Nov. 19, 1968 W. J. PETTERS ET AL 3,411,714

METHOD AND APPARATUS FOR ATOMIZING LIQUIDS USING THE PROPULSION JET OF A ROCKET ENGINE

Filed Oct. 19, 1965 2 Sheets-Sheet 1

FIG. 1

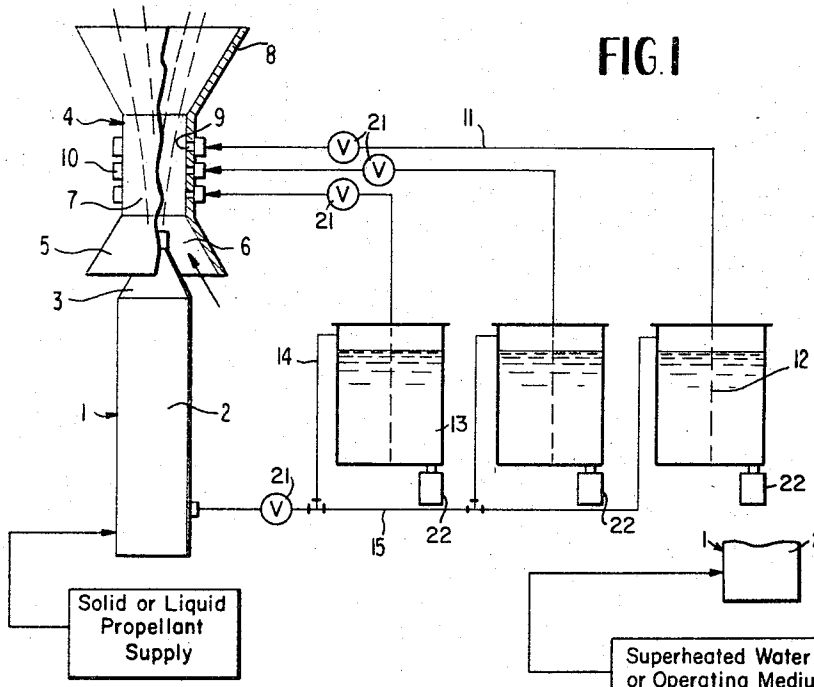
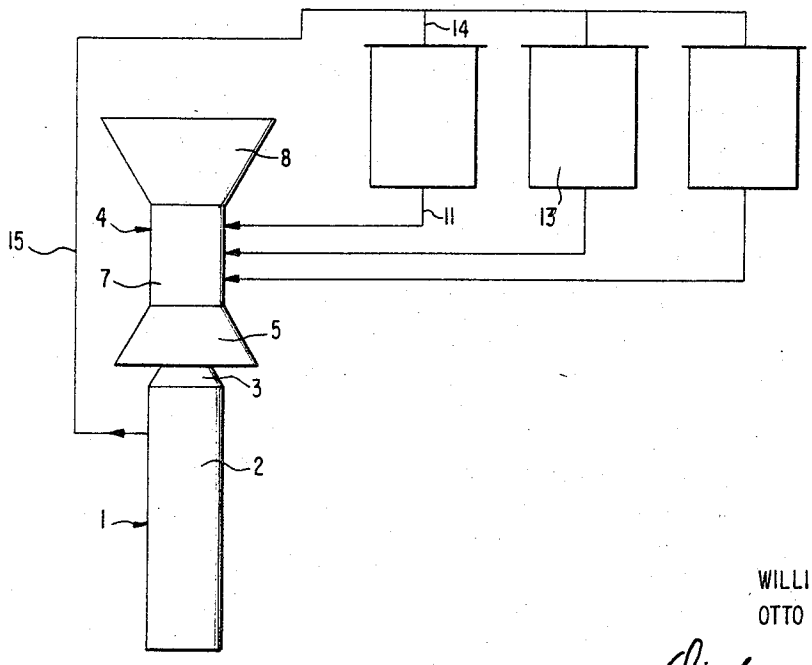


