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(54) **EJECTOR AND METHOD FOR OPERATING A SYSTEM WITH A SUCH EJECTOR**

EJEKTOR UND VERFAHREN ZUM BETRIEB EINES SYSTEMS MIT EINEM SOLCHEN EJEKTOR

ÉJECTEUR ET PROCÉDÉ POUR OPÉRER UN SYSTÈME AVEC UN TEL ÉJECTEUR

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(56) References cited:
**EP-A2- 2 194 280**
**JP-A- 2008 202 812**
**US-A1- 2008 060 378**
**US-A1- 2009 232 665**



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## Description

CROSS-REFERENCE TO RELATED APPLICATIONS

BACKGROUND

**[0001]** The present invention relates to refrigeration. More particularly, it relates to ejector refrigeration systems.

**[0002]** Earlier proposals for ejector refrigeration systems are found in US1836318 and US3277660. FIG. 1 shows one basic example of an ejector refrigeration system 20. The system includes a compressor 22 having an inlet (suction port) 24 and an outlet (discharge port) 26. The compressor and other system components are positioned along a refrigerant circuit or flowpath 27 and connected via various conduits (lines). A discharge line 28 extends from the outlet 26 to the inlet 32 of a heat exchanger (a heat rejection heat exchanger in a normal mode of system operation (e.g., a condenser or gas cooler)) 30. A line 36 extends from the outlet 34 of the heat rejection heat exchanger 30 to a primary inlet (liquid or supercritical or two-phase inlet) 40 of an ejector 38. The ejector 38 also has a secondary inlet (saturated or superheated vapor or two-phase inlet) 42 and an outlet 44. A line 46 extends from the ejector outlet 44 to an inlet 50 of a separator 48. The separator has a liquid outlet 52 and a gas outlet 54. A suction line 56 extends from the gas outlet 54 to the compressor suction port 24. The lines 28, 36, 46, 56, and components therebetween define a primary loop 60 of the refrigerant circuit 27. A secondary loop 62 of the refrigerant circuit 27 includes a heat exchanger 64 (in a normal operational mode being a heat absorption heat exchanger (e.g., evaporator)). The evaporator 64 includes an inlet 66 and an outlet 68 along the secondary loop 62 and expansion device 70 is positioned in a line 72 which extends between the separator liquid outlet 52 and the evaporator inlet 66. An ejector secondary inlet line 74 extends from the evaporator outlet 68 to the ejector secondary inlet 42.

**[0003]** In the normal mode of operation, gaseous refrigerant is drawn by the compressor 22 through the suction line 56 and inlet 24 and compressed and discharged from the discharge port 26 into the discharge line 28. In the heat rejection heat exchanger, the refrigerant loses/rejects heat to a heat transfer fluid (e.g., fan-forced air or water or other fluid). Cooled refrigerant exits the heat rejection heat exchanger via the outlet 34 and enters the ejector primary inlet 40 via the line 36.

**[0004]** The exemplary ejector 38 (FIG. 2) is formed as the combination of a motive (primary) nozzle 100 nested within an outer member 102. The primary inlet 40 is the inlet to the motive nozzle 100. The outlet 44 is the outlet of the outer member 102. The primary refrigerant flow 103 enters the inlet 40 and then passes into a convergent section 104 of the motive nozzle 100. It then passes through a throat section 106 and an expansion (divergent) section 108 through an outlet (exit) 110 of the motive nozzle 100. The motive nozzle 100 accelerates the flow 103 and dccrcascs the pressure of the flow. The secondary inlet 42 forms an inlet of the outer member 102. The pressure reduction caused to the primary flow by the motive nozzle helps draw the secondary flow 112 into the outer member. The outer member includes a mixer having a convergent section 114 and an elongate throat or mixing section 116. The outer member also has a divergent section or diffuser 118 downstream of the elongate throat or mixing section 116. The motive nozzle outlet 110 is positioned within the convergent section 114. As the flow 103 exits the outlet 110, it begins to mix with the flow 112 with further mixing occurring through the mixing section 116 which provides a mixing zone. Thus, respective primary and secondary flowpaths extend from the primary inlet and secondary inlet to the outlet, merging at the exit. In operation, the primary flow 103 may typically be supercritical upon entering the ejector and subcritical upon exiting the motive nozzle. The secondary flow 112 is gaseous (or a mixture of gas with a smaller amount of liquid) upon entering the secondary inlet port 42. The resulting combined flow 120 is a liquid/vapor mixture and decelerates and recovers pressure in the diffuser 118 while remaining a mixture. Upon entering the separator, the flow 120 is separated back into the flows 103 and 112. The flow 103 passes as a gas through the compressor suction line as discussed above. The flow 112 passes as a liquid to the expansion valve 70. The flow 112 may be expanded by the valve 70 (e.g., to a low quality (two-phase with small amount of vapor)) and passed to the evaporator 64. Within the evaporator 64, the refrigerant absorbs heat from a heat transfer fluid (e.g., from a fan-forced air flow or water or other liquid) and is discharged from the outlet 68 to the line 74 as the aforementioned gas.

**[0005]** Use of an ejector serves to recover pressure/work. Work recovered from the expansion process is used to compress the gaseous refrigerant prior to entering the compressor. Accordingly, the pressure ratio of the compressor (and thus the power consumption) may be reduced for a given desired evaporator pressure. The quality of refrigerant entering the evaporator may also be reduced. Thus, the refrigeration effect per unit mass flow may be increased (relative to the non-ejector system). The distribution of fluid entering the evaporator is improved (thereby improving evaporator performance). Because the evaporator does not directly feed the compressor, the evaporator is not required to produce superheated refrigerant outflow. The use of an ejector cycle may thus allow reduction or elimination of the superheated zone of the evaporator. This may allow the evaporator to operate in a two-phase state which provides a higher heat transfer performance (e.g., facilitating reduction in the evaporator size for a given capability).

