Dec. 5, 1950 T. D. JOECK 2,532,554

METHOD FOR ATOMIZING BY SUPERSONIC SOUND VIBRATIONS

Filed Jan. 29, 1946 2 Sheets-Sheet 1

Fig. 1.

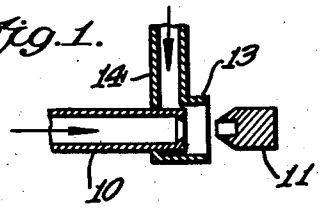


Fig. 2.

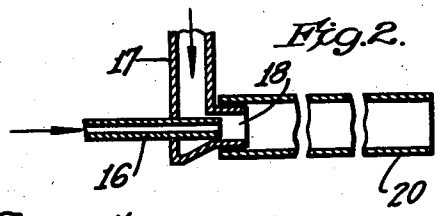


Fig. 2a.

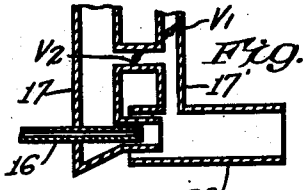


Fig. 3.

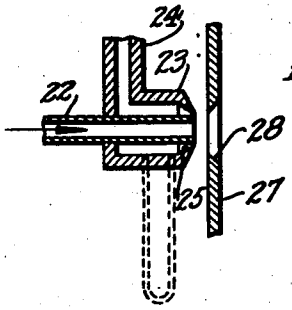


Fig. 4.

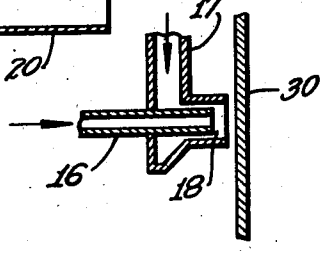


Fig. 5.

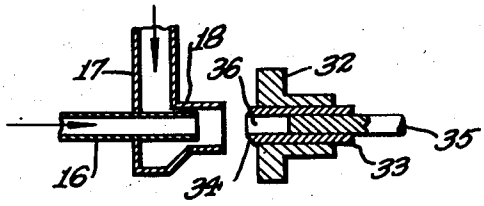


Fig. 6.

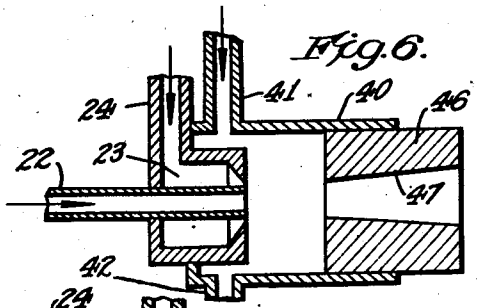


Fig. 6a.

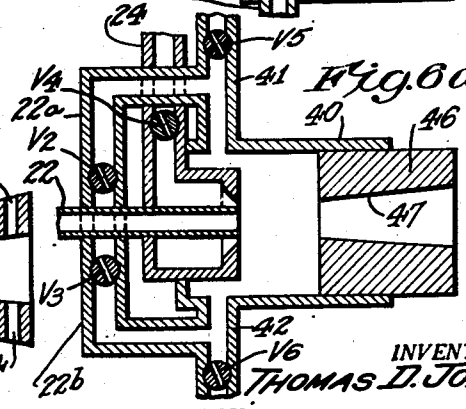
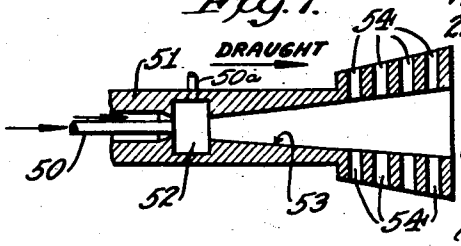


Fig. 7.



