United States Patent

[11] 3,613,722

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[54] **CONDITIONING FLUIDS**
18 Claims, 12 Drawing Figs.

[52] **U.S. Cl.** **137/599,** 137/604, 259/4
[51] **Int. Cl.** **B01f 5/02**
[50] **Field of Search** 137/599, 604; 251/4; 261/118; 239/102, 419, 419.3, 419.5, 426, 427, 427.3, 427.5, 431

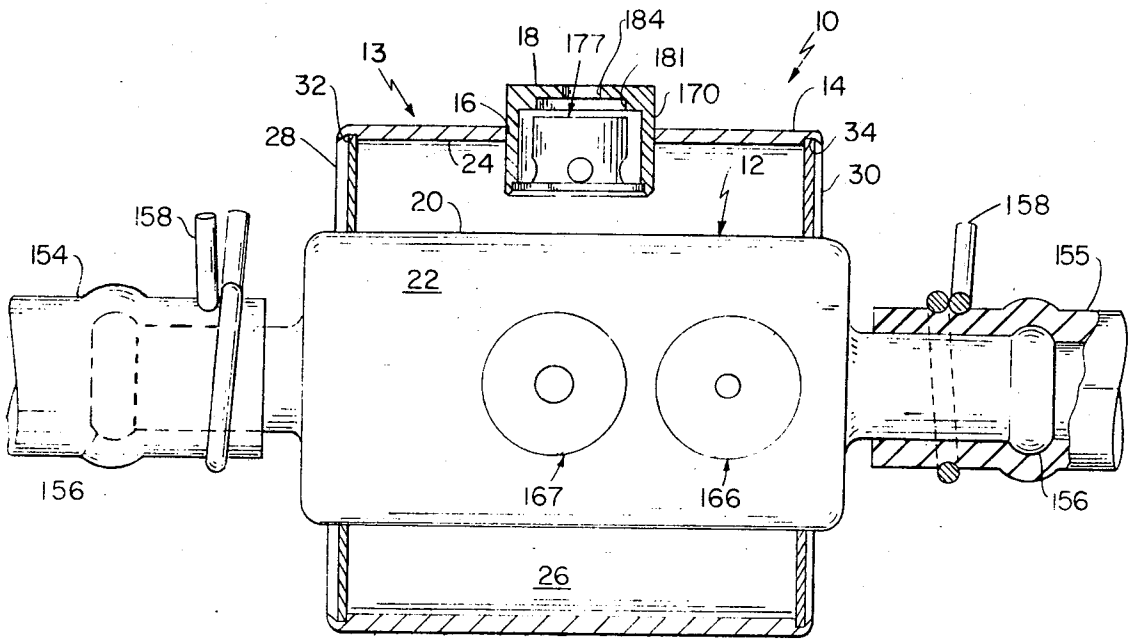
[56] **References Cited**

UNITED STATES PATENTS

1,232,921	7/1917	Hicks	239/427.5 X
3,207,484	9/1965	Rubin	259/4
3,219,483	11/1965	Goos et al.	259/4 X
3,391,908	7/1968	MacDonald	259/4

Primary Examiner—Robert G. Nilson
Attorney—William W. Rymer

ABSTRACT: In a fluid-conditioning apparatus having a fluid conditioner, having an axial flow passage between an axial inlet, an axial outlet, a nozzle mounted axially in this flow passage, and a nozzle mounted radially of the flow passage defining a radial inlet to the flow passage, the improvement comprising a fluid preconditioner comprising a structure defining a fluid source in communication with the inlet end of the radially mounted nozzle of the conditioner providing the fluid supply to this nozzle, the source-defining structure having a fluid inlet, and a fluid-supply nozzle mounted in the source inlet to supply fluid therethrough to the source, the fluid supply nozzle comprising a body defining an axial flow passage having inlet and outlet ends and an even plurality of radial orifices into this passage between its ends, with the radial orifices arranged in coaxial pairs 180° apart.



