United States Patent

Mitchell et al.

[15] 3,662,960

[45] May 16, 1972

[54] INJECTOR HEAD

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[73] Assignee: **United Aircraft Corporation**, East Hartford, Conn.

[22] Filed: **Nov. 21, 1966**

[21] Appl. No.: **596,393**

[52] **U.S. Cl.** ....**239/400,** 239/428, 60/39.74 A

[51] **Int. Cl.** **B05b 7/10**

[58] **Field of Search** 60/258; 239/400, 403, 404, 239/428

[56] **References Cited**

UNITED STATES PATENTS

3,242,670	3/1966	Buswell	60/258
3,260,461	7/1966	Biber et al.	239/403
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FOREIGN PATENTS OR APPLICATIONS

354,884	7/1961	Switzerland	239/400

Primary Examiner—Samuel Feinberg
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[57] **ABSTRACT**

An injector head having a plurality of manifolds formed by plates spaced rearwardly of the face plate. The second plate spaced adjacent said fact plate having a first projection which extends into an opening through the face plate. The third plate positioned rearwardly of said second plate having a second projection which extends into an opening which passes through the first projection of said second plate. An opening passes through said second projection. A back plate is located behind the third plate. Said projections having tapered sections to provide for a desired pressure drop.

13 Claims, 5 Drawing Figures

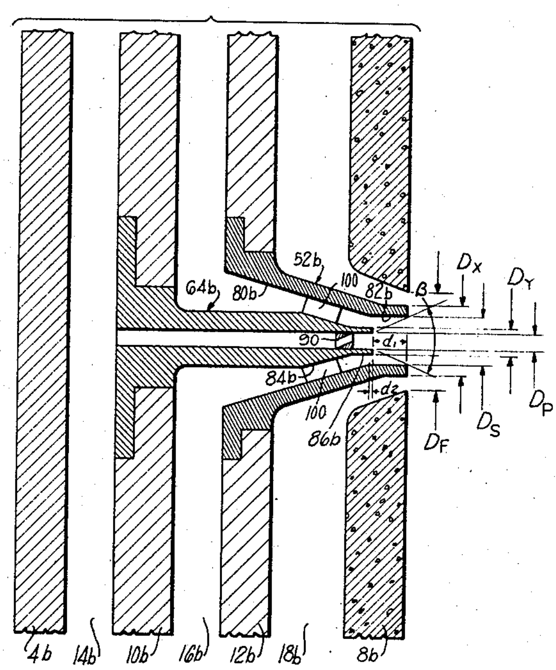

FIG. 1

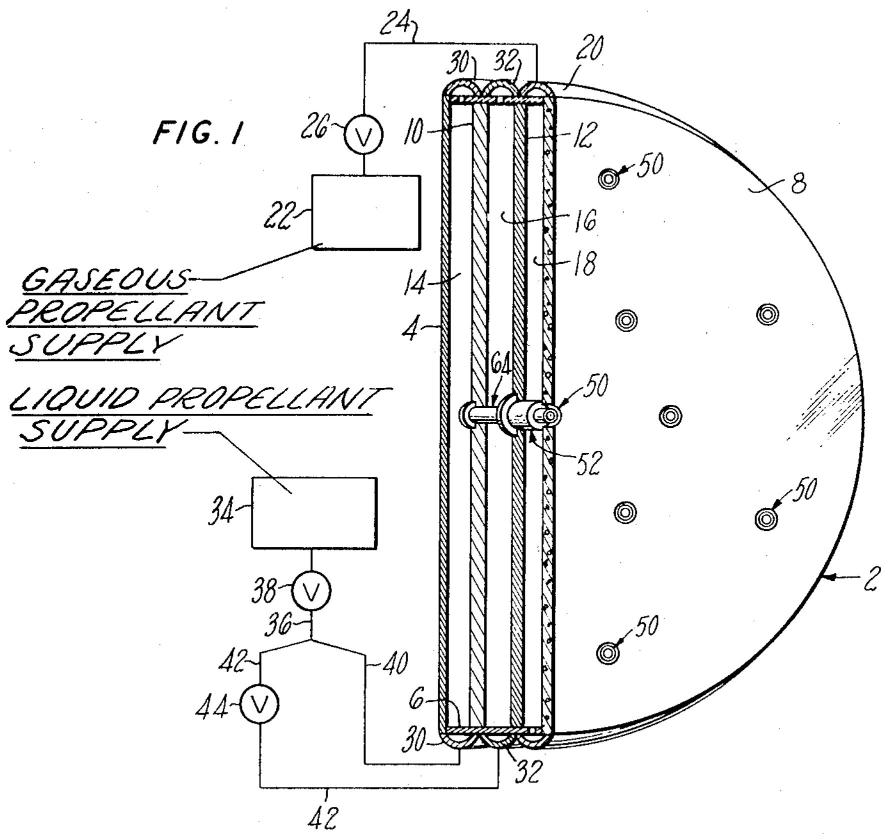

FIG. 2

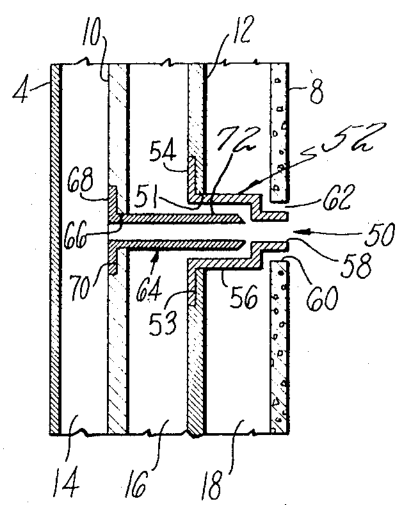

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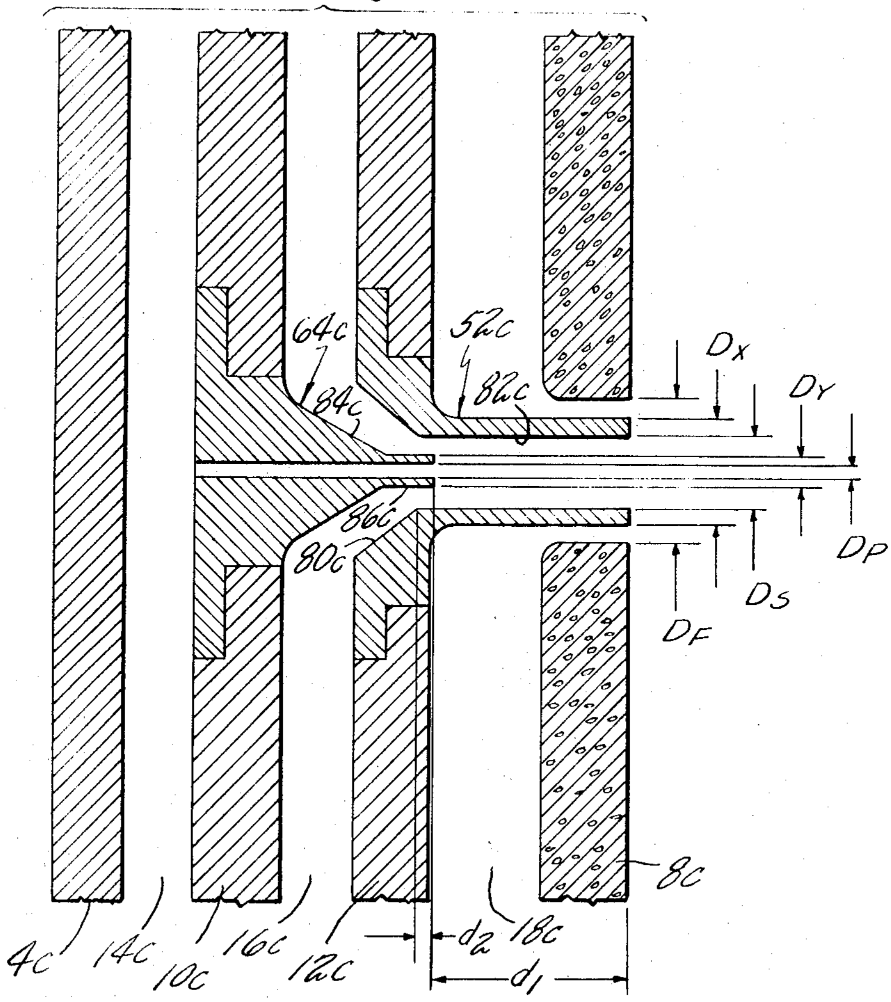
FIG. 5