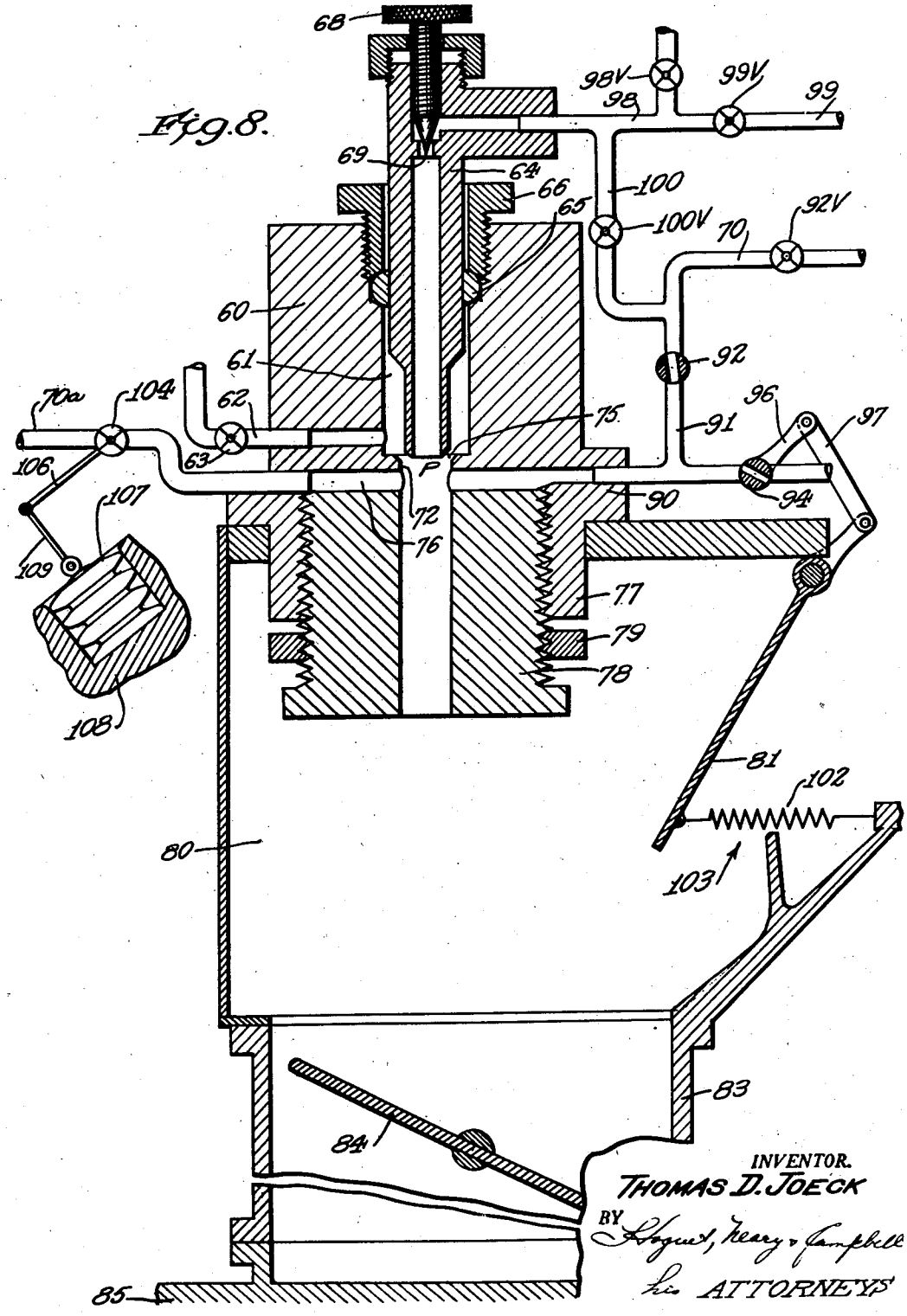
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Dec. 5, 1950 T. D. JOECK 2,532,554

METHOD FOR ATOMIZING BY SUPERSONIC SOUND VIBRATIONS

Filed Jan. 29, 1946 2 Sheets-Sheet 2

Fig. 8.



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2,532,554

METHOD FOR ATOMIZING BY SUPERSONIC SOUND VIBRATIONS

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Application January 29, 1946, Serial No. 644,005

4 Claims. (Cl. 299—1)

1

This invention relates to supersonic generators for changing liquids into vapors or small droplets and to a method for effecting such change.