**[0006]** The exemplary ejector may be a fixed geometry ejector or may be a controllable ejector. FIG. 2 shows controllability provided by a needle valve 130 having a needle 132 and an actuator 134. The actuator 134 shifts a tip portion 136 of the needle into and out of the throat section 106 of the motive nozzle 100 to modulate flow through the motive nozzle and, in turn, the ejector overall. Exemplary actuators 134 are electric (e.g., solenoid or the like). The actuator 134 may be coupled to and controlled by a controller 140 which may receive user inputs from an input device 142 (e.g., switches, keyboard, or the like) and sensors (not shown). The controller 140 may be coupled to the actuator and other controllable system components (e.g., valves, the compressor motor, and the like) via control lines 144 (e.g., hardwired or wireless communication paths). The controller may include one or more: processors; memory (e.g., for storing program information for execution by the processor to perform the operational methods and for storing data used or generated by the program(s)); and hardware interface devices (e.g., ports) for interfacing with input/output devices and controllable system components.

SUMMARY

**[0007]** One aspect of the invention involves an ejector having the features of claim 1.

**[0008]** According to EP 2 194 280 A2 an ejector, according to the preamble of claim 1, has a nozzle for ejecting coolant into an extension part. A casing surrounds a part of the nozzle and the extension part, where one of the nozzle and the casing is formed as a metal forming part. The casing has a diffuser section arranged after a mixing section of the casing, and the extension part is formed as an inlet section of the casing with adjustable cross section. The nozzle is held opposite to the casing by a cover part that closes the casing.

**[0009]** According to US 2008 060378 A1 an ejector for a refrigerant cycle device includes a nozzle portion for decompressing and expanding refrigerant flowing therein, and a body portion which accommodates the nozzle portion to support the nozzle portion at a support portion. The body portion has a refrigerant suction port from which refrigerant is drawn by a high-speed refrigerant flow jetted from a nozzle outlet of the nozzle portion. The nozzle portion is located in the body portion to have an ejector refrigerant passage through which the refrigerant flows. In the ejector, the nozzle portion is supported in the body portion to have the following relationship of $0<L/d< = 14$, in which L/d is a ratio of a length L between a downstream tip portion of the support portion and the nozzle outlet to a diameter d of the nozzle outlet.

**[0010]** According to US 2009/232665 A1 an ejector includes a nozzle for decompressing a fluid in any one state of a gas-liquid state, a liquid state and a supercritical state, and a body portion having a fluid suction port and a mixing and pressurizing portion. The ejector is provided with a suction passage through which a fluid drawn from the fluid suction port flows into the mixing and pressurizing portion. The suction passage is changed such that the fluid drawn from the fluid suction port is decompressed in the suction passage in iso-entropy. Alternatively, the suction passage is changed such that a flow velocity of the fluid flowing into the mixing and pressurizing portion from the suction passage is substantially equal to a flow velocity of the fluid flowing from a jet port of the nozzle into the mixing and pressurizing portion, or is equal to or larger than the sound velocity.

**[0011]** To provide an efficient refrigerating cycle device improving ejector efficiency by accelerating mixing of a driving fluid and a suction fluid within an ejectorJP 2008 202812 A discloses a refrigerating cycle device comprising a compressor causing a refrigerant to be in a high pressure state; a heat radiating side heat exchanger radiating the heat of the refrigerant in the high pressure state from the compressor; a bubble generating means turning the refrigerant after radiating heat from the heat radiating side heat exchanger, into a refrigerant containing fine bubbles. The ejector reduces the pressure of the refrigerant including fine bubbles generated by the bubble generating means to suck the suction fluid from a suction part by the driving fluid flowing out of a nozzle part at high speed, mixes the driving fluid and the suction fluid in a mixing part, and then expands the mixed fluid in a diffuser part to flow out in a low pressure state. An evaporating side heat exchanger evaporates the refrigerant in the low pressure state. The fine bubbles generated by the bubble generating means are supplied to the ejector and made the driving fluid to accelerate mixing with the suction fluid.

**[0012]** In various implementations, the motive nozzle may be mounted in a first bore. The secondary inlet passageway may be at least partially defined by a fitting mounted in a second bore. The second bore may be 30-60° off-perpendicular to the first bore. There may be at least two such secondary inlet passageways. A needle may be mounted for reciprocal movement along the primary flowpath between a first position and a second position. A needle actuator may be coupled to the needle to drive the movement of the needle relative to the motive nozzle.

**[0013]** Other aspects of the invention involve a refrigeration system having a compressor, a heat rejection heat exchanger coupled to the compressor to receive refrigerant compressed by the compressor, a heat absorption heat exchanger, a separator, and such an ejector. An inlet of the separator may be coupled to the outlet of the ejector to receive refrigerant from the ejector.

**[0014]** The details of one or more embodiments are set forth in the accompanying drawings and the description below. Other features, objects, and advantages will be apparent from the description and drawings, and from the claims.

BRIEF DESCRIPTION OF THE DRAWINGS

**[0015]**

FIG. 1 is a schematic view of a prior art ejector refrigeration system.

FIG. 2 is an axial sectional view of a prior art ejector.

FIG. 3 is a schematic axial sectional view of an ejector.

FIG. 3A is an enlarged view of a motive nozzle chamber area of the ejector of FIG. 3.

FIG. 4 is a schematic axial sectional view of a second ejector.

FIG. 5 is a schematic axial sectional view of a third ejector.

FIG. 6 is a schematic axial sectional view of a fourth ejector.

**[0016]** Like reference numbers and designations in the various drawings indicate like elements.

DETAILED DESCRIPTION

**[0017]** FIG. 3 shows an ejector 200. The ejector 200 may be formed as a modification of the ejector 38 and may be used in vapor compression systems (e.g., FIG. 1) where conventional ejectors are presently used or may be used in the future. An exemplary ejector is a two-phase ejector used with $CO_2$ refrigerant (e.g., at least 50% $CO_2$ by weight).

