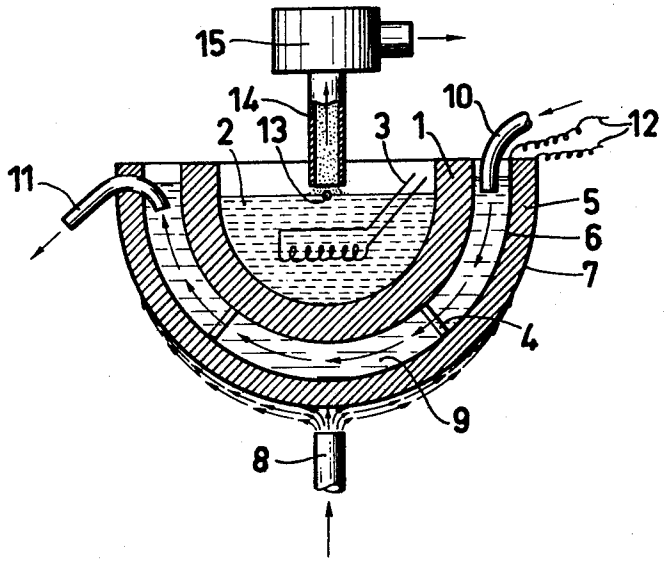
Dec. 11, 1962 P. A. TOVE 3,067,956

METHOD AND DEVICE FOR PULVERIZING AND/OR DECOMPOSING SOLID MATERIALS

Filed Aug. 8, 1960



INVENTOR
PER-ARNE TOVE
By
ATTORNEY

United States Patent Office 3,067,956 Patented Dec. 11, 1962

3,067,956

METHOD AND DEVICE FOR PULVERIZING AND/OR DECOMPOSING SOLID MATERIALS

Per Arne Tove, Uppsala, Sweden, assignor to Kohlswa Jernverks Aktiebolag, Kolsva, Sweden

Filed Aug. 8, 1960, Ser. No. 48,021
Claims priority, application Sweden Aug. 20, 1959
7 Claims. (Cl. 241—1)

U.S. Patent No. 2,997,245 describes a method and a device for pulverizing and/or decomposing solid materials.

The chief object of this invention is to improve such method and/or device, particularly when the supersonic (mechanical) shock waves with ultrasonic frequency are generated electrically or magnetically.

Another object of this invention is to render it possible to produce a fine powder of uniform particle size from a material, which is solid at normal or room temperature, by focusing non-stationary shock waves with a movable wavefront, on a point or small zone on the surface of said material, such mechanical waves being generated electrically or magnetically.

Another purpose of this invention is to produce a very fine powder by using mechanical shock waves generated electrically or magnetically with very high frequencies, preferably of the magnitude 0.1 to 1 megacycle.

Another purpose of this invention is to focus supersonic shock waves with ultrasonic frequency on the upper surface (level) of molten metal, and to suck off upwards the fine powder formed.

Another purpose of this invention is to adapt the acoustic impedances and the thicknesses of the various parts of the electric or magnetic shock wave generator in such manner as to minimize the reflection (dissipation) of the shock waves.

Other purposes will be evident from the following specification and claims.

A device according to this invention is illustrated in the accompanying drawing in which the FIGURE is a vertical sectional view.

In the drawing, the reference numeral **1** designates a bowl or crucible, which preferably is substantially semi-spherical and in which a melt **2** of lead (or other metal or alloy) is contained. The necessary heat may be supplied to the melt through an electric heating coil **3**. The crucible **1** stands on feet **4** on another bowl **5** or basin which is concentric with the crucible **1**. The bowl **5** serves as a transducer (energy converter) and is, on its inner and outer sides, provided with metal coatings **6**, and **7** respectively, to which high frequency electric alternating-current voltage is supplied through conductors **12**, for instance of frequencies between 20 to 1000 kilocycles. As a rule, frequencies within the range 0.1 to 1 megacycle are to be preferred.

Cooling air is blown in on the underside of the transducer bowl **5** via one or more tubes **8**, and cooling water **9** is supplied via a tube **10** to the space between the bowls **1** and **5**. The cooling water is drawn off through the tube **11**.

Above the focus **13** there is located a tube **14** communicating with a vacuum source (suction fan) **15**.

In the embodiment shown which relates to the pulverization of lead, the crucible **1** may be made of magnesium or other suitable material having a melting point higher than that of lead. The transducer or shock wave generator bowl **5** may be made of barium titanate, $BaTiO_3$.

The device described operates in the following manner:

The shock wave generator (emitter) or sender (transducer) **5**, **6**, **7** is fed with alternating-current having a frequency of preferably 1 megacycle (=1000 killocycles) and with an input of 2–20 watts/cm.^{2}. A typical sender

of this kind for 1 megacycle has a diameter of about 12 cm. and if it is about semi-spherical, it thus has a surface (inner surface) of about 150 cm.^{2} and a total input of 300–3000 watts.