One object of this invention is the changing of liquids into vapors or small droplets and the homogeneous mixing of vapors or gases and the methods for the accomplishment thereof, with particular application of such methods to the more efficient operation of internal combustion, turbine or other similar prime movers as well as those operating from a source of substantially constant pressure, by subjecting them to high frequency sound vibrations caused by the escape of gas or air under pressure through an orifice and amplified by the discharge column of fluid tuned to resonate with the high frequency sound vibrations so produced, thereby subjecting fluids so introduced into a chamber or the like to greater disruptive forces so as to break them up into finely divided and well distributed droplets.

Another object of this invention is to subject one or more liquids to supersonic waves to cause them to break up into finely divided droplets and to mix thoroughly and uniformly.

Other objects of this invention are to distribute evenly particles suspended in a gas or gases, to distribute evenly particles such as pigments in one or more liquids and blend the same, to break up and thoroughly mix and blend several different kinds of liquids and/or gases to produce a homogeneous mixture containing each liquid or gas or both in a predetermined proportion and to subject streams of vaporized fluid to great disruptive forces so as to break up the same into more finely divided and more equally distributed droplets.

Another object of this invention is the provision of a supersonic carburetor.

Another object of this invention is to provide a fuel-burning jet or nozzle and the application of such to gas turbines and steam or other vapor pressure generators.

Other objects of this invention will appear as the description proceeds in connection with the drawings illustrating several embodiments, and in which,

Figure 1 shows an embodiment of means for breaking up liquids by supersonic effects;

Figure 2 shows another embodiment utilizing a type of nozzle used in perfume atomizers or paint spray guns but with vacuum and wave power amplifier added;

Figure 2*a* shows the embodiment in Figure 2 provided with pressure (or vacuum) equalizing valves;

Figure 3 shows the invention carried out in connection with another type of spray nozzle used in paint spray guns;

Figure 4 shows another means for increasing the vacuum and consequently the "break up" produced with the type of nozzle shown in Figure 2;

2

Figure 5 shows a combination of the spray nozzle of Figure 2 with an adjustable cavity member of the type shown in Figure 1;

Figure 6 shows an embodiment for drawing different liquids from a plurality of separate containers into a resonance chamber and blowing out a homogeneous mixture of varying predetermined proportions;

Figure 6*a* shows the embodiment in Figure 6 provided with pressure (or vacuum) equalizing valves;

Figure 7 shows a device for producing a more complete "break up" of the particles of liquid atomized; and

Figure 8 shows a carburetor employing the principles of my invention, more particularly the embodiment shown in Figure 6*a*.

A jet of gas issuing from an orifice is not constant but is definitely intermittent in character. To a certain extent this is true of liquid escaping through an orifice under high pressure. Small somewhat conically shaped puffs emerge, producing a pulsating stream of alternately compressed and rarified gas which is roughly similar to a stream of bullets from a modern machine gun.

In Figure 1 there is disclosed one embodiment of a supersonic generator comprising an air tube 10 provided with a conical orifice and a cavity member 11 provided with a conical end. By adjusting the distance between the efflux end of the air tube and the cavity member, as well as coordinating the diameter of the air jet and that of the cavity together with its depth in the cavity member, vibrations can be efficiently generated and propagated in considerable strength in a direction at right angles to the axis of the air jet. The axes of the jet and cavity coincide. The jet and cavity are usually circular in cross section.

In order to increase the intensity or efficiency of the supersonic generator, a chamber is provided around the air tube by means of a cylindrical member 13 here shown as the end of a liquid supply pipe 14. Any suitable provision, such as a threaded connection (not shown) may be made for adjusting the air tube 10 in the liquid supply pipe 14. The walls of the chamber surrounding the end of the air tube produce a small circular orifice allowing liquid to enter the cylindrical chamber at its outer diameter and parallel to its axis in the form of a cylindrical shell, the diameter of which is so calculated as to be in resonance with the supersonic vibrations set up by the generator which comprises the air tube and the cavity member. This increases the "break up" of the liquid considerably.