**[0018]** The exemplary ejector includes a multi-part body assembly (e.g., formed of aluminum, stainless steel, or other machinings). The body parts 202, 204, 206 are axially secured to each other via screws, bolts, or other fasteners 208 and may have appropriate seals 210 (e.g., polymer-o-rings) and the like.

**[0019]** A secondary flow conduit 216 extends from the secondary inlet 42 to a conduit outlet 217 and defines a secondary passageway 218. The terminal portion of the secondary passageway is oriented to discharge the secondary flow off-normal to an axis of the motive nozzle.

**[0020]** An exemplary upstream body section 202 has a central axial bore 220 to which the motive nozzle (or assembly) 222 is mounted. For ease of reference, similar reference numerals will be used for the portion of the motive nozzle 222 as for the prior art nozzle. Similarly, similar reference numerals are used for portions of the outer member (formed by the body portion 202, 204, 206) as are used for the outer member 102. The upstream body section 202 further has a stepped secondary bore 224 to which a secondary inlet fitting 226 (e.g., a conventional stainless steel threaded fitting) is mounted (e.g., via threaded engagement). A downstream end 227 of the exemplary fitting lies within the secondary bore. An upstream end 228 of the secondary inlet fitting may define the secondary inlet 42 of the ejector. A terminal portion 230 of the secondary bore intersects an annular chamber 232 surrounding the motive nozzle. In the exemplary configuration, the terminal portion 230 of the secondary bore defines a terminal portion of the secondary inlet passageway. The terminal portion is oriented coaxial with the fitting along a secondary axis 502. Along the terminal portion, the axis 502 is essentially coincident with the direction and centroid of the secondary flow being discharged into the chamber 232.

**[0021]** The exemplary terminal portion is oriented to discharge the secondary flow essentially parallel to the secondary axis at an angle $\theta$ off-parallel to the centerline 500 of the motive flow and associated motive nozzle axis. The angle $\theta$ must be at least within the range of 10-75°, more narrowly, 30-60°, 35-55° or 40-50° or a narrowest 43-45°. By reducing $\theta$ relative to the prior art 90°, momentum and mixing losses are reduced and pressure recovery improved. Thus, exemplary $\theta$ is less than 75°, more narrowly, less than 60°. However, it may be desirable to impose a minimum value on $\theta$. If $\theta$ is too low, the length of nozzle required for adequate mixing of the primary and secondary flows may be too great. Accordingly, exemplary minimum values of $\theta$ are 10°, more narrowly, 15° or 30°. As is discussed below, a downstream tapering of the adjacent portion of the outer surface of the motive nozzle may further smooth flow and reduce losses.

**[0022]** FIG. 3A shows the effective center of the secondary passageway as the intersection 518 of the centerline/axis 502 with the former outer wall 233 (or projection 520 thereof) which was penetrated by the stepped bore. The local radius at this location 518 relative to the ejector and motive nozzle axis 500 is shown as $R_1$. An axial length between this location 518 and the outlet of the motive nozzle is shown as $L_1$. In some possible embodiments, the outlet/exit of the motive nozzle may be coincident with its throat. The radius $R_1$ must be at least within the range of 0.25-100mm, more narrowly, 1-75mm or 5-45mm. The axial length $L_1$ must be at least within the range of 0-100mm, more narrowly, 3-60mm or 5-40mm. The axis 502 must intersect axis 500 at a location between $2.0R_1$ upstream of the motive nozzle exit and $1.0R_1$ downstream, more narrowly, between $1.0R_1$ upstream and $0.5R_1$ downstream, and, more narrowly, between $0.5R_1$ upstream and the exit itself.

**[0023]** The radial velocity component (at the location of initial mixing proximate the exit 110) of the relatively low velocity ejector suction flow is relevant to optimizing the losses associated with mixing of very high velocity ejector motive flow. If there is no radial velocity component, then the two flows take longer to mix and losses associated with friction increases. If the radial velocity is too large, as compared to the tangential velocity, then mixing occurs fast but losses associated with viscous dissipation increase. There is an optimal radial velocity that minimizes the two losses while maximizing mixing.

**[0024]** The cross-sectional area of the annular flow channel formed along the chamber 232 and mixer 114 upstream of the exit 110 of the motive nozzle largely influences the overall velocity of the secondary (suction) flow. The angles of convergence of the adjacent surfaces then help define the radial velocity relative to axial velocity. A half angle range of 2.5-20° (more narrowly 5-15° or 8-12°) for both: the motive nozzle outer surface portion 258 near the motive nozzle exit 110 ($\theta_2$); and the mixer convergent section 114 inner surface portion 260 at and downstream of the exit 110 ($\theta_3$), is desired in combination with the flow channel diameter of 0.25-20mm (more narrowly 0.5-5mm). FIG. 3A further shows an inner surface portion 262 of the convergent section 114 spaced upstream of the exit 110 and forming a brief chamfer having a half angle $\theta_4$ and a length $L_2$. The chamfer serves to reduce recirculation of suction flow when the flow comes out from suction inlet and into the mixing chamber plenum. $\theta_4$ may be greater than $\theta_3$. $\theta_3$ over a region near the exit and extending downstream therefrom (e.g., by a length of several times the diameter of the motive nozzle exit) and $\theta_2$ over a similar adjacent length of the motive nozzle upstream of the exit 110) largely influence the radial velocity component in view of their radial positions and the flow rate. The angle $\theta$ may then be chosen, in view of any other geometric conditions, to further minimize losses upstream of the portion 262.

