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SMOKE AND FUME SEPARATING

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Fig. 1.

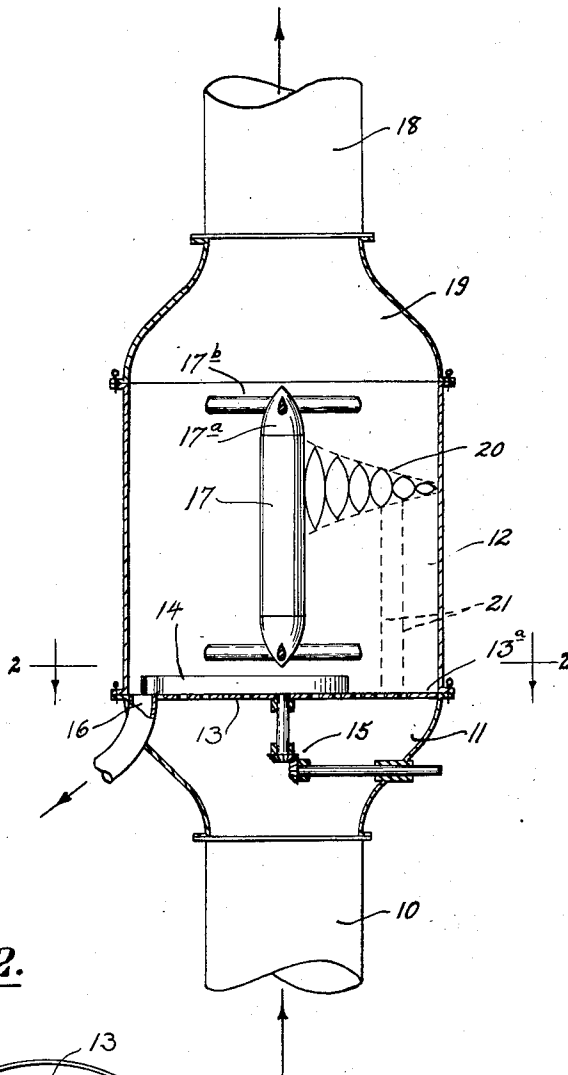
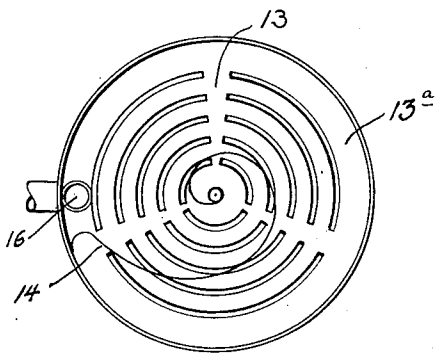


Fig. 2.



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SMOKE AND FUME SEPARATING

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17 Claims. (Cl. 183-114)

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

This invention relates to the art of separating smoke and fumes, and aims generally to improve the same.

In the known art the settling of smelter fumes and similar suspended smoke-like particles from the gases laden with such particles has been accomplished to a degree by mechanical, electrical and chemical means.

Mechanical methods heretofore used depend upon counteracting the haphazard molecular bombardment of the particles which is one factor responsible for their remaining in suspension. This may be accomplished to some extent by introduction of a cold plate into a hot smoke stream, which reduces molecular bombardment from one direction and hence causes deposit of the particles on the cold plate. Other mechanical methods employ centrifugal force or impingement of a jet against a baffle. Such methods, however, fail to effect complete removal of the suspended particles, and are particularly ineffective with extremely fine suspended particles.

In electrical methods, the particles of smoke or fume are given an ionic charge and then attracted to a surface at high potential. For maximum effectiveness, however, the amount of power required is so great as to make the installation and operation excessively expensive.

In chemical methods, the fact that the absorbed fumes must be later separated from the chemical used to remove them from the laden gases both complicates and increases the expense of the process.

In addition to the foregoing methods a method has been disclosed by Reginald S. Dean of the United States Bureau of Mines and described in an article by V. H. Gottschalk and H. W. Saint Clair (Mining and Metallurgy, May, 1937), according to which "supersonic" acoustic waves of the order of 3,000 to 100,000 cycles per second are used to counteract the haphazard mechanical bombardment of the molecules and probably displace the absorbed gas layers on the smoke or fume particles.