The device shown in Figure 1, when used as a carburetor, is found highly satisfactory. An engine equipped with this device produces more

power and runs well on many different kinds of fuel such as alcohol and various mixtures of kerosene, fuel, crude and the light oils, and gasoline; no choking is necessary, and starting is easier. While the illustration is more or less diagrammatic, its connection with the intake manifold is obvious by reference to Figure 8.

In Figure 1 the two elements 10 and 11 alone without the supply pipe 14 and the cylindrical member 13 constitute the well-known "Hartmann" supersonic generator. When this simple device is placed in the intake manifold of a conventional gasoline engine, a better "break up" of the liquid particles occurs which is desired for better fuel economy and improved engine performance.

In Figure 2 is shown a device embodying the usual type of nozzle used in perfume atomizers, some types of spray guns and similar apparatus and which comprises an air tube 16 which is preferably threaded or otherwise adjustably secured in a liquid spray tube 17 provided with a cylindrical end section 18 surrounding the end of the air tube 16. When the distance between the end of the air tube and the end of the cylindrical end section 18 is properly adjusted, a maximum vacuum will be obtained in the liquid chamber provided by the cylindrical end section. The device includes a tube 20 which closely fits over the discharge nozzle, and which produces a much higher vacuum in the liquid chamber and a much better "break up" of the liquid.

The use of this tube produces a loading effect such as is performed by a megaphone as well as the tendency to "compound" the jet. This tube must be of the proper length as too short a tube will have no practical effect, and too long a tube will interfere with the efflux. It is found that by the use of the proper length of tube 20 the supersonic vibrations generated by the nozzle are resonated to such an extent that the vacuum and, therefore, the efficiency of the device is greatly increased.

In Figure 2*a* a pipe 17' provided with a valve V_1 is connected to the tube 20 and to the pipe 17 by a connection provided with a valve V_2. The valves here perform the function of either equalizing the pressures (or vacuum) by tying together the front and rear of the jet or mixing fluids or gases with each other before being subjected to full supersonic force at the point of issue of the jet.

Figure 3 shows another type of spray nozzle used in paint spray guns and is structurally somewhat the same as that disclosed in Figure 2, and is also in principle substantially the same except that the air pressure is applied where the liquid entered, and the liquid enters where the air was applied in Figure 2.

This device comprises a liquid spray tube 22 which may be threaded into the closed end of a cylindrical member 23 on the end of an air supply tube 24, providing an air pressure chamber. The open end of the cylindrical member or air chamber is provided with an inner conical face 25 to direct the air over the edge of the end of the liquid supply tube 22. It is found that supersonic vibrations exist in the air pressure chamber 23 as well as in the air jet. If a glass tube be placed as indicated by the dotted lines and partially filled with light cork dust or lycopodium, the characteristic dust figures appear, indicating that vibrations are set up behind the air orifice as well as in front of it. This is true of all other types of jets shown herein. In this device a plate 27 provided with a conical hole 28 having sharp edges as indicated is placed at the proper distance away from the face of the nozzle to produce resonance. Air passing over the sharp edges of the conical opening 28 further accentuates the vibration condition in the air stream which is desired for better "break up."

Figure 4 discloses the type of nozzle shown in Figure 2, and by placing a flat plate 30 in front of it as shown, the vacuum on the liquid in the cylindrical chamber 18 is increased and consequently the "break up" of the liquid is increased at the point where the mixture escapes past the opening formed by the edge of the wall of the cylindrical chamber 18 and the flat plate 30.

In Figure 5 is shown the combination of the nozzle construction shown in Figure 2 with a modified form of the cavity member 11 shown in Figure 1.

The cavity member comprises an outer supporting member 32 which is somewhat equivalent to the member 30 in Figure 4, a sleeve member 33 provided with a conical end 34, and which may be adjustable in the member 32, and a rod 35, which may be adjustable in the sleeve member 33 by means of which the position and depth of the cavity 36 may be adjusted. In this embodiment the distances between the end of the air tube and the end of the chamber 18, the distance between the end of the chamber 18, and the end face of the member 32, and the length and position of the cavity can be so adjusted in resonance as to obtain a very high degree of "break up" and efficiency.