FIG. 1A

FIG. 2



INVENTORS
WILLI J. PETTERS
OTTO SCHREINER

BY Dicke & Craig
ATTORNEYS

Nov. 19, 1968 W. J. PETTERS ET AL 3,411,714

METHOD AND APPARATUS FOR ATOMIZING LIQUIDS USING THE PROPULSION JET OF A ROCKET ENGINE

Filed Oct. 19, 1965 2 Sheets-Sheet 2

FIG.3

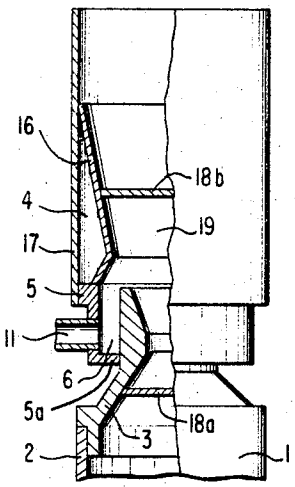


FIG.3A

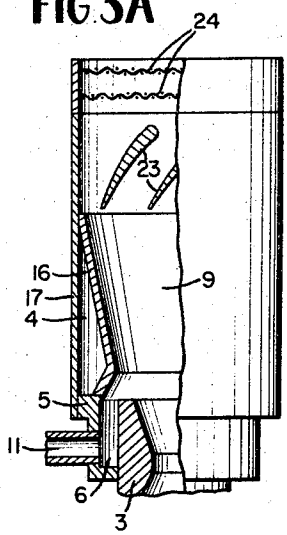
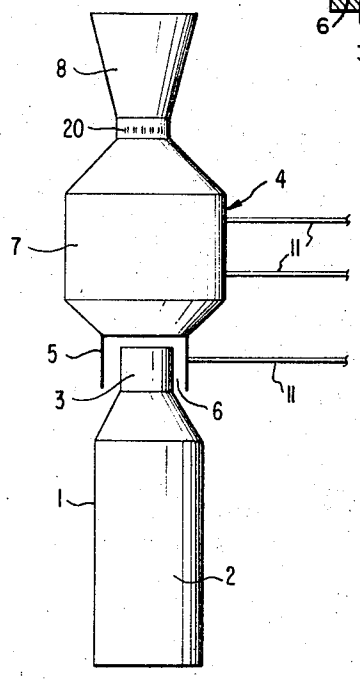


FIG.4



INVENTORS
WILLI J. PETTERS
OTTO SCHREINER

BY Dicke & Craig
ATTORNEYS

United States Patent Office 3,411,714
Patented Nov. 19, 1968

3,411,714

METHOD AND APPARATUS FOR ATOMIZING LIQUIDS USING THE PROPULSION JET OF A ROCKET ENGINE

Willi J. Petters and Otto Schreiner, Liebenau, Germany, assignors to Dynamit Nobel Aktiengesellschaft, Troisdorf, Germany

Filed Oct. 19, 1965, Ser. No. 498,059
Claims priority, application Germany, Oct. 19, 1964, St 22,829
53 Claims. (Cl. 239—8)

ABSTRACT OF THE DISCLOSURE

The present disclosure is directed to a process and apparatus for atomizing liquids, solutions, emulsions, suspensions, or solid materials in finally divided form. More particularly, the present disclosure is directed to a process and apparatus for atomizing the above-mentioned substances wherein the substance to be atomized is supplied to the propulsion jet of a rocket engine where it is atomized by said propulsion jet.

The present invention relates to a process and installation for atomizing liquids, solutions, suspensions, or solid substances in the form of dust, powder, or the like.

For the atomization of liquids, solutions, powders or the like, a number of processes and apparatus are known in the prior art. The most simple and probably also the most frequently used type of atomization, for example, as used with oil burners, spraying boxes, perfume flasks, and the like, is thereby that in which the substance to be atomized is passed through atomizing nozzles by the application of pressure. Related to the order of size and magnitude of the necessary installation, only relatively small quantities of substances can be atomized not only with this prior art installation but also with all other installations known heretofore. Correspondingly, fo the atomization of a larger quantity of a substance, a relatively long time is needed in the prior art. Hence, it is inherent in the prior art devices that by means thereof the aim to atomize in a very short time a relatively large quantity of a substance, cannot be solved in a satisfactory manner.

The purpose and object of the present invention is to provide a solution to the aforementioned problems by means of which the aim mentioned hereinabove can be achieved in a satisfactory manner, i.e., which makes it possible to atomize within very short periods of time relatively large quantities of liquid, solution, emulsion, suspension, or also solid substances in the form of dust, powder, or the like. Starting with the known fact that in rocket engines, large energy quantities are converted in a short time under more or less high pressure, the present invention proposes to realize the atomization by means of the propulsion jet (shown in FIGURE 1 by dashed lines) of a rocket engine. In many cases, this can be realized in a very simple manner in that the substance to be atomized is added to the operating medium of the rocket engine, i.e., for example, a powder is mixed with the propellant fuel of a solid fuel rocket engine and possibly is pressed together with the same. Of course, it is a prerequisite in connection therewith that the substance to be atomized does not participate actively in the energy conversion or that it leaves the same in the form intended to be atomized.