The present invention is based upon principles similar to those employed by Reginald S. Dean, and provides a method and means for applying said principles to large volumes of smoke or fume in a novel and efficient manner.

According to the present invention, the standing wave instead of being of a rectilinear nature, is propagated radially, which enables the separation to be effected easily in a stack, chimney, or other suitable chamber, as with this arrangement the gas flow may be directed across the standing wave, and may have a speed greater than could

be the case if it flowed in the direction of propagation of the wave. In other words, with the arrangement of this invention the gas flow tends to move particles separated at a cylindrical node of the wave along in that nodal zone, only, and does not tend to displace the particles into an anti-nodal zone where re-dispersement would be apt to occur. Preferred modes and forms of apparatus illustrative of the invention are shown in the accompanying drawing in which—

Fig. 1 is a vertical sectional view of one form of apparatus and Fig. 2 is a horizontal section on line 2-2 of Fig. 1, looking in the direction of the arrows.

Referring to Figs. 1 and 2, the apparatus shown therein comprises a smoke or fume inlet 10, preferably of normal stack size and shape, generally cylindrical. This inlet 10 is connected to the separating chamber 12, preferably cylindrical and hingedly removable as shown, by suitable means, as the connector 11. In the preferred form the chamber 12 is made of large cross section relative to the inlet 10, and is provided with a floor plate 13 for catching the precipitated particles and admitting the laden gas to the chamber 12. The floor plate 13, in the form shown (Fig. 2) is provided with concentric circularly disposed slots, preferably aligned with the anti-nodal zones of the hereinafter described standing wave pattern in the chamber, and providing imperforate sections underlying the nodal zones thereof upon which the agglomerated particles descend. Suitable means of any form is provided to remove the deposited particles, this means in the preferred form shown comprising a spiral scraper 14, adapted, as by gearing 15, to be rotated counterclockwise as viewed in Fig. 2, to move the dust to a suitable outlet 16.

By virtue of the enlarged cross section of the chamber, the slots in floor plate 13 may have a total area equal to or preferably greater than the area of the inlet pipe 10, to minimize resistance to the flow of the medium being separated. It is further particularly desirable with upflowing laden gas, to make the area of the chamber large enough, with respect to the area of pipe 10 and the speed of gas flow therethrough, to so reduce the speed of gas flow through the chamber that particles agglomerated at the nodal zones therein may gravitate to the floor 13 countercurrent to the flow of the gas.

The separating chamber, as above noted, comprises means for generating a cylindrically symmetrical standing wave therein. In the form shown this means comprises a radially vibrating magnetostriuctive sound diaphragm 17 similar to that disclosed in the United States patent to Hayes, No. 1,985,251, mounted in any suitable manner, as by streamlined caps 17a and three point arms 17b, also streamlined in the form

shown, one of which may be hollow to provide a conduit for the electrical connections of the magnetostrictive oscillator. With slow moving gases a relatively short vertical height may be used, but for more rapid gas flow or less powerful excitation a relatively tall diaphragm is preferred to provide a standing wave zone of considerable axial length affording ample opportunity for the proper agglomeration of the particles.

With the radially vibrating type of diaphragm a standing wave is obtained, the power of which is an inverse function of the square of the distance from the diaphragm. Thus, the most energy in the form shown is put into the central core of laden gas, which, by virtue of its alignment with inlet 10, is most heavily laden. Furthermore, as the agglomerated material passes toward the outlet 16, there is less and less tendency of the antinodal energy to again mix the agglomerate with the gas, particularly when high supersonic frequencies are used.

To further accentuate the flow of gas to the most strongly energized parts of the separating chamber, the plate 13, as shown, may be slotted only, or more extensively, under the stronger anti-nodal zones, and may even be provided with an unslotted section 13a, underlying the outer, weaker, zones. In this way, the expansion of the inflowing gas above the zone 13a will also tend to aid outward displacement of the agglomerated particles. In any event, the magnetostrictive power should be so adjusted as to be sufficiently strong to the extreme radial extent of the separating zone, which may be of less extent than the chamber diameter, to effect the desired degree of separation of the burden from the gas laden therewith.

The unladen gases are preferably passed vertically from the chamber 12, and if this chamber is interposed in a stack may be guided into the stack continuation 18 by a suitable connection 19.