64c
52c
84c
82c
86c
80c
Dx
Dy
Dp
Ds
DF
8c
4c
14c
10c
16c
12c
d2
18c
d1

Patented May 16, 1972 **3,662,960**

3 Sheets-Sheet 3

FIG. 4

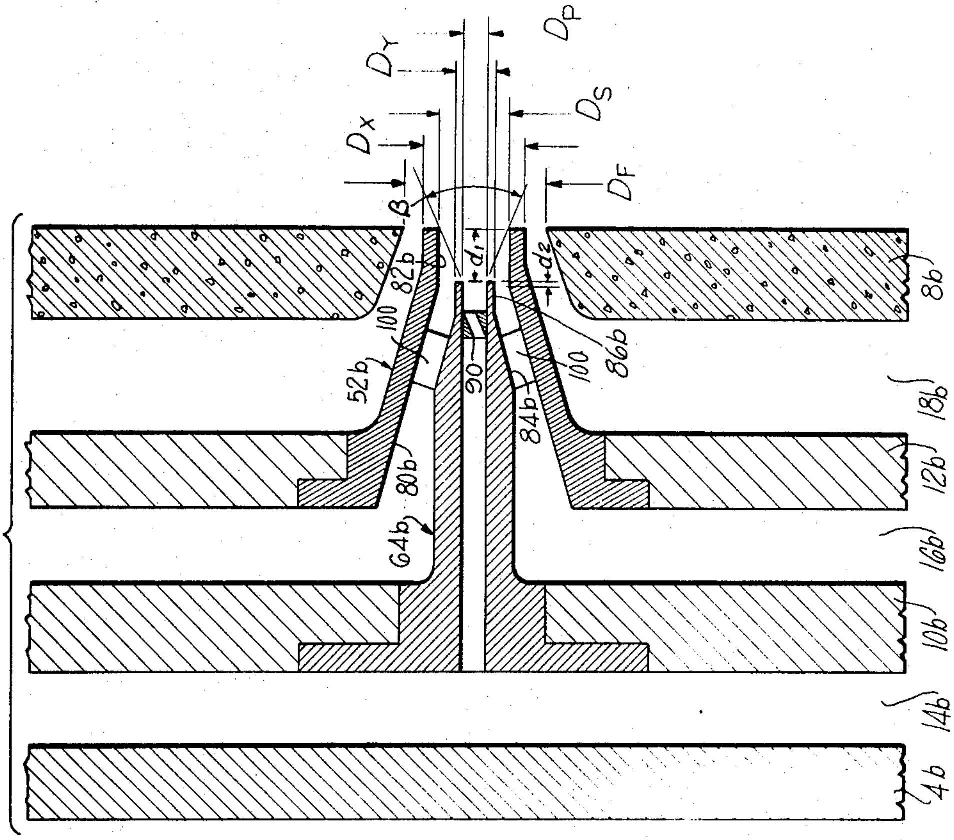
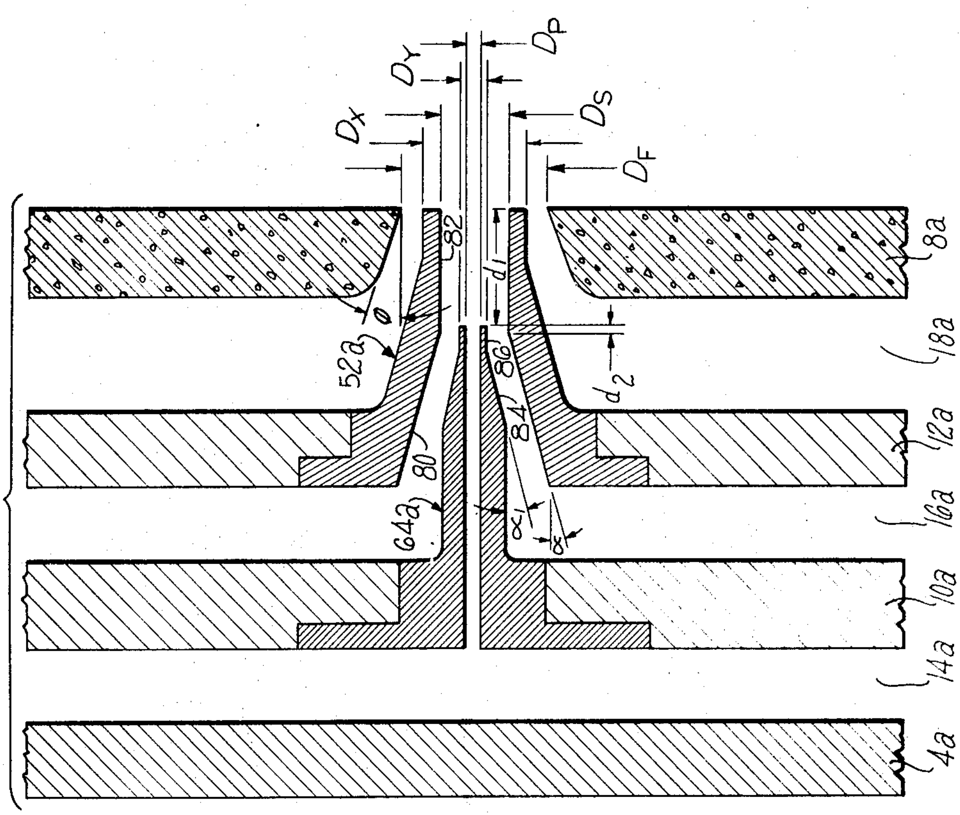


