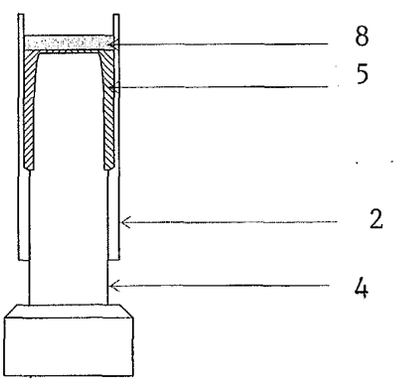


FIG. 2

European Patent Office

# EUROPEAN SEARCH REPORT

Application Number
EP 04 44 7129

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The present search report has been drawn up for all claims

| Place of search | Date of completion of the search | Examiner |
|---|---|---|
| The Hague | 28 July 2004 | Lostetter, Y |

CATEGORY OF CITED DOCUMENTS

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## ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 04 44 7129

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28-07-2004

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