However, more frequently and generally applicable will be the measure according to a further proposal in accordance with the present invention; namely, to connect the substance to be atomized within the area of the nozzle and/or downstream of the nozzle with the propulsion jet of the rocket engine. The supply of the substance to be atomized can be realized exclusively by the vacuum occurring during the operation of the rocket engine in the part of the nozzle on the discharge side and downstream thereof. An increase in the atomization output; that is, the atomization of still larger quantities of the substance or substances per time unit can be achieved, however, in that a pressure drop which is either present in nature or created artificially and/or the pressure of a pressure source, preferably the operating pressure of the rocket engine, is additionally utilized for the supply of the substance to be atomized.

In order to protect the substance to be atomized farreachingly against the heat of the rocket engine propulsion jet, provision may be made according to a further, appropriate feature of the present invention to realize the atomization in the presene of a liquid cooling the propulsion jet. Such liquid may be either the liquid of a solution, suspension, or emulsion to be atomized or may be an additional cooling liquid whereby the additional task may be assigned to the cooling liquid in the latter case, for example, with substances to be atomized in the form of powder-like or similar solid substances or materials to serve as carrier for the facilitated and more convenient supply to the rocket engine propulsion jet. In each of the aforementioned cases and, of course, also when no cooling effect is to be achieved with the liquid, the liquid quantity may be so metered depending on the desired purpose that it evaporates completely and leaves in pure form the substance to be converted into an aerosol, or that it only evaporates partly or not at all so that the substance to be converted into an aerosol remains as residue in the form of a solution, emulsion, or suspension. Additionally, provision may be made to saturate the liquid prior to discharge, possibly by the use of pressure, with a gas, for example, CO_2.

An installation is utilized for the realization of the atomization according to a proposal of the present invention which is characterized by a rocket engine, operated with solid and/or liquid propellant, with superheated water vapor, or with an operating medium heated by an atomic reactor, a plasma burner, or an electric burner, which rocket engine includes a pressure and/or combustion chamber and a nozzle, whereby according to a further proposal of the present invention, a separate atomization chamber may be connected downstream of the nozzle. The above features are diagrammatically illustrated in FIGURES 1 and 1A of the specification. This atomization chamber may form in its entirety a discharge nozzle adjoining the end of the rocket engine nozzle at the outlet or discharge side thereof, or may be constructed as discharge nozzle only toward the outlet or discharge side thereof and may be provided with a mixing chamber adjoining the downstream end of the rocket engine nozzle and connected upstream of the atomization discharge nozzle; the effect of the mixing chamber can be further increased in that baffle plates, sieves, shutters, or other structural devices favoring the mixing and/or utilization of the substance to be atomized are arranged within the atomization chamber. FIGURE 3A shows one possible arrangement of the use of baffle plates and sieve means. It should be noted that the flow resistance of these means should not be so large as to adversely affect the flow during atomization.

According to a further feature of the present invention,

it is proposed to so arrange and construct the atomization chamber that it extends with its end adjoining the rocket engine, the downstream end of the rocket engine nozzle and forms an annular gap together therewith. It is achieved by this measure that owing to the vacuum occurring during the operation of the rocket engine, the rocket nozzle and the atomization chamber cooperate with each other in the sense of an injection pump whereby the air drawn in through the annular gap may be utilized advantageously for the supply or feed of the substance to be atomized and/or of the media participating in the atomization insofar as these media are connected to the atomization chamber within the area of the gap and/or the mixing chamber or possibly also within the area of the discharge nozzle and/or the part constructed as discharged nozzle. In the case of such a connection of the media, the annular gap may also be closed at its end on the side of the rocket engine whereby the injection effect between rocket engine nozzle and atomization chamber is eliminated, but the installation now operates according to the vacuum principle and therewith also assures the feed or supply of the media. In both cases the construction of the annular gap offers the possibility to supply or feed several media participating in the atomization at different places disposed one behind the other in the direction of the rocket engine propulsion jet and also relatively far from one another which is desirable and may be of advantage under certain circumstances. For example, it is possible to connect the substance to be atomized within the area of the annular gap and to connect a gas used for the saturation thereof within the area of the mixing chamber or discharge nozzle. However, a cooling liquid cooling the propulsion jet could be connected within the area of the annular gap and the substance to be atomized wtihin the area of the mixing chamber or of the discharge nozzle. Finally, a part of the media participating in the atomization could also be connected directly to the internal cross section of the rocket engine nozzle, for example, by means of lines extending from the rear end centrally through the pressure or combustion chamber of the rocket engine or by means of lines extending through the wall of the rocket engine nozzle or the like and the rest of the media may be connected with the atomization chamber in the aforementioned manner, that is, within the area of the annular gap and/or of the mixing chamber and discharge nozzle. Of course, the arrangement and construction of a separate atomization chamber connected downstream of the rocket nozzle also does not lose its significance if, for example, all of the media participating in the atomization are connected directly to the interior cross section of the rocket engine nozzle since the jet-directing and atomization as well as mixing effect is also assured in that case.