FIG. 3



INJECTOR HEAD

The invention herein described was made in the course of or under a contract with the Department of the Air Force.

This invention relates to an injector head for a bipropellant rocket engine wherein one propellant reaches the injector in a liquid state and the other propellant reaches the injector in a gaseous state.

An object of this invention is to provide an injector head with a dual orifice nozzle in the liquid side having a deep throttling capability with a range of propellants.

Another object of this invention is to provide an injector head including dual orifice nozzles which will provide high combustion performance in throttlable rocket engines.

A further object of this invention is to provide an injector head having a dual orifice nozzle wherein the primary nozzle is positioned for exhausting a flow therethrough into the secondary orifice such that its outlet is at the beginning of the secondary orifice or projecting thereinto and being retracted into the secondary orifice from the face of the injector head at least 0.5 times the diameter of the secondary orifice.

Another object of this invention is to provide a dual orifice nozzle wherein the conical inlet to the point where the primary nozzle is inserted in the secondary nozzle such that the major secondary pressure drop is approximately at the primary discharge plane.

A further object of this invention is to provide a dual nozzle for an injector head wherein the diameter of the primary orifice lies in the range of from 0.1 to 0.5 times the diameter of the secondary orifice.

Another object of this invention is to provide swirlers in the nozzles to affect higher mixing.

A further object of this invention is to provide an injector which could use gaseous hydrogen for its fuel and liquid fluorine for the oxidizer.