**[0025]** The exemplary ejector body is shown as a modular assembly (e.g., of machined metal/alloy components 202, 204, 206). However, alternative unitary constructions are possible. The modular construction may case optimizing of length for the intended operating condition. For example, different central body portions 204 may be used with given upstream and downstream sections/portions 202 and 206. The different central sections 204 may have varying convergent section lengths and/or mixing section lengths and/or overall lengths to provide desired flow properties and compactness. The exemplary configuration of a precision machined central boss (e.g., of circular transverse section) 234 protruding from the upstream face 235 of the downstream section 206 and received in a mating compartment 236 in the downstream face 237 of the section 204 may help ensure precise radial registration of the portions 204 and 206 so that there is little relative displacement of the centralized local central axis relative to the nominal/intended central axis 500. An exemplary high tolerance on such radial displacement is a maximum of 0.5mm. Lower tolerances are 0.1mm, 0.02mm, and a highest tolerance of 0.005mm. Similar tolerances may be associated with the radial position of the motive nozzle. In the exemplary configuration, it was impractical to provide a similar boss-to-compartment engagement between the sections 202 and 204. Accordingly, the radial positioning is ensured via two or more pins 240 (e.g., round stainless steel) with respective first and second end portions received in respective compartments (bores) 242 of the sections 202 and 204 extending from a respective downstream face 243 and upstream face 244.

**[0026]** Via selection of different lengths for the upstream body portion 202 or via one or more appropriate spacers 248 between the motive nozzle and the base of the chamber 232, axial position of the motive nozzle may be set to a desired value. The exemplary motive nozzle is not rigidly axially secured to the body section 202. Rather, a precision stem portion 250 of the nozzle is accommodated in the axial bore 220 to provide appropriately precise radial positioning. Pressure in the chamber 232 drives the nozzle 222 upstream so that a shoulder 252 of nozzle butts against a base of the chamber (directly or via the one or more spacers) to provide the desired axial positioning.

**[0027]** There may be more than one or even more than two secondary inlets. FIG. 4 shows a ejector 300 having a pair of diametrically opposite secondary inlet passageways 218 (218A&B) formed by associated bores and fittings otherwise similar to that of FIG. 3. For ease of illustration, only separate A and B instances of the secondary inlets (42A&B), passageways (218A&B), passageway terminal portions (230A&B), and their associated axes (502A&B) are separately called out. Other variations involve a greater number of such passageways evenly angularly spaced about the axis. Such a configuration may offer one or more advantages relative to the configuration of FIG. 3. For example, there may be more uniform circumferential distribution of the secondary/suction flow around the primary/motive flow. This may lead to improved mixing and some combination of improved efficiency and/or permitting reduced axial length.

**[0028]** In the exemplary overall system configuration, flow from the heat rejection heat exchanger may be split (e.g., via a Y-fitting-not shown) to separately feed the two secondary passageways.

**[0029]** FIG. 5 shows an ejector 400 wherein the terminal portions of the passageways 218'A, 218'B are at an angle to associated upstream portions as the secondary passageways centerlines may curve or have an abrupt angular change. The exemplary terminal portions are formed by terminal portions 412 extending to ends 414 of bent/curving conduits 410A, 410B replacing the secondary fittings and extending into the chamber 232. Exemplary metal conduits 410A, 410B or portions of an assembly may be inserted from inside the chamber prior to installation of the motive nozzle and assembly of the body sections to each other.

**[0030]** FIG. 6 shows an ejector 600 with relatively lengthened fittings 226" which penetrate/protrude into the chamber 232. The exemplary fitting downstream/outlet ends 227" are at a right angle relative to the associated axis 502 and their center defines the location 518".

**[0031]** The ejectors and associated vapor compression systems may be fabricated from conventional materials and components using conventional techniques appropriate for the particular intended uses. Control may also be via conventional methods. Although the exemplary ejectors are shown omitting a control needle, such a needle and actuator may, however, be added.

**[0032]** Although an embodiment is described above in detail, such description is not intended for limiting the scope of the present invention. It will be understood that various modifications may be made without departing from the scope of the invention defined by the following claims. For example, when implemented in the remanufacturing of an existing system or the reengineering of an existing system configuration, details of the existing configuration may influence or dictate details of any particular implementation.

## Claims

**1.** An ejector (200; 300; 400; 600) comprising:

a primary inlet (40);
a secondary inlet (42);
an outlet (44);
a primary flowpath from the primary inlet to the outlet;
a secondary flowpath from the secondary inlet to the outlet;
a mixer convergent section (114) downstream of the secondary inlet; and
a motive nozzle (222) surrounding the primary flowpath upstream of a junction with the secondary flowpath and having an exit (110);
**characterised in that**:

a secondary inlet passageway (218; 218A, 218B; 218'A, 218'B; 218"A, 218"B) has a terminal portion oriented along a secondary axis (502) to discharge a secondary flow along the secondary flowpath at an angle (θ) of 10-75° off-parallel to a local direction of the primary flowpath;
a center of an outlet of the terminal portion is at a radius (R1) from an axis (500) of the motive nozzle and axially recessed by a distance (L1) relative to the exit (110) of the motive nozzle (222), wherein the distance (L1) is less than 100 mm and the radius (R1) is 0.25 to 100 mm; and
the secondary axis (502) intersects the axis (500) of the motive nozzle (222) at a location between 2.0 times the radius (R1) upstream and 1.0 times the radius (R1) downstream of the motive nozzle exit (110).

**2.** The ejector (200; 300; 600) of claim 1 wherein:

the motive nozzle is mounted in a first bore; and
the secondary inlet passageway is at least partially defined by a fitting mounted in a second bore.

**3.** The ejector (600) of claim 2 wherein:
the fitting protrudes into a chamber (232) surrounding the motive nozzle.

**4.** The ejector of claim 2 wherein:
the second bore is 30-60° off perpendicular to the first bore.

**5.** The ejector of claim 1 wherein:
$L_1$ is less than 40mm and $R_1$ is less than 45mm.

**6.** The ejector of claim 1 wherein:
said angle is 35-55°.

**7.** The ejector (300; 400; 600) of claim 1 wherein:
there are at least two said secondary inlet passageways (218A, 218B; 218'A, 218'B; 218"A, 218"B).

**8.** The ejector of claim 1 further comprising :

a needle (132) mounted for reciprocal movement along the primary flowpath between a first position and a second position; and
a needle actuator (134) coupled to the needle to drive said movement of the needle relative to the motive nozzle.