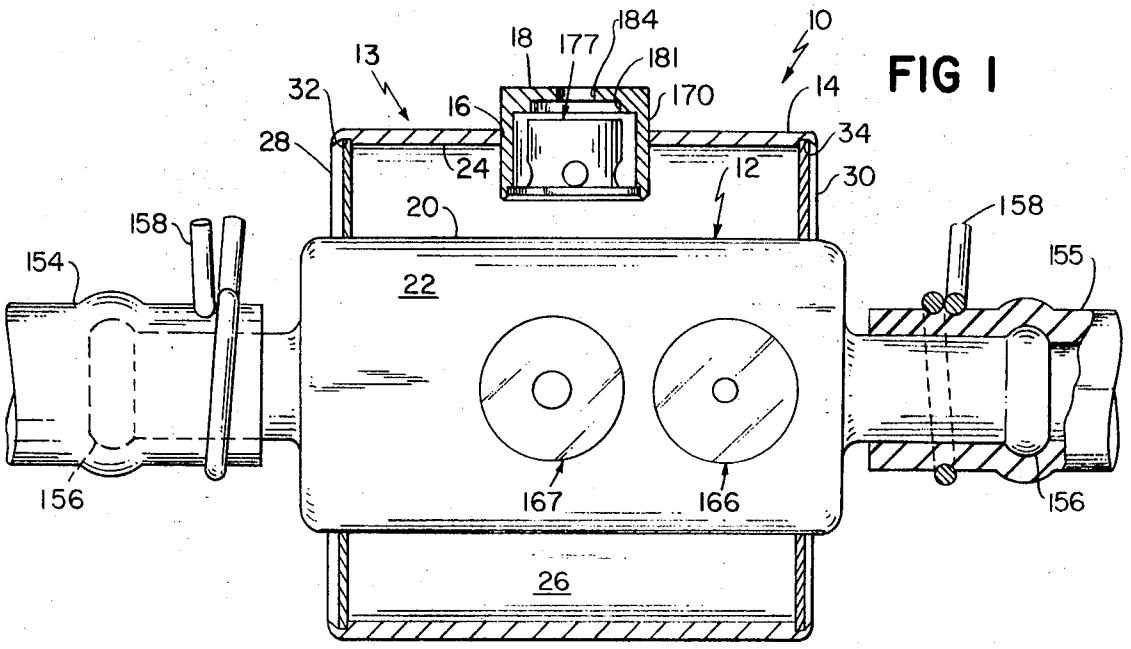

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FIG 1

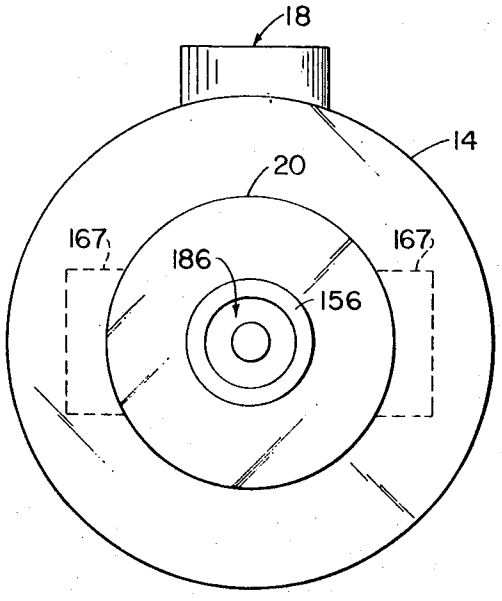
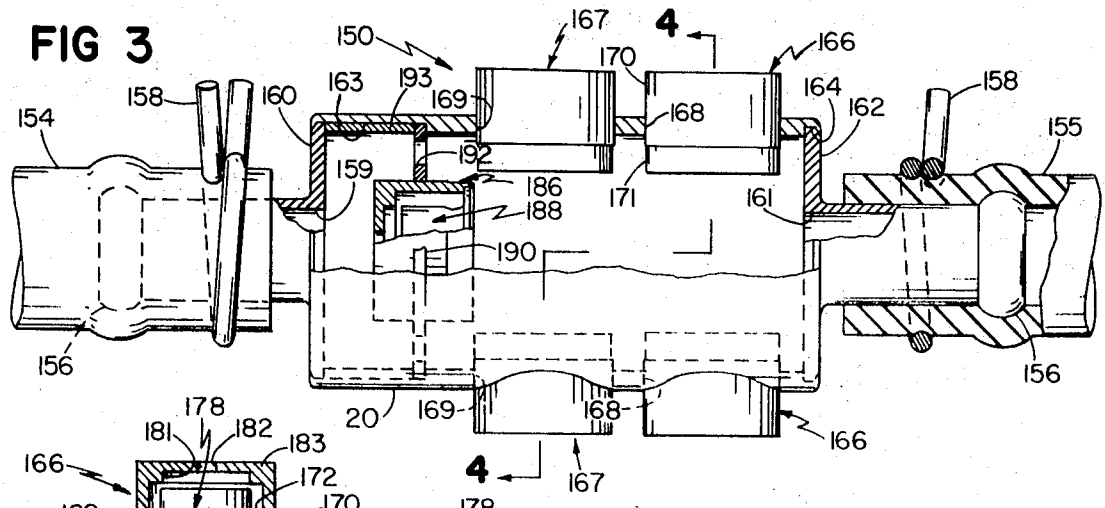