Another object of this invention is to provide an injector having a plurality of elements, each element having dual orifices for the injection of a liquid propellant from primary and secondary manifolds and a single orifice for the injection of a gaseous propellant.

A further object of this invention is to have a flow divider valve in the liquid propellant feedline to the manifold containing the secondary liquid propellant.

Another object of this invention is to provide a swirler in the end of the primary liquid propellant nozzle to enhance mixing between the flows from the primary and secondary orifices.

Other objects and advantages will be apparent from the specification and claims and from the accompanying drawings which illustrate embodiments of the invention.

FIG. 1 is a view showing a schematic perspective view of the injector head cut away through the middle for clarity.

FIG. 2 is a schematic showing of an enlarged sectional view taken through one of the complete nozzles.

FIG. 3 is an enlarged view showing another modification of a dual orifice nozzle.

FIG. 4 is an enlarged view showing still another modification of a dual orifice nozzle having swirlers.

FIG. 5 is an enlarged view showing still another modification of a dual orifice nozzle.

As seen in FIG. 1, an injector head **2** is formed having a back plate **4** and an annular end plate **6** which is faced with a plate of permeable material **8**. Between the back plate **4** and face plate **8**, two other plates **10** and **12** are fixedly positioned and sealed with end wall **6** to form three chambers **14**, **16** and **18**. The rearwardmost chamber **14** is connected to a primary manifold **30** for the liquid propellant and the center chamber **16** is connected to a secondary liquid propellant manifold **32**. A gaseous propellant is admitted from a manifold **20** to the end chamber **18** having the permeable plate **8** as one side thereof.

The gaseous propellant is supplied to manifold **20** from a supply **22** through a conduit **24** having a control valve **26**. A liquid propellant is directed to manifolds **30** and **32** from an oxygen supply **34** by a conduit system involving a feed conduit **36** being connected to two conduits **40** and **42** which are connected to manifolds **30** and **32**, respectively. Conduit **42** has a flow divider valve **44** connected therein. A control system as described here is also shown in U.S. application, Ser. No. 426,711, filed Jan. 15, 1965, to J. P. Mitchell et al.

The liquid propellant is brought to the face of the injector at a plurality of points by injector units **50**. One part **52** of an injector unit **50** extends through a hole **51** in plate **12** and has a flange **54** which cooperates with a recess **53** formed in the back of plate **12** around the hole **51**. This flange **54** is fixedly retained in the recess **53** by any means desired. The part **52** comprises a cylindrical member **56** which extends towards the plate **8** and is narrowed to a second cylindrical member **58** of smaller diameter. This member of smaller diameter, which is cylindrical in shape, projects into a hole **60** formed in the permeable plate **8**. An annular opening **62** is formed around the portion **58**, said annular opening being connected to the chamber **18**.

Another part **64** of injector unit **50** extends through a hole **66** in plate **10** and has a flange **68** which cooperates with a recess **70** formed in the back of plate **10** around the hole **66**. This flange **68** is fixedly retained in the recess **70** by any means desired. This part **64** comprises a cylindrical member **72** which extends into the cylindrical member **56** and is positioned substantially coaxial therewith. The free end of the member **72** is located adjacent the inner end of the second cylindrical member **58**. This construction is arranged to provide an ejector effect between a flow passing through the cylindrical member **72** into the cylindrical member **58** so as to pull fuel from the annular passageway formed between the outer surface of cylindrical member **72** and inner surface of cylindrical member **56**. Parts **52** and **64** can be made integral with plates **12** and **10**, respectively, if desired. This would, of course, make sealing at that location unnecessary.