**9.** The ejector of claim 1 wherein:
an outer member comprises an end-to-end axial assembly of a plurality of sections.

**10.** The ejector of claim 9 wherein the sections include:

an upstream section (202) at least partially surrounding the motive nozzle;
one or more intermediate sections (204) at least partially defining a convergent portion (214) and a mixing portion (216); and
at least one downstream section (206) at least partially defining a divergent portion (118).

**11.** The ejector of claim 10 wherein:
an interface of at least two of said sections (204, 206) comprises a boss of one section protruding into a compartment in the other section.

**12.** A vapor compression system comprising:

a compressor (22);
a heat rejection heat exchanger (30) coupled to the compressor to receive refrigerant compressed by the compressor;
the ejector (200; 300; 400; 600) of claim 1;
a heat absorption heat exchanger (64); and
a separator (48) having:

an inlet (50) coupled to the outlet of the ejector to receive refrigerant from the ejector;
a gas outlet (54); and
a liquid outlet (52).

**13.** A method for operating the system of claim 12 comprising:

compressing the refrigerant in the compressor (22);
rejecting heat from the compressed refrigerant in the heat rejection heat exchanger (30);
passing a flow of the refrigerant through the primary ejector inlet (40); and
passing a secondary flow of the refrigerant through the secondary inlet (42) to merge with

the primary flow.

**Patentansprüche**

1. Ejektor (200; 300; 400; 600), umfassend:

   einen primären Einlass (40);
   einen sekundären Einlass (42);
   einen Auslass (44);
   einen primären Strömungsweg von dem primären Einlass zum Auslass;
   einen sekundären Strömungsweg von dem sekundären Einlass zum Auslass;
   einen konvergierenden Mischerabschnitt (114) stromabwärts von dem sekundären Einlass; und
   eine Treibdüse (222), die den primären Strömungsweg stromaufwärts von einer Verbindung mit dem sekundären Strömungsweg umgibt und einen Ausgang (110) aufweist;
   **dadurch gekennzeichnet, dass**:

      ein sekundärer Einlassdurchgang (218; 218A, 218B; 218'A, 218'B; 218''A, 218''B) einen Anschlussbereich aufweist, der entlang einer sekundären Achse (502) ausgerichtet ist, um eine sekundäre Strömung entlang des sekundären Strömungswegs mit einem Winkel (θ) von 10-75° parallel zu einer lokalen AusRichtung des primären Strömungswegs abzuleiten;
      ein Zentrum von einem Auslass des Anschlussbereichs in einem Radius (R1) von einer Achse (500) der Treibdüse liegt und durch einen Abstand (L1) in Bezug auf den Ausgang (110) der Treibdüse (222) in axialer Richtung vertieft ist, wobei der Abstand (L1) kleiner als 100 mm ist und der Radius (R1) 0,25 bis 100 mm ist; und
      die sekundäre Achse (502) die Achse (500) der Treibdüse (222) an einer Stelle zwischen dem 2,0-fachen des Radius (R1) stromaufwärts und dem 1,0-fachen des Radius (R1) stromabwärts von dem Treibdüsenausgang (110) überschneidet.

2. Ejektor (200; 300; 600) nach Anspruch 1, wobei:

   die Treibdüse in eine erster Bohrung montiert ist; und
   der sekundäre Einlassdurchgang mindestens teilweise durch ein Anschlussstück, das in einer zweite Bohrung montiert ist, definiert ist.

3. Ejektor (600) nach Anspruch 2, wobei:
   das Anschlussstück in eine Kammer (232), die die Treibdüse umgibt, hereinragt.

4. Ejektor nach Anspruch 2, wobei:
   die zweite Bohrung 30-60° senkrecht zur ersten Bohrung verläuft.

5. Ejektor nach Anspruch 1, wobei:
   $L_1$ kleiner als 40 mm ist und $R_1$ kleiner als 45 mm ist.

6. Ejektor nach Anspruch 1, wobei:
   der Winkel 35-55° ist.

7. Ejektor (300; 400; 600) nach Anspruch 1, wobei:
   es mindestens zwei sekundäre Einlassdurchgänge (218A, 218B; 218'A, 218'B; 218''A, 218''B) gibt.

8. Ejektor nach Anspruch 1, ferner umfassend:

   eine Nadel (132), die zur Hin- und Herbewegung entlang des primären Strömungswegs zwischen einer ersten Position und einer zweiten Position montiert ist; und
   eine Nadelbetätigungsvorrichtung (134), die an die Nadel gekoppelt ist, um die Bewegung der Nadel in Bezug auf die Treibdüse anzutreiben.

9. Ejektor nach Anspruch 1, wobei:
   ein äußeres Element eine durchgängig axiale Anordnung einer Mehrzahl von Abschnitten umfasst.

10. Ejektor nach Anspruch 9, wobei die Abschnitte Folgendes beinhalten:

   einen stromaufwärtigen Abschnitt (202), der die Treibdüse mindestens teilweise umgibt;
   einen oder mehrere Zwischenabschnitte (204), die mindestens teilweise einen konvergierenden Bereich (214) und einen Mischbereich (216) definieren; und
   mindestens einen stromabwärtigen Abschnitt (206), der mindestens teilweise einen divergierenden Bereich (118) definiert.

11. Ejektor nach Anspruch 10, wobei:
   eine Schnittstelle von mindestens zweien der Abschnitte (204, 206) eine Nabe von einem Abschnitt umfasst, die in ein Fach in dem anderen Abschnitt hereinragt.

12. Dampfverdichtungssystem, umfassend:

   einen Verdichter (22);
   einen wärmeabgebenden Wärmetauscher (30), der an den Verdichter gekoppelt ist, um durch den Verdichter verdichtetes Kältemittel zu empfangen;
   den Ejektor (200; 300; 400; 600) nach Anspruch 1;
   einen wärmeabsorbierenden Wärmetauscher (64); und

einen Abscheider (48), der Folgendes aufweist:

einen Einlass (50), der an den Auslass des Ejektors gekoppelt ist, um Kältemittel von dem Ejektor zu empfangen;
einen Gasauslass (54); und
einen Flüssigkeitsauslass (52).