The nozzle designs which discharge in a plane perpendicular to the axis of the jet of air may be used in spraying and dusting devices. The device shown in Figure 2 throws a well broken up stream coincident with the axis of the jet and is directly adapted for use as a carburetor or individual fuel injector.

In Figure 6 is disclosed a device which is highly efficient in breaking up a liquid and in discharging the same as a stream coincident with the axis of the jet. This device includes as in Figure 3 a liquid pipe 22 adjustable in the closed end of the cylindrical chamber 23 on the end of the air pipe 24. Surrounding the cylindrical chamber 23 is a cylindrical member 40 providing a chamber into which liquids may enter through liquid supply pipes 41 and 42 which may be equipped with controlling valves, as shown in Figure 6*a*, by means of which the amounts of the several liquids that may be drawn into the chamber in the cylindrical member 40 may be controlled.

Mounted in the open end of the cylindrical member 40 is a disc-like nozzle 46 which is adjustable toward and away from the end of the cylindrical member 23 and by selecting the proper radius for the cylindrical member 40 and adjusting the distance between the nozzle member 46 and the end of the cylindrical member 23, the liquid in the chamber 40 may be caused to be in resonance with the vibrations produced at the nozzle comprising the end of the tube 22 and the end of the cylindrical member 23 which is about equal to the diameter of the tube 22. The nozzle disc 46 is provided with an outwardly tapering port 47 the angle of which is determined by the natural pattern of efflux from the nozzle tip as formed by the shapes of tube 22 and member 23.

This type makes it possible to draw by its own

vacuum a plurality of different liquids from as many separate containers into the resonance chamber and blow out a homogeneous mixture of varying proportions of each, which may be controlled at will by control valves as described in connection with Figure 6*a*, in the pipes leading from various containers or sources of supply. The number of containers and pipes leading to the resonance chamber may be increased to a large extent. It has been found that powerful supersonic vibrations are set up throughout the system, and, therefore, that liquids introduced into the resonance chamber are subjected to a terrific "shaking-up."

In Figure 6*a* the pipe **22** is connected by branch pipes **22***a* and **22***b* to the pipes **41** and **42** and valves V_2, V_3, V_4, V_5 and V_6 are provided in the pipes **22***a*, **22***b*, **24**, **41** and **42** to perform the function of either equalizing the pressure (or vacuum) by tying together the front and rear of the jet or mixing liquids or gases with each other before being subjected to full supersonic force at the point of issue of the jet.

Figure 7 discloses a device which produces a more complete "break up." This device includes a liquid pipe **50** which projects into the tapered end of a duct member **51** and which is relatively adjustable with respect thereto. The member **51** includes a resonance chamber **52** and a flaring outlet **53** of an angle determined as in the device in Figure 6 and which is provided with radial openings **54** of increasing lengths toward its outer end. The dimensions of the openings **54** in the direction of the length of the outlet of the member **51** and radially thereof are adjusted or chosen to resonate with the vibrations in the chamber **52**. The vibrations in an open pipe are reflected as a rarification at the ends, and, therefore, the rarifications are at the outer ends of the openings **54**. The best "break up" occurs at the point of rarification of the wave and, therefore, the best results may be obtained by means of an external draft of air flowing in the direction of the arrow which carries away the well broken up liquid at the point of rarification. The liquid can also enter the jet through a pipe **50***a*.

All of the various jet designs as described in Figures 1, 2, 3, 4, 5, 6 and 7 are efficient fuel burners of fuel in both liquid and gaseous form.

The designs as shown in Figures 2, 2*a*, 6 and 6*a* are the most useful as fuel burners because of their discharge axis coinciding with the axis of the final efflux of the air-fuel mixture.

A vibrator or carburetor built in accordance with the principles disclosed in Figures 6 and 6*a* is shown in Figure 8 of the drawings.