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FIG 2

FIG 3



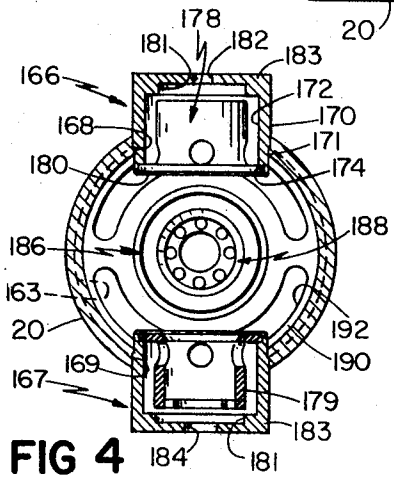


FIG 4

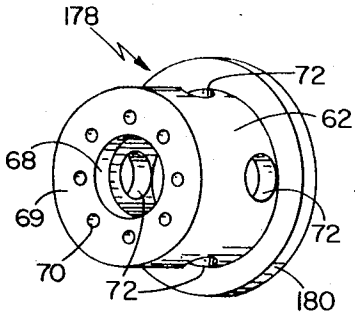


FIG 5

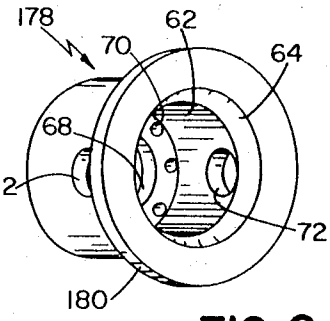


FIG 6

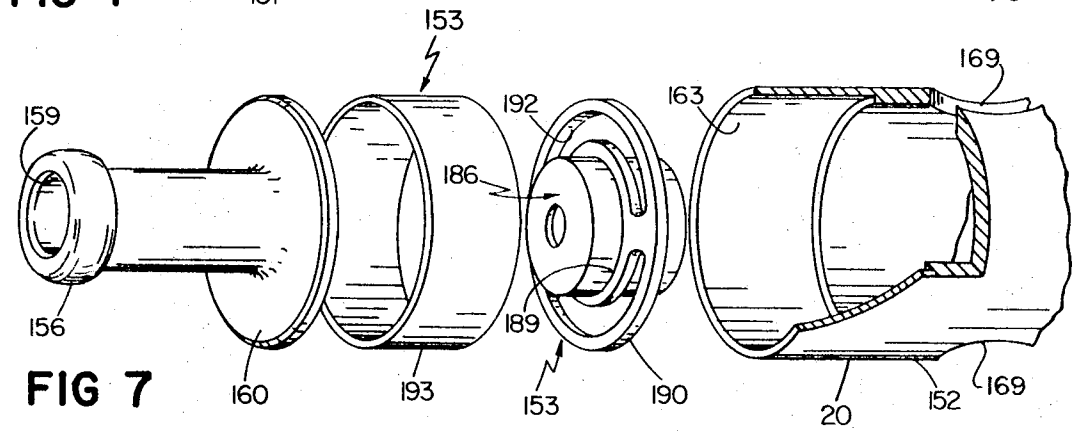
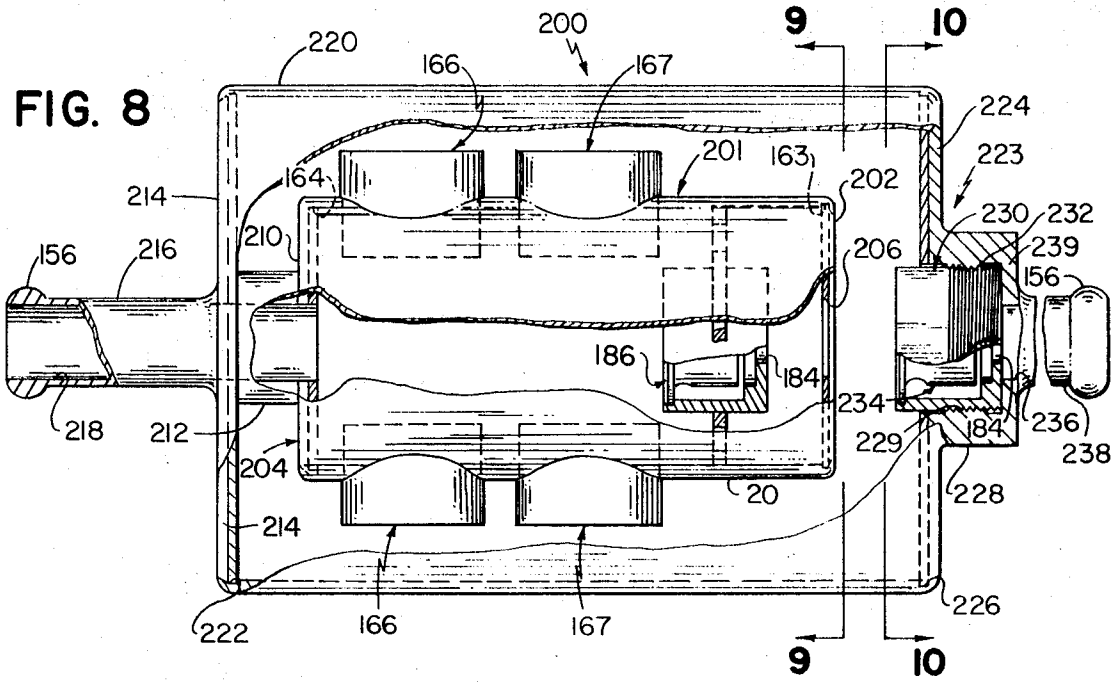