**13.** Verfahren zum Betrieb des Systems nach Anspruch 12, umfassend:

Verdichten des Kältemittels in dem Verdichter (22);
Abgeben von Wärme aus dem verdichteten Kältemittel in den wärmeabgebenden Wärmetauscher (30);
Leiten eines Stroms des Kältemittels durch den primären Ejektoreinlass (40); und
Leiten eines sekundären Stroms des Kältemittels durch den sekundären Einlass (42), um ihn mit dem primären Strom zusammenzuführen.

## Revendications

**1.** Éjecteur (200 ; 300 ; 400 ; 600) comprenant :

une entrée primaire (40) ;
une entrée secondaire (42) ;
une sortie (44) ;
un trajet d'écoulement primaire depuis l'entrée primaire vers la sortie ;
un trajet d'écoulement secondaire depuis l'entrée secondaire vers la sortie ;
une section convergente de mélangeur (114) en aval de l'entrée secondaire ; et
une buse motrice (222) entourant le trajet d'écoulement primaire en amont d'une jonction avec le trajet d'écoulement secondaire et ayant une sortie (110) ;
**caractérisé en ce que** :

un passage d'entrée secondaire (218 ; 218A, 218B ; 218'A, 218'B ; 218''A, 218''B) a une partie terminale orientée le long d'un axe secondaire (502) pour décharger un écoulement secondaire le long du trajet d'écoulement secondaire selon un angle (θ) de 10 à 75° non parallèle à une direction locale du trajet d'écoulement primaire ;
un centre d'une sortie de la partie terminale est à un rayon (R1) depuis un axe (500) de la buse motrice et axialement en retrait d'une distance (L1) par rapport à la sortie (110) de la buse motrice (222), dans lequel la distance (L1) est inférieure à 100 mm et le rayon (R1) est de 0,25 à 100 mm ; et
l'axe secondaire (502) coupe l'axe (500) de la buse motrice (222) à un emplacement compris entre 2,0 fois le rayon (R1) en amont et 1,0 fois le rayon (R1) en aval de la sortie de buse motrice (110).

**2.** Éjecteur (200 ; 300 ; 600) selon la revendication 1, dans lequel :

la buse motrice est montée dans un premier alésage ; et
le passage d'entrée secondaire est au moins partiellement défini par un raccord monté dans un second alésage.

**3.** Éjecteur (600) selon la revendication 2, dans lequel : le raccord fait saillie dans une chambre (232) entourant la buse motrice.

**4.** Éjecteur selon la revendication 2, dans lequel : le second alésage est non perpendiculaire au premier alésage de 30 à 60°.

**5.** Éjecteur selon la revendication 1, dans lequel : $L_1$ est inférieur à 40 mm et $R_1$ est inférieur à 45 mm.

**6.** Éjecteur selon la revendication 1, dans lequel : ledit angle est de 35 à 55°.

**7.** Éjecteur (300 ; 400 ; 600) selon la revendication 1, dans lequel : il y a au moins deux desdits passages d'entrée secondaires (218A, 218B ; 218'A, 218'B ; 218"A, 218"B).

**8.** Éjecteur selon la revendication 1, comprenant en outre :

une aiguille (132) montée pour un mouvement de va-et-vient le long du trajet d'écoulement primaire entre une première position et une seconde position ; et
un actionneur d'aiguille (134) couplé à l'aiguille pour entraîner ledit mouvement de l'aiguille par rapport à la buse motrice.

**9.** Éjecteur selon la revendication 1, dans lequel : un élément externe comprend un ensemble axial bout à bout d'une pluralité de sections.

**10.** Éjecteur selon la revendication 9, dans lequel les sections comportent :

une section amont (202) entourant au moins partiellement la buse motrice ;
une ou plusieurs sections intermédiaires (204) définissant au moins partiellement une partie convergente (214) et une partie de mélange (216) ; et

au moins une section aval (206) définissant au moins partiellement une partie divergente (118).

**11.** Éjecteur selon la revendication 10, dans lequel : une interface d'au moins deux desdites sections (204, 206) comprend un bossage d'une section faisant saillie dans un compartiment dans l'autre section.

**12.** Système de compression de vapeur comprenant :

un compresseur (22) ;
un échangeur de chaleur à rejet de chaleur (30) couplé au compresseur pour recevoir du réfrigérant comprimé par le compresseur ;
l'éjecteur (200 ; 300 ; 400 ; 600) selon la revendication 1 ;
un échangeur de chaleur à absorption de chaleur (64) ; et
un séparateur (48) ayant :

une entrée (50) couplée à la sortie de l'éjecteur pour recevoir du réfrigérant depuis l'éjecteur ;
une sortie de gaz (54) ; et
une sortie de liquide (52).

**13.** Procédé pour opérer le système selon la revendication 12, comprenant :

la compression du réfrigérant dans le compresseur (22) ;
le rejet de chaleur depuis le réfrigérant comprimé dans l'échangeur de chaleur à rejet de chaleur (30) ;
le passage d'un écoulement du réfrigérant à travers l'entrée d'éjecteur primaire (40) ; et
le passage d'un écoulement secondaire du réfrigérant à travers l'entrée secondaire (42) pour se confondre avec l'écoulement primaire.