The carburetor comprises a body portion **60** provided with a bore constituting a compressed air chamber **61** into which air under pressure is supplied through a tube **62** controlled by an air valve **63**. Mounted within and concentric with the wall of the chamber **61** is a liquid nozzle **64** secured therein by a compressible packing **65** and tightening nut **66**. The upper end of the nozzle is provided with a needle valve **68** cooperating with a restricted section **69** in the bore of the fuel nozzle **64** and controlling the amount of fluid that may be admitted to the nozzle from a fuel inlet pipe **70** or **99**.

The lower end of the chamber **61** is provided with a restricted outlet **72** concentric to and axially aligned with the end of the fuel nozzle **64**. By adjusting the nozzle **64**, the correct compressed air orifice at **75** between the end of the fuel nozzle and the restricted outlet **72** of the chamber **61** for producing the desired supersonic vibrations may be determined.

The lower end of the body **60** is provided with an enlarged resonance chamber **76**, the walls **77** of which are threaded to receive a disc-like nozzle **78** which may be locked in adjusted position by a lock nut **79**. For each setting of the fuel nozzle **64** the disc nozzle **78** controlling the size of the resonance chamber is adjusted for maximum vacuum in the fuel delivery line **70** and **70***a* as well as the line **99** when desired. The mixture of compressed air and finely divided fuel blown out through the disc nozzle **78** enters an air mixing chamber **80** into which air is drawn in amounts controlled by a valve or gate **81**. From there the mixture passes into the throttle tube **83** and past the throttle **84** into the intake manifold **85**.

The wall **77** of the resonance chamber **76** is provided with a peripheral radial port **90** communicating by means of a pipe **91** controlled by a fuel selector valve **92** with the fuel line **70** and through an air bleed valve **94** with the outside atmosphere, by means of which the mixture is controlled through mechanism such as the pantograph type movement comprising the arm **96**, link **97** and the upper extension of the valve **81**.

The fuel pipe **70** may be equipped with a valve **92V**, and other pipes **98** and **99** connected to other sources of liquids or gases may be controlled by valves **98V** and **99V**, and their common connection **100** with the pipe **70** may be controlled by a valve **100V** whereby any two or three liquids or gases may be injected in any desired relative volumetric proportions into the mixture. By this means it would be possible to add water vapor to the mixture in an easy and efficient manner.

With the air bleed valve **94** and the needle valve **68** closed, and the fuel selector valves **92** and **104** closed, the fuel nozzle **64** is adjusted to produce the proper supersonic vibrations, and then the disc nozzle **78** is adjusted to cause resonance of the air in the resonance chamber **76** with the supersonic vibrations set up at the fuel nozzle **64** to produce maximum vacuum in the fuel line **70** and a second fuel line **70***a*. The needle valve **68** is then adjusted to control the admission of fuel through the fuel nozzle **64**, and the bleed valve **94** is opened to control the mixture in the resonance chamber **76** by means of the mechanism connected to flapper valve **81**. This is in turn actuated by a suitable tension spring **102** tending to keep opening **103** at a minimum. As the demand for fuel by the engine is increased, valve **81** is moved inward to some position as shown in Figure 8 and comes to rest at a point where the spring tension and the air pressures on both sides of valve **81** balance; as the demand decreases, valve **81** tends to close and at the same time reduces the vacuum on the fuel lines as explained above, thereby keeping substantially a constant fuel air ratio fed to the engine.

Fuel valve **92V** in the line **70** and the valve **104** in the line **70***a* controlling the fuel flow lines to two separate tanks each containing different fuels can be connected to and controlled by flapper valve **81** by a linkage similar to that shown by arm **96** and link **97** but connected to the aforesaid fuel valves. Under these conditions it might be desirable to eliminate the automatic control of the air bleed valve **94** in which case it is simply disconnected from the linkage and closed or adjusted at a fixed position. In this manner the

fixed fuel-air ratio is also maintained by the demand of the engine.