It may suffice for the connection of the media participating the atomization to the rocket engine nozzle and/or the atomization chamber, if each of the connections has access to the rocket engine propulsion jet by way of an aperture of correspondingly dimensioned cross section. However, it is of greater advantage to connect each of the media with the propulsion jet by way of several apertures arranged uniformly distributed over the circumference of the nozzle and/or the atomization chamber and of correspondigly dimensioned total cross section, whereby a separate line or the like is then inserted into or connected with each of these apertures. In the alternative, however, several or all of the apertures may be connected with one line each by way of distributor lines or other distribution installations, especially by way of an annular channel formed on the outside of the nozzle or atomization chamber.

The simplest form of the construction and arrangement of the installation according to the present invention would be to diffuse or atomize water from a naturally present water body, for example, a pond. In such a case, the rocket engine, for example, operated with solid fuel, only needs to be connected with the interior cross section of its nozzle or with an atomization chamber connected downstream thereof by way of a corresponding dimensioned line, possibly by the utilization of a naturally present drop with the water and the rocket engine has to be set into operation thereafter. However, such type of application will be possible relatively rarely as the substances to be atomized in general will involve those which do not occur in nature in the form in which they are intended to be atomized. According to a further proposal of the present invention, the media participating in the atomization are therefore accommodated and stored in one or several containers or vessels and these vessels, either individually or also several lines together, are connected to the other end of the aforementioned lines or the like. Insofar as an installation is concerned which is fixed or to be operated as a stationary installation, open containers may be used whereby these containers are arranged appropriately with the entire extent thereof above the connecting place on the side of the rocket engine at the nozzle and/or the atomization chamber and may be connected with the bottoms thereof with the connecting line so that an automatic feed of the media to the rocket engine and possibly also the complete emptying of the containers is assured. However, the installation of the present invention becomes more generally utilizable and also for operation in which the location has to be changed, when the containers are constructed as closed tanks or the like and are provided with a pressure source for the expulsion of the medium or are connected with such a pressure source, for example, if a gas generator is arranged within the containers, or the containers are connected with an outside pressure source, for example, with one or several bottles filled with compressed air.

However, it is even more favorable to connect the containers with the pressure or combustion chamber of the rocket engine. In this manner, not only the operating pressure occurring inherently during the operation of the rocket engine, can be utilized advantageously, but additionally, a particularly light-weight and space-saving arrangement and construction can also be achieved if the containers are constructed approximately of annular shape and are arranged concentrically ot the rocket engine about the pressure or combustion chamber thereof or also are constructed as hollow cylinders and are provided in extension of the rocket engine at the rear end thereof. Such an arrangement is particularly recommendable if consideration is to be given to the fact that the installation is to be carried by an air-borne structure and is to be set into operation during the flight or also only upon impact on the target which does not exclude, however, that such arrangement may also be utilized in other cases.

With a construction of containers connected to the pressure and combustion chamber of the rocket engine and arranged above the connecting places with the propulsion jet as well as also with the use of the installation where the location is changed, care must be taken that the media participating in the atomization cannot reach prematurely the pressure or combustion chamber, for example, as long as the rocket engine has not reached a corresponding operating pressure. This is achieved in a simple manner according to the present invention in that the pressure line between the pressure chamber and the containers is closed by means of a disk bursting upon attaining the operating pressure of the rocket engine. However, it may also be appropriate or even necessary in other cases, depending on the given circumstances, to take corresponding measures which may essentially consist that rapidly opening valves and/or check valves or other suitable installations are arranged in the pressure line or in the pressure lines. Especially with several media participating in the atomization it may be appropriate also to provide within the connecting lines between the containers

and the rocket engine or also between the containers between one another, automatically operating or selectively actuated switching, control and closure devices of any appropriate conventional construction.

These and further objects, features, and advantages of the present invention will become more obvious from the following description when taken in connection with the accompanying drawings, which shows, for purposes of illustration only, several embodiments in accordance with the present invention, and wherein:

FIGURE 1 is a schematic view of one arrangement of an atomizing installation in accordance with the present invention having material containers connected by way of riser feed pipes to an atomization chamber connected downstream of the rocket engine nozzle and connected by way of pressure lines with the pressure or combustion chamber of the rocket engine;

FIGURE 1A diagrammatically shows the operating medium heated by an atomic reactor, a plasma burner or an electric burner;

FIGURE 2 is a schematic view of a modified embodiment of an atomizing installation in accordance with the present invention having a falling feed line system to the atomizer part;

FIGURE 3 is an elevational view, partially in cross section and on an enlarged scale, through a still further modified atomizing chamber in accordance with the present invention constructed as discharge nozzle;

FIGURE 3A shows one possible arrangement of the use of baffle plates and sieve means in the atomization chamber; and

FIGURE 4 is a schematic view of a still further modified embodiment of an installation in accordance with the present invention provided with an atomizing chamber which includes a mixing chamber.