The standing wave produced by generator 17 is indicated diagrammatically in Fig. 1 at 20, the preferred alignment of its anti-nodes with the slots of plate 13 being indicated by dotted lines 21, while the concentric nodal agglomeration zones lie generally intermediate these lines.

With a frequency of say 3300 cycles per second, and a gas in which sound travels 1100 feet per second, it will be seen that the standing wave will have a wavelength of one-third of a foot, determining the preferred spacing of the slots of plate 13. With 6600 cycles per second and the same speed conditions the wavelength of one-sixth of a foot would determine the preferred two-inch spacing of slots. Under similar conditions a frequency of 13,200 cycles would require a preferred slot spacing of one inch; and of 26,400 of one-half inch, etc. The gas streams coming through the slots, due to the restricted area locally existing there, will prevent agglomerated particles from dropping through them, and will tend to throw the particles upwardly and outwardly when the scraper 14 moves them over the slots, because the scraper will prevent expansion inwardly of the gas entering adjacent it, while the absence of any wall outwardly will permit the entering gas to expand from the slots in that direction.

In accordance with the provisions of the patent statutes, we have herein described the principle and operation of our invention, together with the apparatus which we now consider to be the best embodiment thereof, but we desire it to be understood that the apparatus shown is only illustrative and that the invention can be carried out or

embodied in other forms. For example, while the drawing shows the magnetostrictive oscillator (comprising a diaphragm surrounding electromagnetic actuating means) as located centrally with respect to a surrounding annular reflecting wall, this arrangement may be reversed, in which case the outer wall will constitute the sound diaphragm, actuated by electromagnetic means external thereof, and the central cylindrical member will constitute the reflecting wall. As a further example, any equivalent form of radially vibrating sound diaphragm may be used in lieu of that shown.

As a further example, while for separation of a uniform smoke or fume, a fixed resonant frequency of standing wave is preferred; when a smoke or fume of varying consistency, temperature or other factor likely to alter the velocity of propagation of sound waves through it is anticipated, our invention contemplates cyclically varying or wobbling the frequency of actuation of the diaphragm, so that periods of resonance will be obtained notwithstanding changing character of the medium, in which case the natural mechanical resonance frequency of the diaphragm will preferably approach the mean value of the cyclically varying frequencies employed.

We claim:

1. A method of separating suspended particles from gaseous or vaporous media which consists in passing the medium substantially vertically, through a substantially vertical cylindrical separating chamber, and exciting intense radially propagated supersonic standing waves in the medium throughout a considerable vertically extending zone of said chamber to produce concentric cylindrical nodes and antinodes in said zone, whereby gravitation of the particles agglomerated in the nodes regions in the zone may occur there along without traversing of antinodal regions.

2. A method of separating suspended particles from gaseous or vaporous media which consists in passing the medium in a slow stream substantially vertically upward through a substantially vertical cylindrical separating chamber, and exciting intense radially propagated supersonic standing waves in the medium throughout a considerable vertically extending zone of said chamber to produce concentric cylindrical nodes and antinodes in said zone, whereby gravitation of the particles agglomerated in the nodal regions in the zone may occur therealong without traversing of antinodal regions, the speed of passage of the stream being of such slowness that the particles may descend therein by natural gravitation, and removing the gravitated particles from the chamber at a zone below the zone of excitation of the medium.

3. A supersonic separator of the class described, comprising a cylindrical separating chamber, means extending axially of said chamber for propagating radially therein an intense cylindrical supersonic standing wave, and means for passing longitudinally through said chamber a medium to be separated.

4. A supersonic separator of the class described comprising a substantially vertical cylindrical separating chamber, means extending vertically thereof for producing therein a supersonic standing wave having nodal and antinodal zones concentric with said chamber, and means for passing lengthwise of said zones a medium to be separated.

5. A supersonic separator of the class described

comprising a substantially vertical cylindrical separating chamber, a radially vibrating magnetostrictive sound diaphragm arranged axially of said chamber and producing intense standing waves in the medium to be separated therein, means for passing a suspension-laden fluid to be separated into said chamber, means for passing the unladen fluid substantially vertically from said chamber, and means for removing the separated particles from said chamber.