FIG 7

FIG. 8



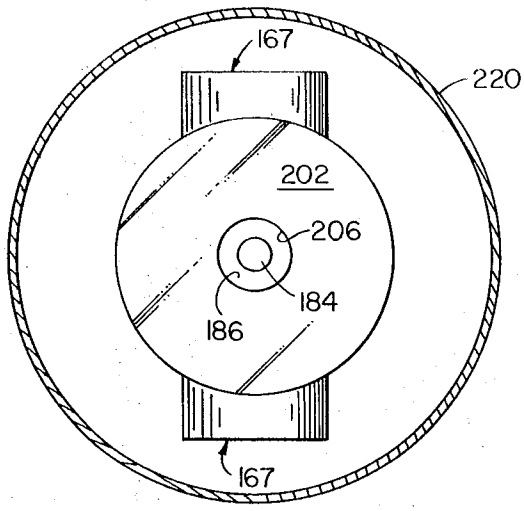


FIG 9

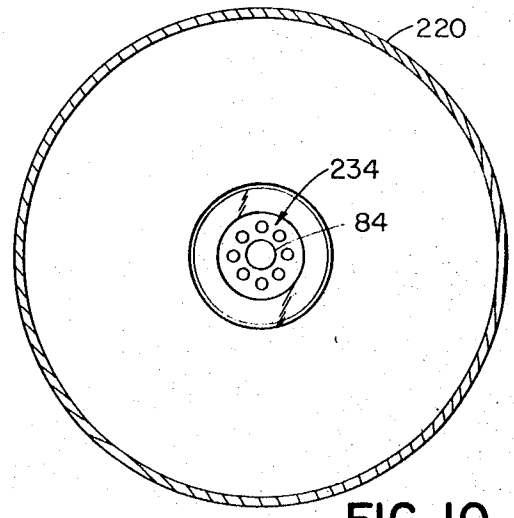


FIG 10

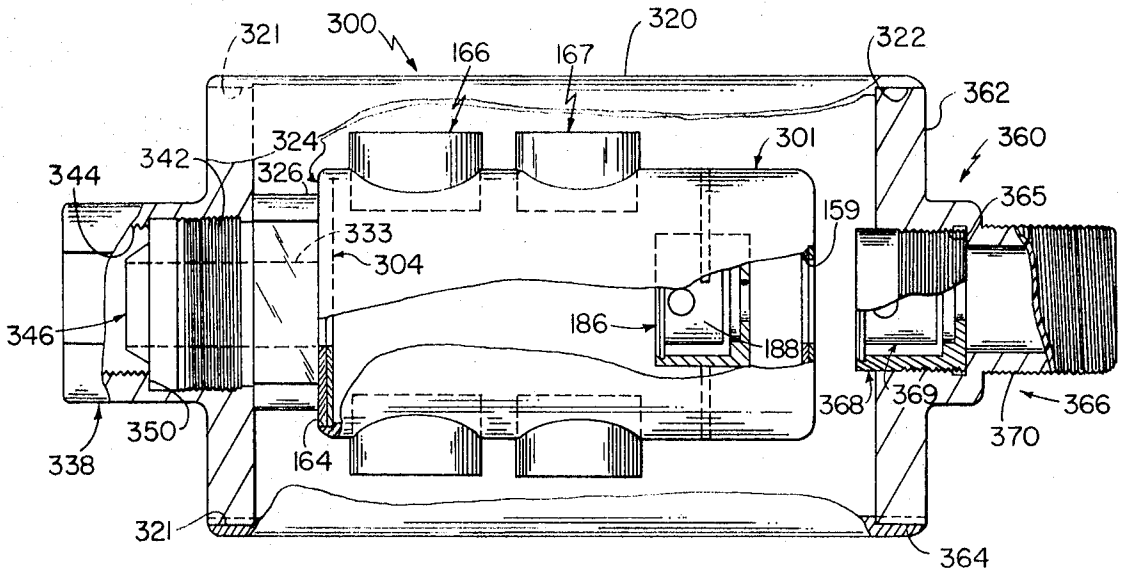

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FIG 11

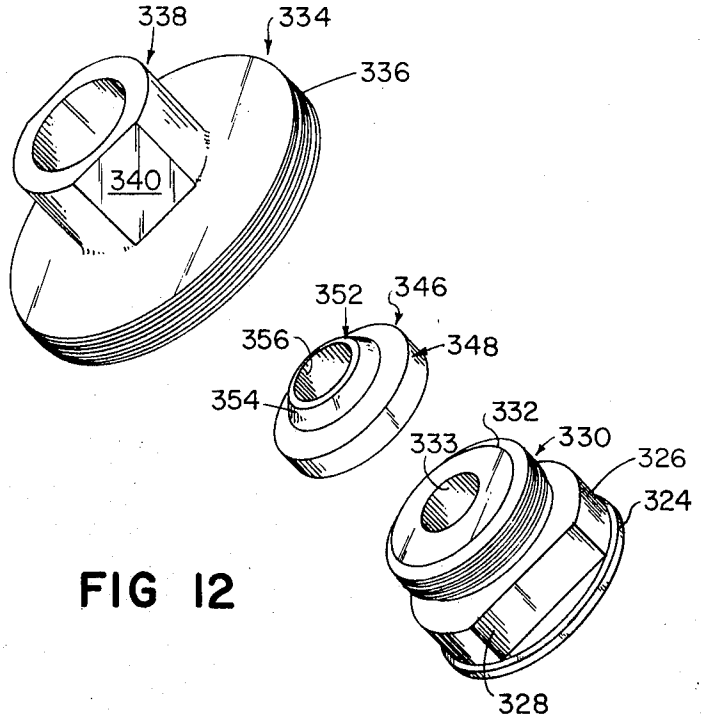

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FIG 12

CONDITIONING FLUIDS

This invention relates to conditioning of gases and liquids, e.g., for mixing or reaction, such as combustion.