Referring now to the drawing, wherein like reference numerals are used throughout the various views to disignate like parts, and more particularly to FIGURE 1, reference numeral **1** generally designates therein the rocket engine consisting of combustion chamber **2** and nozzle **3** and operated, for example, with solid fuel. The atomizing chamber generally designated by reference numeral **4** is connected downstream of the rocket engine **1**. The end **5** of the atomizing chamber **4** on the side of the rocket engine **1**, extends over the nozzle **3** and forms therewith an annular gap **6**. The discharge nozzle **8** adjoins the mixing chamber **7** on the discharge side thereof. The injection nozzles **9**, arranged in the axial direction one behind the other, are provided in the wall of the mixing chamber **7** which may be either individual nozzles or ring nozzles. The nozzles **9** are in communication with the lines **11** by way of the annular channel **10** which are arranged on the outside of the mixing chamber **7**. The last portion of each line **11** near the respective container is constructed as riser pipe **12** and extends almost to the bottom of the corresponding material container **13**. The pressure lines **14** are connected to the upper end of the containers **13** which pressure lines **14** are in communication by way of common pressure lines **15** with the combustion chamber **2** of the rocket engine **1**.

Due to the gas jet which leaves the nozzle **3** with high velocity during the burning of the propellant charge, a vacuum is produced to the rear or downstream of the nozzle **3** which has a consequence that air is sucked in through the annular gap **6** in the direction of the arrow. The excess pressure produced at the same time in the combustion chamber **2** is established—apart from possible throttling losses—by way of the line **15** and the lines **14** also in the upper part of the containers **13**; that is, in the container space above the respective material or substance disposed therein whereby the corresponding substance or material is pressed downwardly and therewith by way of the riser lines **12** is forced out of the container **13** and is injected under pressure by way of line **11**, annular channel **10**, and injection nozzle or nozzles **9** into the mixing chamber **7** where the substance is mixed by the exhaust gas jet of the rocket engine **1** in combination with the drawn-in air and with the possible other types of media or materials of the other containers and is thus atomized as well as blown out through the discharge nozzle **8**.

Of course, it is understood that the only schematically illustrated installation of FIGURE 1 may be varied in numerous ways. For example, the three containers **13** may be connected to a common line **11** and/or may possibly be interconnected with each other in a predetermined manner by conventional shifting, control, closure, and other regulating means insofar as the containers store similar substances or, for example, also such media which are intended to produce together an aerosol of a solution, emulsion or suspension. In the instant case, it may be contemplated, for instance, within the scope and purview of the present invention that a liquid cooling the propulsion jet is injected through the injection nozzle or nozzles on the side of the rocket engine, that the substance to be atomized is injected through the central nozzle or nozzles and that a gas for the saturation of the substance is injected through the nozzle or nozzles on the discharge side. Of course, a solution, emulsion, or suspension, made beforehand in the form in which it is intended to be atomized may be stored in a single container of correspondingly large dimension and may be supplied by way of a single, correspondingly dimensioned line to the mixing chamber **7**. The same is also true, of course, if the containers **13**, whose indicated number is to be understood only in an illustrative sense, contain one and the same substance. Similarly, provision may also be made to inject individual ones or all of the media into the annular gap **6**.

Furthermore, for purposes of achieving a practically complete emptying of the containers **13**, provision may also be made to connect the riser pipes **12** near the container bottoms externally at the wall of the containers **13** in lieu of extending the same into the containers, or the container bottoms could also be constructed of conical shape and the riser pipes **12** could be extended to near the apex of the cone. It is further within the scope of the present invention that the containers **13** are connected by way of separate pressure lines to the combustion chamber **2** and/or the pressure lines are connected to the containers **13** on the side of the covers thereof.

Finally, it is also clear if use of the installation is contemplated independent of the location thereof at any time, that corresponding measures have to be taken in order to satisfy the correct operation thereof. In particular, the lines would have to be provided with corresponding actuating, control and closure members **21** or the like of conventional construction which prevent that the media participating in the atomization are displaced prematurely and in any manner other than the intended manner. In particular, care must be taken also in that case that the pressure used for expelling the substances out of the containers, be it—as illustrated—the pressure of the combustion chamber or also the pressure of another separate pressure source, always remains effective on the correct side to the rear of the substance which may, for example, be achieved in that a slidable piston is arranged between the medium to be expelled and the connection of the pressure line. The containers **13** can also be supplied with an outside pressure source such as gas generators **22**.