6. A supersonic separator of the class described comprising a separating chamber, means for passing a medium to be separated substantially vertically upwardly through said chamber, separating means comprising a generator propagating supersonic waves transversely of said chamber of such a wave-length as to produce standing waves between said generator and the opposing wall of said chamber, a perforated bottom in said chamber through which said medium passes on entering said chamber and on which separated particles collect, said particles being prevented from passing through the perforations of said bottom by the medium entering there-through, and means for removing the collected particles from the chamber.

7. A method of separating suspended particles from gaseous or vaporous media which consists in passing the medium in a continuous current through a cylindrical separating chamber, exciting intense radially propagated supersonic waves in the medium passing through the said chamber, and cyclically varying the frequency of the supersonic waves through a range including the frequency producing standing waves in the medium.

8. A supersonic separator of the class described comprising a vertically arranged cylindrical separating chamber having axially arranged at its bottom an expanding inlet means for expanding suspension-laden fluid into said chamber, and having at its top axially aligned outlet means for unladen fluid, and means in said chamber for radially propagating therein supersonic vibrations which decrease in amplitude with increase of radial distance from the axis of said chamber, whereby the intensity of supersonic waves varies so that the greatest intensity lies substantially in the most direct flow path from inlet to outlet with progressively lesser intensities lying in progressively less direct and thus longer flow paths from inlet to outlet.

9. A supersonic separator according to claim 6, said perforated bottom having its perforations located to underlie anti-nodal areas of the standing wave.

10. A supersonic separator according to claim 6, said means for removing the particles from the chamber comprising a spiral member of substantial height rotatable in such direction as to move the particles outwardly and a discharge passage located adjacent the outer periphery of the perforated bottom.

11. A supersonic separator of the class described comprising a separating chamber, means for passing a medium to be separated through said chamber, a magnetostrictive supersonic generator comprising a magnetostrictive element and exciting means therefor, said magnetostrictive element, including the parts thereof forming the magnetic circuit therein, being surrounded by

the medium being separated, whereby heat generated by hysteresis in the magnetic circuit in the magnetostrictive element may be directly dissipated to the medium.

12. The method of separating suspended particles from gaseous or vaporous media, which consists in passing the medium through a separating chamber, exciting intense supersonic waves in the medium within said chamber, and cyclically varying the frequency of the supersonic waves through a range including a frequency producing standing waves in the medium in said chamber.

13. In a method of separating suspended particles from gaseous or vaporous media of the type in which the medium is passed through a separating chamber and intense supersonic waves are excited in the medium within the chamber, the improvement which consists in varying the frequency of excitation of the supersonic waves propagated in the medium over a range of frequencies including a frequency producing standing waves in the medium, said range of frequencies providing tolerance for variation in the wave propagating properties of the medium.

14. Means for separating smoke and fume suspensions from gaseous or vaporous media, comprising an annular chamber, means for propagating supersonic standing waves radially in a separating zone in said annular chamber, and means for longitudinally passing the medium through said separating zone generally parallel with the annular nodal and anti-nodal regions of the radially propagated waves.

15. The method of separating smoke and fume suspensions from gaseous or vaporous media, which comprises propagating a zone of supersonic standing waves of agglomerating frequency presenting alternated parallel regions of nodal and anti-nodal displacement, and passing the medium through said zone generally parallel with the said nodal and anti-nodal regions, whereby particles agglomerated in the nodal regions may be passed out of said zone without traversing of anti-nodal regions.

16. A method of separating suspended particles from gaseous or vaporous media which consists in exciting intense radially propagated supersonic standing waves throughout a zone of considerable axial length of a cylindrical chamber to produce concentric cylindrical nodes and anti-nodes in said zone, and passing the medium through said zone generally parallel to said nodes and anti-nodes, whereby particles agglomerated in the nodal regions may be passed out of said zone without traversing of anti-nodal regions.

17. A generator of regularly varied supersonic standing waves comprising means for radially propagating in a medium supersonic waves having annular wave fronts, and means concentrically related to said first-named means for radially reflecting said annular waves in said medium back toward said first named means, said two means having substantial axial extent and providing for the establishment therebetween of a resonant condition of said waves producing concentrically arranged nodes and anti-nodes in said medium varying in intensity inversely as a function of their radii.

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