As seen in FIG. 3, this modification of the dual orifice nozzle sets forth a different configuration of the two main parts, **52*a*** and **64*a***. While the manner in which these parts are connected to plates **10*a*** and **12*a*** remains the same, the configuration which projects outwardly differs. The part **52*a*** is shown having an opening therethrough formed of a conical surface **80** and a cylindrical surface **82**. The section **64*a*** extends into the opening through section **52*a*** and has a conical surface **84** formed on the exterior thereof adjacent the end which has a short cylindrical surface **86**. The conical surface **84** and short cylindrical surface **86** cooperate with the conical surface **80** and cylindrical surface **82** to insure that the secondary flow between the parts **52*a*** and **64*a*** will not be restricted upstream of the primary discharge plane. The cylindrical surface **82** forms with cylindrical surface **86** the secondary orifice while the passageway through the part **64*a*** forms the primary orifice. It can be seen, therefore, that the angle α of the conical surface **80** will never be less than the angle α_1 of the conical surface **84** ($\alpha>\alpha_1$).

The tip of the part **64*a*** should extend to at least the inner end of the cylindrical surface **82**, ($d_2>0$) and this tip of the part **64*a*** should also be recessed from the open end of the cylindrical surface **82** a minimum of one-half times the diameter of the cylindrical surface **82** ($d_1>0.5D_S$). This length of the cylindrical surface **82** forming a mixing chamber between the tip of **64*a*** and the tip of the part **52*a***. As mentioned before concerning the general nozzle arrangement in this specific construction, the primary orifice having a diameter D_P must be concentric with the cylindrical surface **82** having a diameter D_S, within 0.1 times D_S. Further, D_P should fall in a range of from 0.1 D_S to 0.5 D_S.

As seen in FIG. 4, this modification of the dual orifice nozzle sets forth a construction basically similar to that shown in FIG. 3; however, swirler vanes **100** have been located in the passageway between the conical surfaces **80*b*** and **84*b***. Further, a swirler unit **90** has been placed in the passageway extending through the part **64*b***. The swirler **90** must have its vanes arranged so that the primary flow will not impinge the sides of the secondary orifice. As viewed in FIG. 4, it must be spread only as wide as the angle β shown drawn from the end of the part **64*b***. This angle is determined neglecting secondary flow. In a modification having a swirler unit **90**, the tip of the part **64*b*** should extend to at least the inner end of the cylindrical surface **82*b***, and this tip of the part **64*b*** can also extend to the outer end of the cylindrical surface **82*b***. It can be seen that at the location of this tip, the size is of maximum angle β for a particular nozzle. The use of the swirler unit **90** permits the mixing chamber to be reduced in length.

As seen in FIG. **5**, this modification of the dual orifice nozzle sets forth a construction while basically similar to that shown in FIG. **3**, has a long cylindrical surface **82**. Two injectors were constructed and tested having a configuration such as shown in FIG. **5** for the dual orifice units. The injectors had the following dimensions:

Injector No. 1	Injector No. 2
D_F = 0.170 in.	D_F = 0.170 in.
D_Y = 0.125 in.	D_Y = 0.125 in.
D_S = 0.072 in.	D_S = 0.072 in.
D_X = 0.036 in.	D_X = 0.031 in.
D_P = 0.010 in.	D_P = 0.0155 in.
d_1 = 0.200 in.	d_1 = 0.200 in.
d_2 = 0.015 in.	d_2 = 0.015 in.

For both injectors, the permeable material used for the face plate **8** had a permeability of 40 scfm and the angle α was approximately 20° and the angle α_1 was approximately 15°. The oxidizer used was fluorine and the fuel was gaseous hydrogen.

An injector was constructed and tested having a configuration such as shown in FIG. **3**. The injector had the following dimensions:

Injector No. 3
D_F=0.127 in.
D_Y=0.106 in.
D_S=0.066 in.
D_X=0.035 in.
D_P=0.0151 in.
d_1=0.150 in.
d_2=0.015 in.