According to FIGURE 2 in which the parts corresponding to those of FIGURE 1 are designated by corresponding reference numerals, the supply and feed of the substances to the mixing chamber **7** takes place by way of falling lines **11** connected with the containers **13** at the bottom side thereof, with the containers **13** arranged at a correspondingly high or raised location. As a result of such an arrangement and under the assumption that the installation substantially maintains the position shown in the drawing, a somewhat greater atomization output can be achieved, with the embodiment of FIGURE 2, than with the embodiment of

FIGURE 1 with the conditions otherwise remaining the same. The arrangement of conventional, automatically responsive and/or selectively actuatable closure means **21** in the falling lines **11** is self-evident in this embodiment. As to the rest, the same aforedescribed measures may also be provided with the embodiment of FIGURE 2 as with that of FIGURE 1.

The atomization chamber **4**, illustrated on a slightly enlarged scale in FIGURE 3 and in cross section in the left half and in elevation in the right half, is constructed on the inside thereof as discharge nozzle **16** in its part extending over the end of the rocket engine **3**. The nozzle **16** is supported in this embodiment toward the outside against the cylindrical pipe **17** which is somewhat extended beyond the end of the nozzle **16** on the discharge side thereof for purposes of an improved holding together of the discharged jet. The end **5** of the atomization chamber **4** on the side of the rocket engine **1** extends again over the rear end of the rocket engine nozzle **3** and forms together with the nozzle **3** an annular gap **6** which is sealed tightly on the side of the rocket engine **1** by means of the flange-like, inwardly projecting part **5***a*. The supply or feed line **11** is connected to the annular gap **6**. The rocket engine nozzle **3** and the discharge nozzle **16** are closed tightly against the combustion chamber **2** and against the discharge end by means of conventional bursting disks **18***a* and **18***b*, respectively, and the space **19** disposed between these two disks **18***a* and **18***b* is already filled in this embodiment with the substance to be atomized. As to the rest, the arrangement can be made corresponding to the arrangement of FIGURES 1 and 2 whereby also the modifications mentioned in connection with these two embodiments are possible.

As soon as the bursting disks **18***a* and **18***b* break and disintegrate, after starting the rocket engine **1**, under the effect of the pressure of the starting propulsion jet, the substance present within the space **19** is atomized by the propulsion jet and is thrust out through the discharge nozzle **16**, and simultaneously therewith further substances are continuously supplied to the propulsion jet by the vacuum occurring downstream of the rocket engine nozzle **3** as well as possible by the existing head and/or the pressure of a pressure source, for instance, of the combustion chamber **2** of the rocket engine **1**, as long as such substances are present and/or as long as the rocket engine is in operation.

As shown in FIGURE 3A baffle means **23** and/or sieve means **24** can be provided in the atomization chamber. These mixing means should not be so large or so positioned as to create an undesirable flow resistance. Also the sieve means can be mutually spaced plates having variable size and number of openings provided therein.

According to FIGURE 4, the atomization chamber **4**, which again cooperates with the rocket engine nozzle **3** according to the injector principle, is provided in its central part with an enlarged mixing chamber **7** that narrows or tapers conically in the direction toward the rocket engine **1** as well as also toward the discharge side.

Appropriate eddying surfaces **20** of conventional constructing causing suitable turbulence are arranged at the transition to the discharge nozzle **8** arranged on the discharge side. In lieu of the eddying surfaces **20** or in addition thereto, conventional structural parts effecting eddying and favoring the atomization and mixing of the media may be provided also at other places of the mixing chamber **7**. As to the rest, the considerations mentioned hereinabove in connection with FIGURES 1 and 2 are equally applicable to this embodiment.

The present invention will now be described by reference to the following specific example which is to be interpreted only as illustrative of the present invention but in no way restrictive thereof.

Example

By the use of available parts in an arrangement analogous to that of FIGURE 2, but having an atomization chamber constructed corresponding to that of FIGURE 3 and with separate pressure lines, two containers made of thick-walled steel pipes closed tightly on both sides thereof by means of covers and having each a content of 30 liters were connected, on the one hand, to the combustion chamber and, on the other, to the atomization chamber of a rocket engine connected downstream of the nozzle. Combustion chambers of 15 cm. in diameter and 7-pipe-solid-fuel-propellant charges were used. The connection between the containers and the annular gap between the rocket engine nozzle and the atomization chamber consisted of two ½" water pipes each, which were connected to the atomization chamber evenely distributed over the circumference. The connection between the containers and the combustion chamber consisting of one 12 mm. pressure line each. Water mixed with blue coloring powder was used as substance to be atomized. The entire liquid was expelled in less than one second as coherent gas-droplet jet up to a height of 40 meters. The expelling operation was terminated shortly before termination of the burning of the propellant charge of the propulsion unit, i.e., the utilized 60 liters of water were not quite sufficient. The pressure in the containers was about 5 atmospheres absolute excess pressure, and the pressure in the combustion chamber about 10 atmospheres absolute excess pressure.