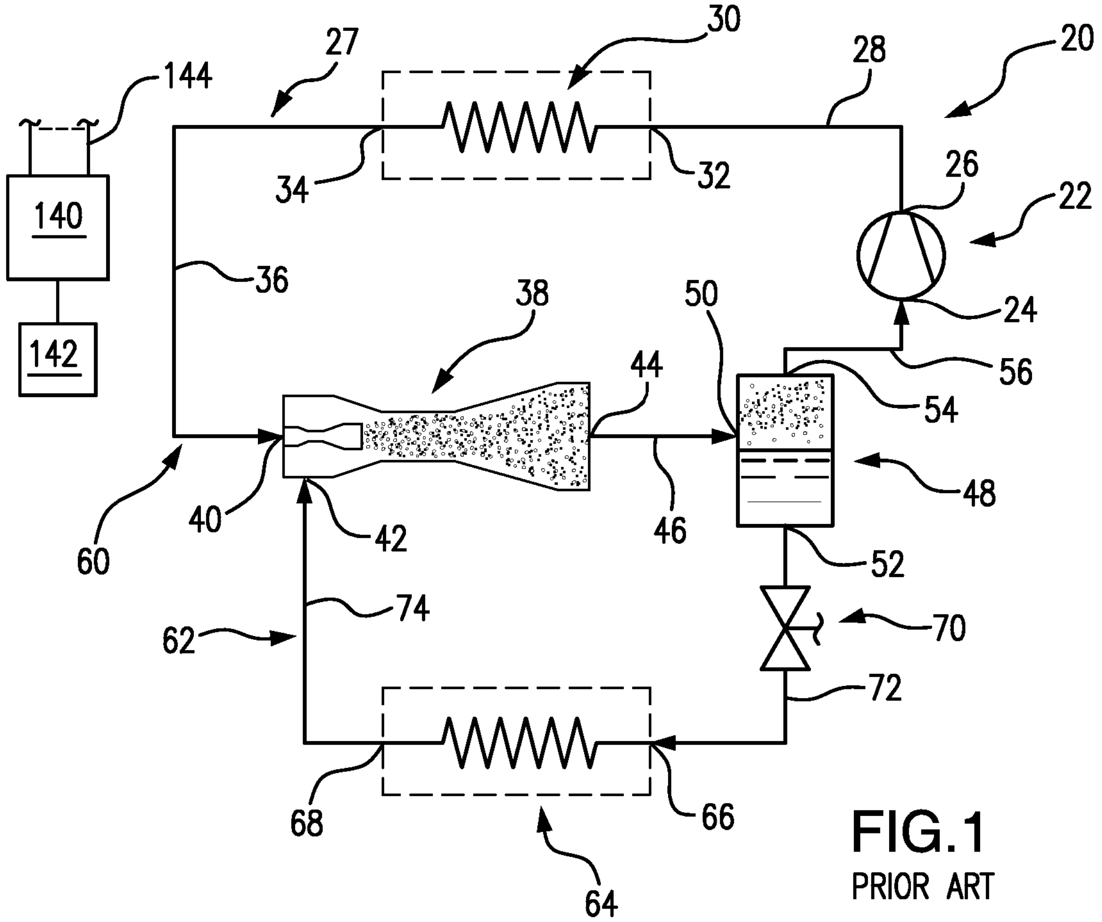


FIG.1
PRIOR ART

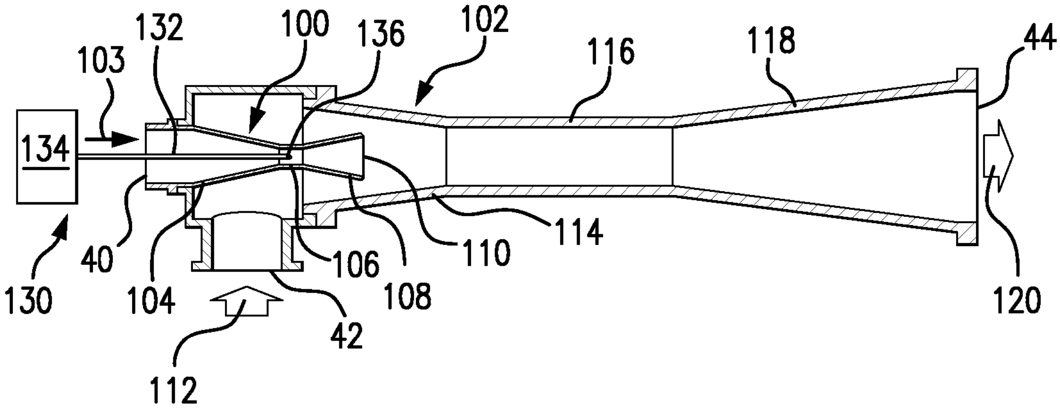


FIG. 2
PRIOR ART

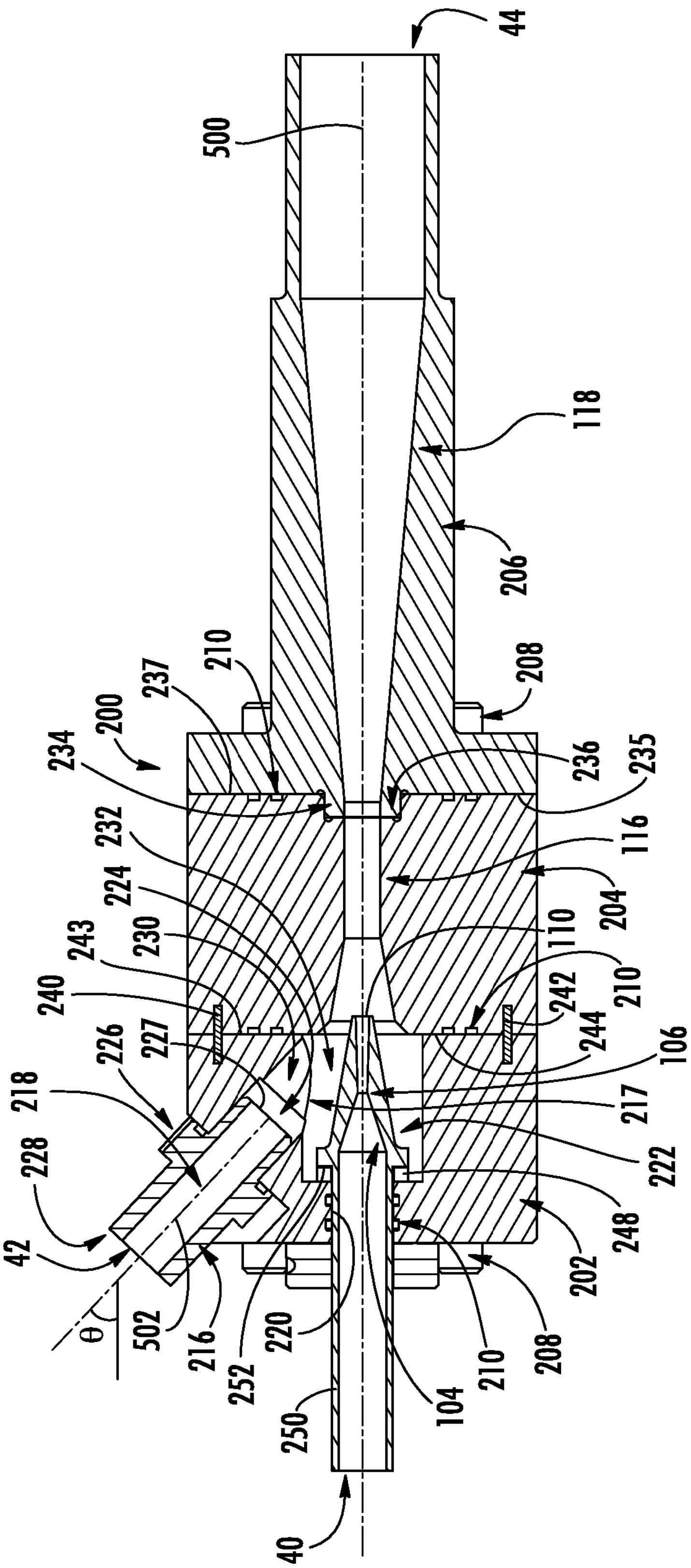
44
500
118
206
210
208