A primary object of the invention is to enhance the directly useable energy in gas streams (e.g., for mixing and atomization) with simple devices that can be simply and efficiently utilized in a wide variety of physical process. Another object is to enhance this energy with little or no addition of material to the gas stream. Other objects are to improve fuel economy and efficiency of internal combustion engines, and to reduce the emission therefrom of incompletely combusted substances.

The invention features, in a fluid-conditioning apparatus comprising a fluid conditioner, the conditioner having a fluid inlet and a fluid outlet and comprising a body defining an axial flow passage having inlet and outlet ends, the outlet end communicating with the fluid outlet, and at least one radial orifice into the passage between these ends, an axially mounted nozzle comprising a body defining an axial flow passage having inlet and outlet ends, and an even plurality of radial orifices into this axial flow passage between these ends, the radial orifices being arranged in coaxial pairs 180° apart, the axially mounted nozzle being mounted within the axial flow passage through the conditioner between said inlet and said radial orifice of said conditioner, with the axial flow passage through the nozzle arranged in parallel with the axial passage through the conditioner and this nozzle outlet facing the conditioner outlet, and a radially mounted nozzle comprising a body defining an axial flow passage having inlet and outlet ends, and an even plurality of radial orifices into this nozzle passage between the ends, these orifices being arranged in coaxial pairs 180° apart, this radially mounted nozzle mounted in a radial orifice of said conditioner with its outlet end communicating with the axial flow passage through the conditioner to define the flow path into the conditioner through its radial orifice, the improvement wherein said apparatus includes a fluid preconditioner comprising a structure defining a fluid source in communication with the inlet end of the radially mounted nozzle of the conditioner providing the fluid supply to this nozzle, the source-defining structure having a fluid inlet, and a fluid-supply nozzle mounted in the source inlet to supply fluid therethrough to the source, the fluid-supply nozzle comprising a body defining an axial flow passage having inlet and outlet ends and an even plurality of radial orifices into this passage between its ends, with the radial orifices arranged in coaxial pairs 180° apart. In one preferred embodiment, the fluid-supply nozzle has its axial flow passage radial to the axial flow passage of the conditioner, and perpendicular to the axial flow passages of the conditioner's radially mounted nozzles (e.g., 90° apart from each of two 180° spaced apart radially mounted nozzles); and, the fluid-supply nozzle is mounted in a radial orifice of a cylindrical member which defines, with the outer surface of the conditioner body, an annular fluid source all of the fluid outlets of which are radial inlets to the axial flow passage of the conditioner. In another preferred embodiment, the fluid source is also in communication with the axial inlet to the conditioner and therethrough with the inlet of the conditioner's axially mounted nozzle, and the fluid source inlet and the fluid source nozzle mounted therein are upstream of the conditioner inlet and coaxial with axial flow passages of the conditioner and of its axially mounted nozzle; and, the fluid source is defined by a cylindrical member concentric with a cylindrical conditioner body, and having an upstream end wall containing said fluid source inlet spaced upstream of the end wall of the conditioner, the cylindrical member and conditioner body defining therebetween a fluid source all outlets of which are into the axial flow passage of said conditioner. In the preferred embodiments, the fluid-supply nozzle is mounted in a tube the inner wall of which defines with the body of the nozzle an annular passage surrounding the nozzle and communicating with its radial orifices; the tube has an end wall portion defining concentric successive axial inlets of increasing cross-sectional area from outermost to innermost; the body of the nozzle includes a portion defining inlets of area less than that of the axial flow passage of the nozzle; the nozzle has four radial orifices spaced 90° apart and the nozzle body has a countersink at the outlet end of the axial flow passage; the fluid-conditioning apparatus is mounted in an internal combustion engine to pass fluid passing therethrough (some or all of which is from a fluid reservoir with the engine) to the manifold of the engine to improve combustion of substances in the engine; and, the fluid-conditioning apparatus is mounted in the airline of a paint sprayer to improve paint atomization downstream of the apparatus.

Other objects, features, and advantages will appear from the following description of a preferred embodiment of the invention, taken together with the attached drawings thereof in which:

FIG. **1** is an elevational view, partially broken away, of one preferred embodiment of the present invention;

FIG. **2** is an end view of the embodiment of FIG. **1** with the hose and clamp removed from that end;

FIG. **3** is an elevational view, partially broken away, of a portion of the embodiment of FIG. **1**;

FIG. **4** is a sectional view of the device of FIG. **3** along line **4—4** thereof, one nozzle being shown in plan and one in section;

FIGS. **5** and **6** are enlarged perspective views of a nozzle employed in the embodiment of FIG. **1**;

FIG. **7** is an exploded view, partially broken away, of one end of the device of FIG. **3**, with the radially mounted nozzles removed;

FIG. **8** is an elevational view, partially broken away, of another embodiment of the present invention;

FIG. **9** and **10** are sectional views of the embodiment of FIG. **8**, along lines **9—9** and **10—10**, respectively;

FIG. **11** is an elevational view, partially broken away, of another embodiment of the present invention; partially

FIG. **12** is an exploded view of one end of the embodiment of FIG. **11**.