While we have shown and described several embodiments in accordance with the present invention, it is understood that the same is not limited thereto, but is susceptible of numerous changes and modifications as known to a person skilled in the art; and we therefore do not wish to be limited to the details shown and described herein, but intend to cover all such changes and modifications as are encompassed by the scope of the appended claims.

We claim:

1. A process for atomizing liquids, solutions, emulsions, suspensions or solid materials in the form of dust, powder or the like, comprising atomizing the substance to be atomized by the propulsion jet of a rocket engine including the step of supplying the substance to be atomized to the propulsion jet of the rocket engine.

2. A process according to claim **1**, in which the substance to be atomized is effectively supplied to the propulsion jet of the rocket engine within the area of the discharge nozzle of said rocket engine.

3. A process according to claim **1**, in which the substance to be atomized is effectively supplied to the propulsion jet of the rocket engine downstream of the nozzle of said rocket engine.

4. A process according to claim **1**, in which the substance to be atomized is effectively supplied to the propulsion jet of the rocket engine within the area of as well as downstream of the nozzle of said rocket engine.

5. A process for atomizing liquids, solutions, emulsions, suspensions or solid materials in the form of dust, powder or the like, comprising the steps of feeding the substance to be atomized to the propulsion jet of a rocket engine within an area defined by the nozzle of the rocket engine and downstream thereof, atomizing the substance to be atomized by the propulsion jet of a rocket engine.

6. A process according to claim **5**, wherein the substance to be atomized is fed to the propulsion jet by utilizing the vacuum occurring during operation of the rocket engine.

7. A process according to claim **5**, wherein the substance to be atomized is fed to the propulsion jet by utilizing a pressure head.

8. A process according to claim **7**, wherein said pressure head is naturally present.

9. A process according to claim **7**, wherein said pressure head is artificially created.

10. A process according to claim 6, wherein the substance to be atomized is fed to the propulsion jet by utilizing a pressure head.

11. A process according to claim 5, wherein the substance to be atomized is fed to the propulsion jet by using an operating pressure.

12. A process according to claim 11, wherein the operating pressure is derived from the operating pressure of the rocket engine.

13. A process according to claim 11, wherein the operating pressure is derived from a separate pressure source.

14. A process according to claim 5, wherein the atomization is carried out in the presence of a liquid cooling the propulsion jet.

15. A process according to claim 14, wherein the liquid is so metered that it evaporates partly under the influence of the heat of the propulsion jet.

16. A process according to claim 14, wherein the liquid is so metered that it evaporates completely under the influence of the heat of the propulsion jet.

17. A process according to claim 14, wherein the liquid is saturated with a gas prior to ejecting the same.

18. A process according to claim 14, wherein the liquid is saturated with a gas under pressure prior to ejecting the same.

19. An installation for atomizing liquids, solutions, emulsions, suspensions, or solid materials in finely divided form which comprises a rocket engine means containing a combustion chamber and a discharge nozzle means, an atomizing chamber disposed downstream of the rocket engine means and extending around the discharge nozzle means forming an annular gap therewith, injection nozzle means provided in the wall of the atomizing chamber, means for operating the rocket engine to produce a propulsion jet and means for feeding the media participating in the atomization to the injection nozzle means, said injection nozzle means supplying said media to the atomizing chamber to be atomized by the propulsion jet.

20. The installation according to claim 19, wherein said operating means includes a fuel selected from the group consisting of solid and liquid fuel and mixtures thereof.

21. The installation according to claim 19, wherein said operating means includes superheated water vapor.

22. The installation according to claim 19, wherein said operating means includes atomic reactor means.

23. The installation according to claim 19, wherein said operating means includes plasma burner means.

24. The installation according to claim 19, wherein said operating means includes electrically heated burner means.

25. An installation according to claim 19, wherein the atomization chamber is disposed coaxially to the rocket discharge nozzle means at the outlet side thereof.

26. An installation according to claim 25, wherein said atomization chamber means is constructed on the outlet side of the rocket engine as discharge nozzle means.

27. An installation according to claim 26, wherein said atomization chamber means includes discharge nozzle means and an enlarged mixing chamber connected upstream of the discharge nozzle means thereof.

28. An installation according to claim 27, wherein said mixing chamber includes structural means for improving the mixing effect.

29. An installation according to claim 28, wherein said structural means includes baffle plates.

30. An installation according to claim 28, wherein said structural means includes sieve means.

31. An installation according to claim 28, wherein said structural means includes shutter means.

32. An installation according to claim 19, wherein the annular gap is sealed tightly at the end thereof near the rocket engine means.