One of the features of this carburetor is its ability to deliver from separate tanks a plurality of fuels to the engine after mixing them thoroughly in a controlled proportion. This is done by a pantograph or other means (not disclosed) connecting the proportioning valves in the various fuel lines as is understood. If the gas cock holes are substantially at right angles to each other, it can be seen that a movement in either direction will open one and close the other. Any intermediate position will produce a corresponding relative opening. If this linkage were connected to a thermostat 107, actuated by the temperature of the engine 108 through other links 106 and 109, then the proportion of liquid fuels entering the fuel air mix could be so controlled. Without the thermostatic feature, the liquid fuel ratio is controlled manually or by any other desirable mechanical means.

It will be understood from the foregoing description that one of the important features of the invention resides in the use of a chamber, associated with a source of supersonic waves and with one or more sources of liquid, the said chamber being so constructed and arranged as to be resonant to the frequency of the supersonic waves. By this construction and method, the supersonic vibrations within the resonance chamber are greatly intensified and hence the degree of vaporization of the liquid or liquids is materially increased.

It will be further understood that the design of the various parts of the devices herein disclosed follows well-known acoustical principles applicable to the resonance of sound waves. For example, such devices previously described embody various combinations of resonant cavities of the closed and/or open "organ pipe" character. More particularly and referring to Fig. 6, the resonant cavity or chamber defined by member 40 comprises three portions, namely the diameter of the member 40, the distance between the nozzle member 46 and the end of the cylindrical member 23, and the length of the member 46. The aforesaid diameter portion corresponds to a closed "organ pipe" in which event the diameter should be equal to an odd number of quarter wave lengths corresponding to the supersonic frequency supplied. On the other hand, the distance between the members 46 and 23 and the length of the member 46 corresponds to the open "organ pipes." Thus in accordance with the laws governing resonance of such open pipes, these lengths should be equal to an even number of quarter wave lengths corresponding to the supply frequency. In this manner, the chamber defined by the member 40 will be resonant to the frequency of the supersonic vibrations supplied thereto and will be greatly intensified in order to secure a high degree of "breaking-up" of the liquid or liquids.

The description of the invention with reference to preferred embodiments illustrated for purposes of disclosure is not to be considered limiting, and it accordingly is to be understood that applicant reserves the right to all such changes and modifications as fall within the principles of this invention and the scope of the appended claims.

I claim:

1. The method of intimately mixing liquids which comprises discharging concentric streams of said liquids under pressure into a sound augmenting resonance chamber, and subjecting said liquids to a jet of supersonic sound vibrations in said chamber, whereby the liquids are homogeneously and intimately mixed, said chamber being resonant to the frequency of said supersonic sound vibrations.

2. The method of breaking up a liquid into finely divided particles to vaporize the same, which comprises continuously supplying under pressure, into a chamber at one end thereof, a jet of supersonic sound vibrations, said chamber being resonant to the frequency of said vibrations to thereby intensify the vibrations, continuously supplying a stream of liquid to said chamber to subject the liquid to the intensified supersonic vibrations in the chamber to produce a vaporized mixture, and discharging the vaporized mixture from said chamber at the other end thereof.

3. The method of breaking up a liquid into finely divided particles to vaporize the same, which comprises continuously supplying under pressure, into a chamber at one end thereof, a jet of supersonic sound vibrations, said chamber being resonant to the frequency of said vibrations to thereby intensify the vibrations, continuously supplying a stream of liquid to said chamber concentrically of said jet to subject the liquid to the intensified supersonic vibrations in the chamber to produce a vaporized mixture, and discharging the vaporized mixture from said chamber at the other end thereof.

4. The method of breaking up a liquid into finely divided particles to vaporize the same, which comprises continuously supplying under pressure, into a chamber at one end thereof, a jet of supersonic sound vibrations, said chamber being resonant to the frequency of said vibrations to thereby intensify the vibrations, continuously supplying a stream of liquid to said chamber concentrically of said jet, supplying a separate stream of liquid to said chamber, the liquids in said chamber being subjected to the intensified supersonic vibrations therein to produce a vaporized mixture, and discharging the vaporized mixture from said chamber at the other end thereof.

THOMAS D. JOECK.

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