FIGS. **1–7** show a fluid-conditioning apparatus **10** including a fluid conditioner member **12** and a fluid preconditioner **13** including cylindrical tube **14**, having a radial bore **16** in which is press fit a tubular fluid-supply cell **18**. Member **12** includes a cylindrical tube **20**, the outer surface **22** of which defines, with the inner surface **24** of cylindrical tube **14**, an annular passage **26**. Annular end caps **28**, **30** are located in counterbores **32**, **34** respectively, of cylindrical tube **14**, each end of tube **14** being roll swaged about the outer wall of the respective end cap, as shown in FIG. **1**, to form an airtight fit.

Cylindrical tube **20** (outer diameter 1 inch, inner diameter 0.870 inch) has an inlet portion **153** (FIG. **7**), and is secured at its inlet end to a first hose **154** (e.g., a return line for returning incompletely combusted substances, such as oil droplets, to the manifold of an internal combustion engine for combustion) and at its outlet end to a second hose **155** (leading to the manifold) by protuberances **156** and clamps **158**. Tube **20** includes an axial inlet **159** (diameter 0.312 inch) through inlet cap **160** and an identically sized axial outlet **161** through outlet cap **162**. Caps **160**, **162** are tightly fitted in counterbores **163**, **164**, respectively, of tube **152** which are swaged about the outer walls of the end caps, as shown in FIG. **3**. Tubular cells **166** are located 180° apart in opposed radial bores **168** in tube **152** to define a first radial air inlet zone, whereas tubular cells **167** are located 180° apart in opposed radial bores **169** in tube **152** to define a second radial air inlet zone.

Each cell **18**, **166**, **167** has an outer cylindrical wall **170** (outer diameter 0.528 inch), including a reduced outer diameter (0.525 inch) cylindrical portion **171** (0.100 inch long), for indexing each cell into a bore **16**,**168** or **169**, for subsequent press fitting therein. Inner wall **172** (diameter 0.431 inch) has a counterbore **174** (diameter 0.470 inch) and an identical nozzle **177**, **178**, **179** is mounted in each cell **18**, **166**, **167**, respectively, with flange **180** (outer diameter 0.468 inch) secured in counterbore **174** by swagging of the end of the wall forming counterbore **174**.

Each nozzle **178** has a cylindrical wall **62** (outside diameter 0.346 inch, inside diameter 0.260 inch) open at its outlet end across 45° countersink **64**, which is surrounded by flange **180**. Axial inlet **68** (diameter 0.177 inch) in end wall **69** is concentric with an imaginery circle containing the centers of eight equally spaced holes **70** (each of diameter 0.0315 inch). Four radial holes **72** (each of diameter 0.093 inch) in wall **62** have coplanar axes spaced 90°. Each tubular cell **18, 166, 167** includes a stepped inlet coaxial with inlet **68** to nozzles **177, 178, 179** and formed of an inner inlet hole **181** (diameter 0.345 inch), and an outer inlet hole in end wall **183**, outer inlet hole **182** to cells **166** having a diameter of 0.093 inch and outer inlet hole **184** to cells **18** and **167** having a diameter of 0.125 inch.

Tubular cell **186**, which is identical to tubular cell **167**, and contains a nozzle **188** identical with nozzle **178**, is tightly secured in a central opening **189** of mounting plate **190**, which has arcuate air passages **192**, and is seated in counterbore **163**, being spaced therein from end cap **160** by spacer ring **193**.

Additional dimensions of the assembly are:

Length of cell **18, 166** or **167** between downstream face of wall **183** and upstream face of counterbore **174**	0.267"
Length of nozzle **178** between wall **69** and countersink **64**	0.221"
Depth of countersink **64**	0.029"
Length of tube **20**	1.875"
Length of counterbore **163**	0.422"
Length of counterbore **164**	0.056"
Distance between center of radial bore **168** and outer edge of counterbore **164**	0.400"
Distance between center of radial bore **169** and center of radial bore **168**	0.615"
Length of tube **14**	1.695"

In operation, under subatmospheric pressure from the manifold, an oil droplet—air mixture is drawn from hose **154** into tube **20** through axial inlet **159**, and through cell **186** and mounting plate openings **192**. At the same time atmospheric air is drawn through cell **18** into annular passage **26**, and therefrom into and through cells **166, 167** at right angles to the oil-air flow form inlet **159**. The combined flow exits to a suitable manifold.

The air/fuel mixture then passes to the engine for combustion which has been found to be more complete, with less exhaust emission of pollutants such as carbon monoxide and nitrous oxide, than when the same engine carburetor is operated under the same conditions but without the nozzles. For example, a 1970 Pontiac showed a reduction in emissions from 1.14 percent to 0.58 percent CO, and from 1,204 p.p.m. to 713 p.p.m. NO when equipped with the fluid-conditioning device of FIGS. **1–7** and tested in accordance with the seven-mode cycle Test Procedures for Vehicle Exhaust Emissions specified by the State of California Air Resources Board.

Referring to FIG. **8–10**, fluid-conditioning apparatus **200** includes a fluid conditioner member **201**, identical to fluid conditioner member **12** except that inlet cap **160** and outlet cap **162** of member **12** have been replaced by inlet cap **202** and outlet cap **204** in member **201**. Inlet cap **202** includes an axial inlet **206** (diameter 0.312 inch), and is tightly fitted in counterbore **163** of tube **20**, which is swaged about the outer wall of inlet cap **202**. Outlet cap **204** includes a portion **210** tightly fitted in counterbore **164** of tube **20**, which is swaged about the outer wall of portion **210**, a tubular portion **212**, a circular plate **214**, and an outlet tube **216**, an outlet passage **218** (diameter 0.312 inch) extending axially along the entire width of outlet cap **204**.