33. An installation according to claim 32, wherein feed line means are provided which extend through the combustion chamber means from the end of the rocket engine means opposite the engine nozzle means and operatively connect the media participating in the atomization with the rocket propulsion jet within the area of the engine nozzle means.

34. An installation according to claim 19, wherein feed line means are provided which extend through the combustion chamber means from the end of the rocket engine means opposite the engine nozzle means and operatively connect the media participating in the atomization with the rocket propulsion jet within the area of the engine nozzle means.

35. An installation according to claim 32, further comprising feed line means for feeding the media to be atomized to the propulsion jet, at least one of said line means extending through the walls of the rocket engine nozzle means.

36. An installation according to claim 19, further comprising feed line means for feeding the media to be atomized to the propulsion jet, at least one of said line means extending through the walls of the rocket engine nozzle means.

37. An installation according to claim 19, further comprising feed line means for feeding the media to be atomized to the propulsion jet, said feed line means being connected with said atomization chamber means within the area of said annular gap.

38. An installation according to claim 27, further comprising feed line means for feeding the media to be atomized to the propulsion jet, said feed line means being connected with said atomization chamber means within the area of said mixing chamber.

39. An installation acocrding to claim 27, further comprising feed line means for feeding the media to be atomized to the propulsion jet, said feed line means being connected with said atomization chamber means within the area of said annular gap and of said mixing chamber.

40. An installation according to claim 36, further comprising bore means forming injection nozzle means substantially uniformly distributed over the circumference of at least one of the two parts consisting of the nozzle means an atomization chamber means, said line means being connected with said bore means by way of annular channels formed on the outside of said engine nozzle means and of the atomization chamber means.

41. An installation according to claim 37, further comprising bore means forming injection nozzle means substantially uniformly distributed over the circumference of at least one of the two parts consisting of the nozzle means and atomization chamber means, said line means being connected with said bore means by way of annular channels formed on the outside of said engine nozzle means and of the atomization chamber means.

42. An installation according to claim 39, further comprising bore means forming injection nozzle means substantially uniformly distributed over the circumference of at least one of the two parts consisting of the nozzle means and atomization chamber means, said line means being connected with said bore means by way of annular channels formed on the outside of said engine nozzle means and of the atomization chamber means.

43. An installation according to claim 36, wherein the other end of said line means is operatively connected with at least one container means for storing the media participating in the atomization.

44. An installation according to claim 43, wherein said container means are arranged with the entire extent thereof above the connecting place of the line means with the rocket engine means, and the line means are connected with the bottom of the container means.

45. An installation according to claim 43, wherein said container means are constructed as closed tanks, and pressure means operatively connected with said tanks.

46. An installation according to claim 45, wherein said

pressure means is a gas generator arranged within the container means.

47. An installation according to claim **45**, wherein said pressure means is the pressure in the combustion chamber means of the rocket engine.

48. An installation according to claim **44**, wherein said container means are constructed as closed tanks, and pressure means operatively connected with said tanks.

49. An installation according to claim **47**, wherein said pressure means includes pressure line means, and bursting disk means closing said pressure line means, said bursting disk means bursting when said rocket engine means reaches the normal operating pressure.

50. An installation according to claim **49**, wherein said pressure line means includes rapidly opening valve means and check valve means.

51. An installation according to claim **45**, wherein said pressure line means includes rapidly opening valve means.

52. An installation according to claim **45**, wherein said pressure line means includes check valve means.

53. An installation according to claim **45**, wherein said pressure line means includes rapidly opening valve means and check valve means.

References Cited

UNITED STATES PATENTS

1,362,997	12/1920	Koleroff	239—265.17
1,493,753	5/1924	Koleroff	239—265.17
2,518,000	8/1950	Goddard	60—264 X
2,705,396	4/1955	Boyce et al.	60—264 X
2,770,097	11/1956	Walker	60—39.58 X
2,949,009	8/1960	D'Ooge	60—264 X
2,962,934	12/1960	Seidner	60—264 X
3,036,430	5/1962	Eggers et al.	239—265.23
3,070,957	1/1963	McCorkle	239—127.3
3,095,694	7/1963	Walter	60—264 X
3,233,833	2/1966	Bertin et al.	239—265.23
3,300,978	1/1967	Pennington	239—265.23 X
3,303,654	2/1967	Bringer	239—127.3
3,325,103	6/1967	Abbott	239—265.23 X

FOREIGN PATENTS

364,130	10/1938	Italy.

M. HENSON WOOD, JR., *Primary Examiner.*

V. C. WILKS, *Assistant Examiner.*