Oct. 24, 1950 B. VONNEGUT 2,527,231

METHOD OF GENERATING SILVER IODIDE SMOKE

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Fig.1.

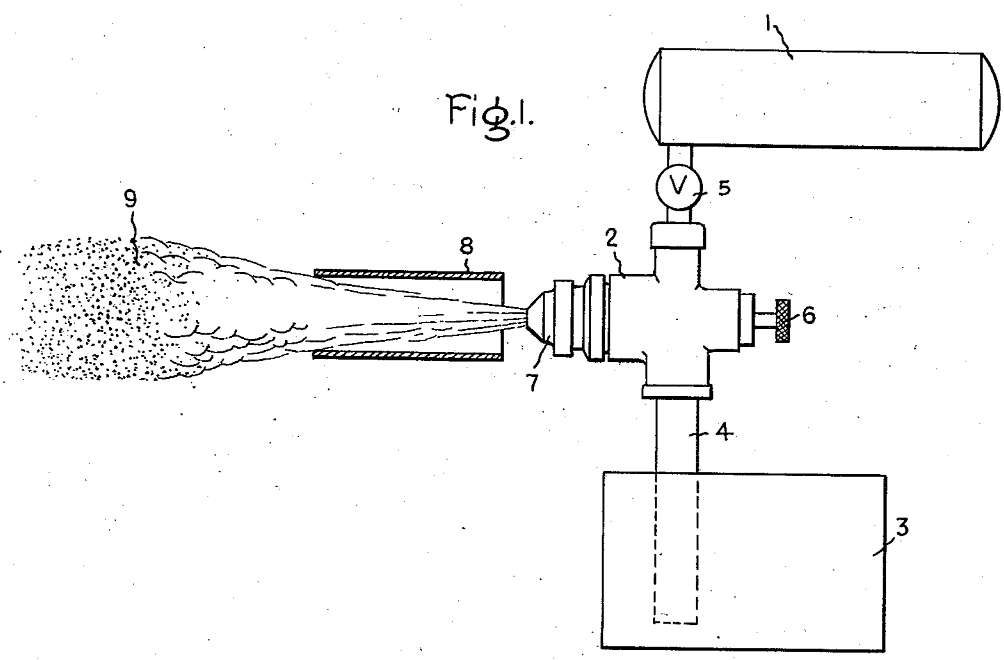
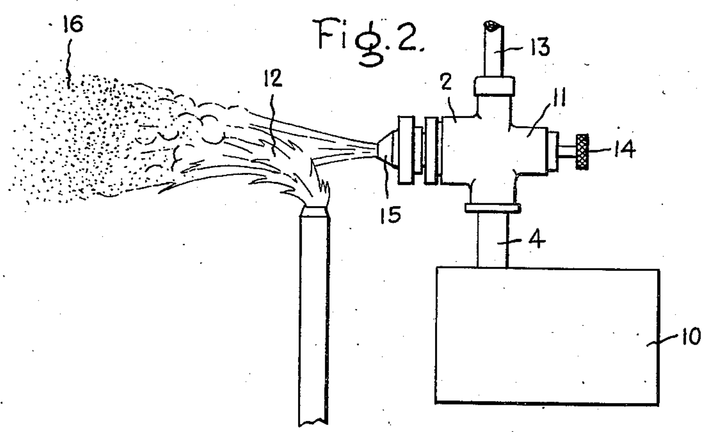


Fig.2.



Inventor:
Bernard Vonnegut,
by [signature]
His Attorney.

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METHOD OF GENERATING SILVER IODIDE SMOKE

Bernard Vonnegut, Alplaus, N. Y., assignor to General Electric Company, a corporation of New York

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7 Claims. (Cl. 252—305)

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This invention relates to the generation of silver iodide in the form of very fine particles. More particularly, the invention is concerned with a process for obtaining a multitude of fine particles of silver iodide which comprises spraying a solution of silver iodide into a flame or heated zone maintained at a temperature of at least 1500° C.

One of the objects of this invention is to provide a method for producing smokes comprising fine particles of silver iodide.

Another object of this invention is to provide a method of producing large numbers of very small particles of silver iodide.