For this injector, the permeable material used for the face plate **8** had a permeability of 40 scfm, and the angle α was approximately 15° and the angle α_1 was approximately 12.5°. The angle θ was approximately 20°. This was done to produce a sharp edged orifice and to permit nozzle assembly since the plate **8*a*** forming the surface of the injector was formed as a cone and the parts **52*a*** were formed integral with the plate **12*a***.

It is to be understood that the invention is not limited to the specific embodiments herein illustrated and described, but may be used in other ways without departure from its spirit as defined by the following claims.

We claim:

1. An injector head for a rocket engine having in combination: a face plate, said face plate having a hole therein, a second plate means spaced rearwardly from said face plate forming a first propellant manifold with said face plate, said second plate having a first projection which extends into said hole, said first projection having a first opening therethrough, a third plate means spaced rearwardly from said second plate means forming a secondary second propellant manifold with said second plate means, said third plate means having a second projection extending therefrom into said first opening passing through said first projection, said second projection having a second opening passing therethrough, a fourth plate means spaced rearwardly from said third plate means forming a primary second propellant manifold with said third plate means, said first opening in said first projection having a conical section tapering inwardly from the secondary manifold to a cylindrical section at its free end, said second projection having a conical outer surface which tapers inwardly to a short cylindrical surface adjacent the end of the projection, and said mating conical section of said first projection and conical surface of said second projection forming a conical inlet such that the major pressure drop is downstream of the outlet end of the conical inlet.

2. An injector head as set forth in claim **1** wherein said first opening in said first projection has a cylindrical section at its free end, and said free end of said second projection extending into said first opening at least as far as the beginning of the cylindrical section.

3. An injector head as set forth in claim **1** wherein said first opening in said first projection has a cylindrical section at its free end, and said free end of said second projection being spaced from the free end of said cylindrical section a minimum distance of 0.5 times the diameter of the cylindrical section.

4. An injector head as set forth in claim **1** wherein said first opening in said first projection has a cylindrical section at its free end, and said free end of said second projection extending into said first opening to a point between the beginning of the cylindrical section and a point located a distance of 0.5 times the diameter of the cylindrical section from the free end of the cylindrical section.

5. An injector head as set forth in claim **2** wherein the diameter of the second opening lies in the range of from 0.1 to 0.5 times the diameter of the cylindrical section.

6. An injector head as set forth in claim **1** wherein said conical section of said first opening forms an angle in the range of from 30° to 40° and the conical surface of said second projection forms an angle in the range of from 25° to 30°.

7. An injector head as set forth in claim **1** wherein said first projection has an outer end which forms an annular opening with said face plate, said face plate being permeable.

8. An injector head as set forth in claim **7** wherein said face plate has a permeability of approximately 40 scfm.

9. An injector head as set forth in claim **1** wherein said first opening in said first projection has a cylindrical section at its free end, and said free end of said second projection extending into said opening approximately 0.015 in. and being spaced from the free end of the cylindrical section a distance of between 0.15 and 0.20 in.

10. An injector head as set forth in claim **1** wherein the first opening must be concentric with the second opening within 0.1 times the diameter of the first opening.

11. An injector head as set forth in claim **1** wherein the diameter of said first opening is approximately 0.072 in., the diameter of the second opening is approximately 0.010 in., and the diameter of said short cylindrical surface is approximately 0.036 in.

12. An injector head as set forth in claim **12** wherein a swirler unit is located within said second opening adjacent the end of the second projection.

13. An injector head as set forth in claim **1** wherein said swirler unit is arranged to direct a liquid therefrom having an increasing cone of flow which does not impinge upon the free end of the first opening.

* * * * *

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UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,662,960 Dated May 16, 1972

Inventor(s) James P. Mitchell and Bruce T. Brown

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Claim 12, Column 4, line 57, change "12" to --1--

Claim 13, Column 4, line 60, change "1" to --12--

Signed and sealed this 19th day of September 1972.

(SEAL)
Attest:

EDWARD M.FLETCHER,JR.
Attesting Officer

ROBERT GOTTSCHALK
Commissioner of Patents