Cylindrical tube **220** includes a counterbore **222** in which is tightly secured plate **214**, the tube being roll swaged about the outer peripheral wall of plate **214** in an airtight fit. An inlet structure **223** includes a circular plate **224**, which is tightly secured in counterbore **226** of tube **220**, the tube being roll swaged about the outer peripheral wall of plate **224** in an airtight fit. A projecting portion **228** has a partially threaded bore **229** into which is screwed a tubular fluid-supply cell **230** having a threaded portion **232**. Cell **230** is otherwise identical to cell **167** and contains a nozzle **234** identical to nozzle **178**. An inlet passage **236** (diameter 0.312 inch) extends through inlet tube **238** and the end wall **239** of portion **228**, and is coaxial with the inlet **184** to cell **230**, and the inlet **184** of cell **186**. Tubes **216** and **238** have protuberances **156** to which a hose may be clamped in the manner previously shown in FIG. **1** and **3**.

In operation, in an internal combustion engine, with inlet tube **238** in communication with a return line as previously described and outlet tube **216** in communication with the engine manifold, the air-oil-droplet mixture is drawn through fluid-supply cell **230** into the interior of tube **220**, and thence through one of cells **166, 167** or through opening **206** and thence through cell **186** and mounting plate openings **192**. The combined flow then exits to a suitable manifold. Again, combustion of the air/fuel mixture in the engine is more complete, with less exhaust emission of pollutants than when the same engine carburetor is operated under the same conditions but without the nozzles. For example, a 1970 Pontiac showed a 10 to 1 reduction in CO emissions, a 2 to 1 reduction in hydrocarbon emissions, and a 40 percent reduction in NO emissions when tested in accordance with the above described seven-mode cycle Test Procedure, with the openings **182** and **184** to cells **166, 167, 186**, and **230** all being 0.172 inch.

In addition, since no additional fluids are added to the carburetor, the device of FIGS. **8** to **10** may be retrofit onto existing carburetors without having to adjust the fuel-air ratio to the carburetor.

FIGS. **11** and **12** show a fluid-conditioning apparatus **300** including a fluid conditioner member **301**, identical to fluid conditioner member **201** in FIG. **8**, except for outlet cap **304**, and a cylindrical tube **320**, identical to cylindrical tube **220**, except that counterbores **321, 322** are of greater width than counterbores **222** and **226**, and are threaded. Outlet cap **304** includes a portion **324** tightly fitted in counterbore **164** of tube **20**, which is swaged about the outer peripheral surface of portion **324**, an intermediate annular portion **326** of decreased outer diameter, having parallel squared-off sides **328**, and a threaded annular head **330**, terminating in 45° countersink **332**. Outlet cap **304** has an axial passage **333** (0.312 inch diameter) therethrough. Outlet structure **334** includes a threaded annular plate **336** threadedly engaged in counterbore **321**, and an annular head **338** having parallel squared-off sides **340**. A first bore **342** is partially threaded to threadedly engage outlet cap head **330**, and a counterbore **344** is also threaded. Connector **346** includes an annular flange **348** having an outer diameter substantially equal to the inner diameter of bore **342**, is received in the unthreaded portion of bore **342**, and is secured therein between outlet cap **304** and the annular shoulder **350** between bore **342** and counterbore **344**. Connector head **352** has a 45° tapered outer wall **354**, and axial passage **356** (diameter 0.312 inch) extends through connector **346** and is aligned with passage **333** through outlet cap **304**.

Inlet structure **360** includes an annular plate **362** having a threaded outer surface **364** threadedly engaged in counterbore **322** of tube **320**, and has a threaded inner bore **365** extending through plate **362** and head **366**, for receiving a tubular fluid-supply cell **368**, which is identical to cell **230** of FIG. **8**, and contains a nozzle **369** identical to nozzle **178**. Head **366** has a threaded outer surface **370** of equal pitch and diameter threads with that of threaded counterbore **344**.

In operation, fluid-conditioning device **300** is inserted in the airline of a conventional paint sprayer, so that air to be mixed with paint for paint atomization in a convention paint sprayer

is preenergized by passage through device **300**. The airline is simply screwed into the counterbore **344** and threaded head **370** then is screwed into the previous airline connector. Finer paint atomization is thereby achieved using far lower air pressures than conventional paint sprayers (down to about 1–2 p.s.i.a.), resulting in rapidly and uniformly applied painted surfaces.

Other embodiments will occur to those skilled in the art and are within the following claims.