In the copending application of Vincent J. Schaefer and myself, Serial No. 3,544, filed January 21, 1948, and assigned to the same assignee as the present invention, there is disclosed and claimed a method for causing crystal formation in supercooled water droplets and vapors supersaturated with respect to ice by introducing into these masses minute particles of silver iodide. The present invention is concerned with methods for producing the minute particles of silver iodide employed in practicing the invention disclosed and claimed in the aforementioned Schaefer and Vonnegut application.

In accordance with my invention, I prepare a solution of silver iodide using any of the methods well known in the art. Thus, I may employ a solution of silver iodide in a combustible or flameable solvent, such as acetone, using a small amount of sodium iodide in the solution for the purpose of making the silver iodide more soluble. A silver iodide solution may also be prepared using water as the solvent medium and a soluble iodide, such as sodium iodide, for increasing the solubility of the silver iodide therein. Additional examples of silver iodide solutions may be, for instance, silver iodide in a water solvent employing a soluble cyanide, such as KCN, for increasing the solubility of the silver iodide, silver iodide using ammonium hydroxide as the solvent, silver iodide employing liquid ammonia as the solvent, etc. It will, of course, be apparent to those skilled in the art that other means for preparing the silver iodide solutions may be employed without departing from the scope of this invention.

The concentration of the silver iodide in the solution may be varied within wide limits depending on such factors as solubility, solvent medium, the method used to obtain the multitude of fine particles, etc. I have found that good results are obtained when the silver iodide comprises from about 1 to 40 per cent, for instance, from 10 to 20 per cent, by weight, of the total weight of the solution. However, I do not intend to be limited to these proportions since larger or smaller proportions of silver iodide may also be employed.

Various methods may be employed in obtaining

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the large number of fine particles desired for practicing the invention disclosed and claimed in my aforementioned copending joint application with Vincent J. Schaefer. One method comprises spraying the silver iodide solution into a heated zone, specifically, a flame, maintained at the temperature at least at which silver iodide has an appreciable vapor pressure. It has been found that the heated zone should be at a temperature of at least about 1500° C. in order to obtain the desired degree of size of silver iodide particles. It will be obvious to those skilled in the art that much higher temperatures may be employed, for example, from 1500 to 3000° C. or higher without departing from the scope of the invention.

Another method for practicing the invention comprises atomizing the silver iodide solution with a gas, either combustible or non-combustible, and thereafter conducting the atomized silver iodide solution into a heated zone described as above. Among non-combustible gases which may be employed for atomizing the silver iodide solution are, for instance, helium, nitrogen, air, etc. Combustible gases which may be used in atomizing the silver iodide solution are, for example, hydrogen, methane, butane, acetylene, etc. Generally, the type of gas employed for effecting atomization of the silver iodide solution is not critical and any gas which can be maintained under pressure may be employed.

I have obtained good results when the solvent employed for the silver iodide is of a combustible nature, for example, acetone, and the gas used for atomizing the silver iodide solution is also combustible. If this combination of conditions is employed, it is possible to ignite the mixture of combustible gas and atomized solution of silver iodide at a point near which they mix to obtain a heated zone having the necessary temperature.

The accompanying drawing shows specific embodiments of the manner in which this invention may be practiced.

Fig. 1 is a cross-sectional view of an apparatus wherein a combustible gas, such as hydrogen, under pressure is confined in a tank 1. The gas is allowed to course through an atomizing apparatus 2, similar to an ordinary paint spraying apparatus, so as to atomize, i. e., cause a fine spray, of a silver iodide solution which is confined in a tank 3 and which is connected to the atomizing apparatus by means of a conduit 4. A valve 5 controls the rate of flow of the hydrogen gas and another valve 6 controls the rate of exit of the mixture of hydrogen gas and silver iodide solution. The silver iodide solution, which preferably comprises a combustible solvent such as acetone, comes out of the atomizing apparatus at its nozzle 7 in the form of a fine spray and is directed into a flame holder 8. At this point it is ignited and, due to the combustible properties of the combustible gas and the combustible solvent, the spray will continue to burn as it leaves the nozzle. Because of the burning of the gas and silver iodide solution, the solvent is volatilized leaving behind minute particles 9 of silver iodide suspended in the flame, which then evaporate to form a gas, which gas upon leaving the flame condenses as very fine particles of silver iodide, greatly smaller than the original particles formed by the spray nozzle.