The transducer **5–7** is a piezoelectric oscillator which operates with thickness vibrations (i.e. oscillations in directions perpendicular to the semi-spherical surface) and generates shock waves (with ultrasonic frequency) which are focused to the point (the small range) **13** where thus a very strong concentration of energy is obtained. At suitable dimensioning and adaptation of the various media (in **5**, **9**, **1**, **2**) to each other, the reflections (dissipation) of the waves in the contact surfaces between the various materials are reduced to a minimum and consequently maximum concentration of energy in focus **13** and thus high density of energy of the shock waves therein is attained. In the crucible **1** such a large melt **2** is maintained that focus **13** lies in, or adjacent to the upper surface (level) of the molten metal, and the shock waves will then tear off metal particles of very small size to form a very fine metal powder which is thrown up as a small "fountain" or cascade upwards from the focus **13** and sucked up through the tube **14** by the fan **15**. It to be observed that the shock waves drive away the metal particles (powder particles) up from the melt so that they can be easily sucked off and collected.

The details of the device may be varied in accordance with the results desired and with the material to be pulverized. In certain cases a solid material may be used instead of a melt, thus simplifying the cooling problem; for instance, the cooling liquid **9** may sometimes be omitted, and also the crucible **1**. The solid material may be heated or not. Of course, the material to be pulverized must be solid at ordinary (room) temperature.

In the embodiment shown, the transducer or piezoelectric oscillator **5** is made of barium titanate which can operate at temperatures of up to about 100° C. (below the Curie point). Other materals may also be used, e.g. quartz. If, in the embodiment shown, a material is used which can work piezoelectrically at the melting point of lead (about 325° C.), the intermediate members or adapters **1** and **9** may sometimes be omitted; one object of said adapters is to cool the transducer **5** so that the latter does not exceed its maximum operating temperature for piezoelectric oscillation.

One of the intermediate layers must, in the example shown, have such a good cooling and/or heat insulating capacity that the molten metal **2** and the transducer **5** can be kept at their individual and different working temperatures.

The number of intermediate layers like **1**, **9** may be varied, just as the materials of said intermediate layers. The guiding viewpoints for their selection is to attain both an efficient cooling action and the least possible totally resulting shock wave reflection at the contacting surfaces. The cooling by air (at **8**) on the underside of the transducer may be replaced by other cooling, for instance cooling by water; the air supplied through the tube **8** may be cooled before being blown on the transducer.

When adjusting and adapting the different materials (media) relatively to each other for reducing the reflection of the shock waves at the contacting surfaces to a minimum, it is primarily important to adjust (dimension) the acoustic impedances of the media (i.e. their shock wave impedances), as well as their respective thicknesses (in the direction of propagation of the shock waves) so that said thicknesses will be a suitable portion of the wave length for the shock wave oscillation used in the material. Such dimensioning will be based upon analogies with corresponding courses and phenomena in electrical transmission lines and chains.

In order to obtain the necessary focusing, various con-

structions of the transducer 5 may be used. The crucible 1 may be suspended in wires or the like instead of resting on the legs 4.

The arrangement will be analogous, when magnetostrictive generation is used.

The shock wave generators need not be of semi-spherical shape, but also other shapes may be used. It is, however, important that a sufficient focusing is obtained. Two or more generators working on a common focus may be used.

The powder attained has a very uniform particle size and has the same fine quality as that obtained in accordance with the principal patent mentioned above.

What I claim is:

1. The method of pulverizing materials which are solid at room temperature which comprises generating in a solid medium a sequence of shock wave fronts of spherical form, said shock wave fronts being composed of compressional waves having an ultrasonic frequency and advancing radially inwards into a concentrated zone at the center of the spherical front at a supersonic rate, causing said shock wave fronts to move exclusively in a non-gaseous medium and subjecting said material in said zone to said wave fronts to produce therein alternate compressive and expansive forces adapted to cause disintegration thereof.

2. The method set forth in claim 1 in which said waves advance through a liquid medium.

3. The method set forth in claim 1 in which said waves are generated by mechanico electrically.

4. The method set forth in claim 1 including the step of removing the pulverized material in solid state from said concentrated zone.

5. The method set forth in claim 1 in which said waves have a frequency above 20,000 cycles per second.

6. The method set forth in claim 1 in which said waves have a frequency between 0.1 and 1 megacycle.

7. Apparatus for pulverizing fusible materials which are solid at room temperature which comprises a vessel having a wall of semi-spherical form adapted to contain at least at its radial center the material to be pulverized, means heating said material to a temperature above the fusion point thereof, electromechanical means producing in said wall compressional waves of spherical wave front having an ultrasonic frequency, said wall being adapted to propagate said waves radially inward at a supersonic speed as shock waves having a movable wave front to converge at a focus in the material at said center whereby the material at said center is subjected to alternate compressive and expansive forces adapted to cause disintegration thereof, and means withdrawing the disintegrated material from said center.

References Cited in the file of this patent

UNITED STATES PATENTS

1,992,938	Chambers et al.	Mar. 5, 1935
2,163,649	Weaver	June 27, 1939
2,613,877	Hunrath	Oct. 14, 1952
2,738,172	Spiess et al.	Mar. 13, 1956
2,859,952	La Tour et al.	Nov. 11, 1958
2,889,580	Wald et al.	June 9, 1959