1. In a fluid-conditioning apparatus comprising a fluid conditioner, said conditioner having a fluid inlet and a fluid outlet and comprising

a body defining an axial flow passage having inlet and outlet ends, said outlet end communicating with said fluid outlet, and at least one radial orifice into said passage between said ends,

an axially mounted nozzle comprising a body defining an axial flow passage having inlet and outlet ends, and an even plurality of radial orifices into said passage between said ends, said orifices being arranged in coaxial pairs 180° apart,

said nozzle mounted within the said axial flow passage through said conditioner between said inlet and said radial orifice of said conditioner, with the axial flow passage through said nozzle arranged in parallel with the axial passage through said conditioner, and said nozzle outlet facing said conditioner outlet, and

a radially mounted nozzle comprising a body defining an axial flow passage having inlet and outlet ends, and an even plurality of radial orifices into said passage between said ends, said orifices being arranged in coaxial pairs 180° apart,

said radially mounted nozzle mounted in a radial orifice of said conditioner with said outlet end communicating with the axial flow passage through said conditioner to define the flow path into said conditioner through said radial orifice,

a fluid preconditioner comprising structure defining a fluid source in communication with the inlet end of said radially mounted nozzle providing the fluid supply to said nozzle, said source-defining structure having a fluid inlet, and

a fluid supply nozzle mounted in said source inlet to supply fluid therethrough to said source, said fluid-supply nozzle comprising a body defining an axial flow passage having inlet and outlet ends and an even plurality of radial orifices into said passage between said ends, said orifices being arranged in coaxial pairs 180° apart.

2. The apparatus of claim **1** wherein the axial flow passage of said fluid-supply nozzle is arranged radially of the axial flow of said conditioner body.

3. The apparatus of claim **2** wherein the axial flow passage of said fluid-supply nozzle is arranged perpendicularly of the axial flow passage through said radially mounted nozzle.

4. The apparatus of claim **3** wherein said conditioner body includes at least one radial air inlet zone defined by a pair of said radial orifices, 180° spaced apart and coaxial, into said axial passage between said ends, said conditioner includes one said radially mounted nozzle in each said radial orifice, and said fluid-supply nozzle is 90° spaced apart from each of said radially mounted nozzles.

5. The device of claim **2** wherein said source-defining structure comprises a cylindrical member having a radial fluid inlet, and defining, with the outer surface of said conditioner body, an annular fluid source having fluid outlets, all of said fluid outlets being radial orifices into the said axial flow passage of said conditioner.

6. The apparatus of claim **1** wherein said fluid-supply nozzle is mounted in a tube the inner wall of which defines with the body of said nozzle an annular passage surrounding said nozzle and communicating with the said orifices of said nozzle, and the end wall portion of which defines an axial inlet to said nozzle.

7. The apparatus of claim **6** wherein said end wall portion defines concentric successive axial inlets of increasing cross-sectional area from the outermost to the innermost said inlet.

8. The apparatus of claim **1** wherein the said body of said nozzle includes a portion defining an inlet of area less than that of said axial flow passage directly downstream of said inlet, and said passage is a counterbore to said inlet.

9. The apparatus of claim **8** wherein said portion provides openings into said passage radially outwardly of said inlet, there are four of said radial orifices spaced 90° apart, and said body has a countersink at the outlet end of said passage.

10. The apparatus of claim **9** wherein said openings are circular holes arranged in a ring, the area of said inlet differs from the total area of said radial orifices by no more than half the area of any one said radial orifice, said orifices are tangent to said countersink, and said nozzle has a flange at its outlet end and is mounted in a tube to define an annular passage surrounding said nozzle and communicating with said radial orifices, said tube having an inlet opening to said nozzle.

11. The apparatus of claim **1** wherein said fluid source is also in communication with the inlet end of said axially mounted nozzle, and said source inlet is located upstream of said conditioner body and is coaxial with the axial flow passage defined by said conditioner body, and said fluid-supply nozzle is mounted in said source inlet with the axial flow passage through said nozzle in parallel with the axial flow passage through said axially mounted nozzle.

12. The apparatus of claim **11** wherein said conditioner body includes an inlet portion at said inlet end defining an axial inlet to the axial flow passage of said body, and said source inlet is spaced upstream of said inlet portion.

13. The apparatus of claim **12** wherein the axial inlet to said conditioner body is spaced upstream of the axial inlet to the axially mounted nozzle in said conditioner.

14. The apparatus of claim **13** wherein the axial inlet of said fluid source nozzle, said conditioner body, and said axially mounted nozzle are coaxial.

15. The apparatus of claim **11** including an outlet portion at said outlet end of said conditioner body defining an axial outlet from the axial passage of said body, said outlet portion arranged to seal said axial outlet from said fluid source.

16. The apparatus of claim **11** wherein said conditioner body includes at least one radial air inlet zone, in communication with said fluid source, defined by a plurality of radial orifices having coplanar axes, into said axial passage between said ends and equally spaced around the periphery of said passage.

17. The apparatus of claim **16** wherein said conditioner body and said fluid source are defined by concentric cylindrical members, the inner cylindrical member defining said conditioner body and having an upstream end wall including the said axial inlet to said body, and the outer cylindrical member defining said fluid source and having an upstream end wall which includes said fluid inlet and which is spaced upstream of the said upstream end wall of said inner cylindrical member, the inner wall of said outer cylindrical member defining with the outer fluid wall of said inner cylindrical member an annular passage communicating with the inlet of said radially mounted nozzle.

18. The apparatus of claim **11** wherein the axial inlet to said fluid-supply nozzle has a cross-sectional area smaller than the cross-sectional area of the said axial inlet to said device.