Fig. 2 is a cross-sectional view of another apparatus designed to give a large number of small minute particles of silver iodide. More particularly, a silver iodide solution confined in a tank 10 is sprayed by means of a spraying apparatus 11 into a heated zone 12 such as, for example, a flame. The spraying is accomplished by introducing a gas through a pipe 13 under pressure into the spraying apparatus so that atomization of the silver iodide solution is effected. The gas used need not be ignitible and may be ordinary air under pressure. The solvent for making the silver iodide solution also need not be combustible and may comprise ordinary water. The valve 14 controls the rate of atomization of the silver iodide solution. As the fine spray of silver iodide solution comes out of the nozzle 15 of the atomizing apparatus and enters the heated zone, the heat evaporates the solvent from the fine spray leaving behind a multitude of fine particles 16 of silver iodide, which are vaporized and converted to a still smaller size in the manner described above in the use of the apparatus embodied in Fig. 1.

In employing the claimed method for producing the large number of particles of silver iodide for causing crystal formation in natural-occurring clouds, it has been found effective to spray the silver iodide solution into the flame of a ram-jet burner. Thus, with a fuel consumption of about 10 gallons of kerosene per hour, 1 lb. of silver iodide per hour can be dispersed as a smoke. With this arrangement, a high concentration of silver iodide is used in the solution, for example, about 20 to 30 per cent, by weight, of the solution.

The diameter of the silver iodide particles produced in accordance with my method may vary, for example, from about 0.003 micron to about 10 microns or somewhat larger in size. The number of silver iodide particles produced has been found to be as high as 10^{14} particles per second. The size of the silver iodide particles produced may be controlled by adjusting the rate at which silver iodide is introduced into the atomizing apparatus; the rate of introduction into the apparatus may in turn be controlled by the concentration of the solution or by changing the rate of flow of the solution.

It will, of course, be apparent to those skilled in the art that instead of employing a silver iodide solution for producing minute particles of that particular salt, namely, silver iodide, other solutions of salts may be employed in place of the silver iodide solution so as to produce either large numbers of particles of the particular salt employed or else large numbers of particles of conversion products of the salts employed originally in the solution.

Thus, it is possible to atomize solutions of such salts as, for example, sodium chloride, aluminum sulfate, sodium hydroxide, iron sulfate, etc. Because of the stability to heat of such salts as sodium chloride and sodium hydroxide, it will be apparent that the fine particles produced in accordance with my claimed process will comprise essentially the finely divided form of the starting material. In connection with the salts which are not heat stable, but instead are oxidized at the elevated temperatures of the flame, there will be obtained oxides of the aforementioned salts. In connection with this, when one employs, for instance, aluminum sulfate, the conversion product produced by the heat of the flame into which the aluminum sulfate solution is sprayed will be aluminum oxide, and iron oxide will be obtained from a solution of iron sulfate sprayed into the flame.

What I claim as new and desire to secure by Letters Patent of the United States is:

1. The process of obtaining a multitude of fine particles of silver iodine which comprises spraying a solution of silver iodide into a heated zone maintained at a temperature of at least 1500° C.

2. The process of obtaining a large number of fine particles of silver iodide which comprises spraying a solution of silver iodide into a heated zone maintained at a temperature of at least 1500° C. while simultaneously passing a current of gas through said zone to disperse the particles of silver iodide.

3. The process of obtaining a multitude of fine particles of silver iodide which comprises atomizing a solution of silver iodide and injecting the atomized solution into a heated zone maintained at a temperature of at least 1500° C.

4. The process of obtaining a large number of fine particles of silver iodide which comprises atomizing a solution of silver iodide with air and conducting the atomized solution into a flame having a temperature of at least 1500° C.

5. The process of producing a large number of fine particles of silver iodide which comprises (1) atomizing a solution of silver iodide in which the solvent is combustible and (2) igniting the atomized solution at a temperature of at least 1500° C.

6. The process of preparing a large amount of fine particles of silver iodide which comprises (1) atomizing with a combustible gas a solution of silver iodide and (2) subjecting the combustible gas at the point of atomization to an ignition temperature of at least 1500° C.

7. The process of obtaining myriads of fine particles of silver iodide which comprises (1) atomizing with hydrogen gas a solution of silver iodide containing a combustible solvent and (2) subjecting the mixture of atomized solution and hydrogen gas at the point of atomization to an ignition temperature of at least 1500° C.

BERNARD VONNEGUT.

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