237
200
234
236
235
232
116
224
204
230
110
243
210
240
242
244
106
226
227
217
218
222
228
248
42
202
θ
502
216
252
220
210
208
104
250
40

FIG.3

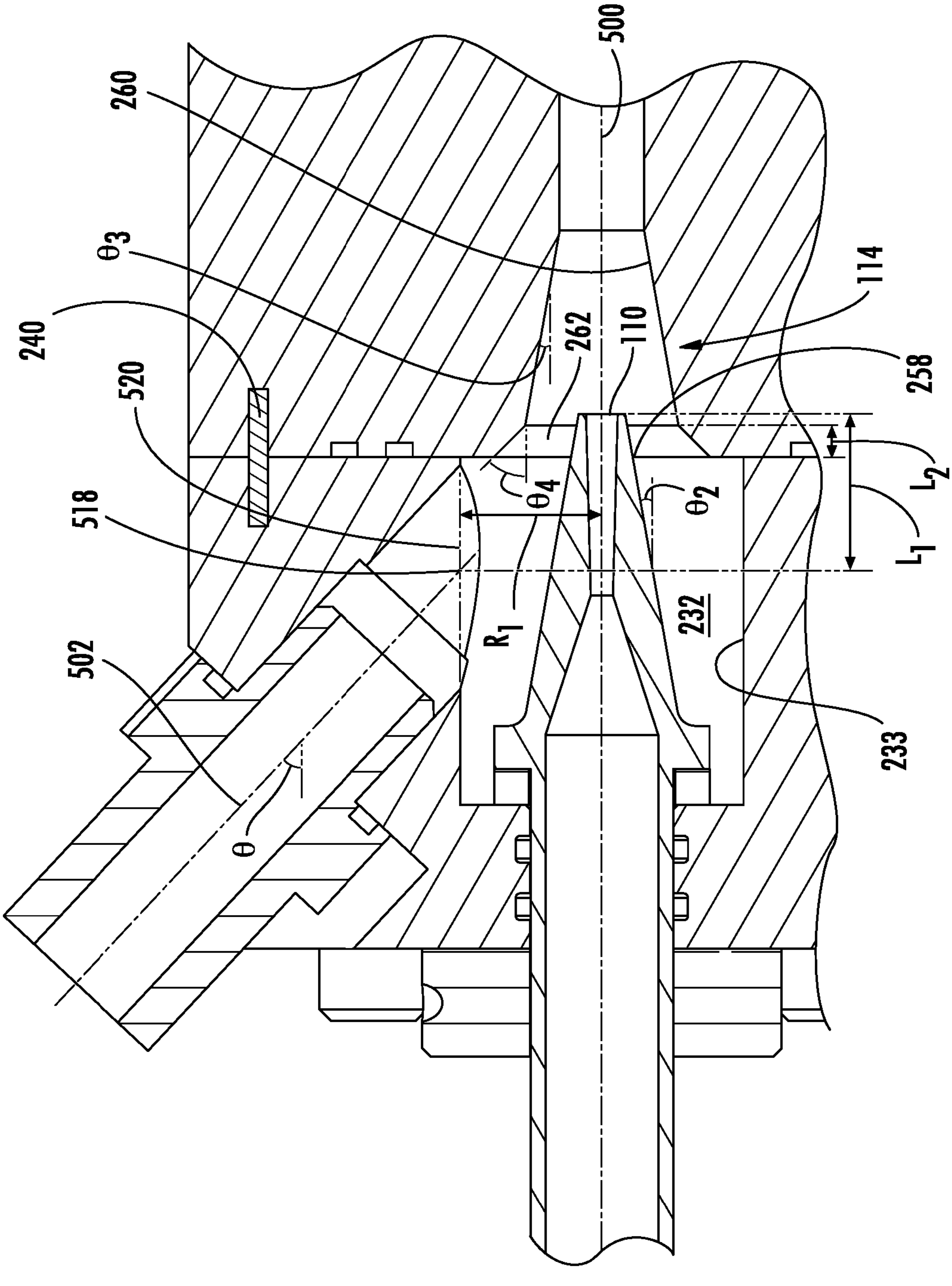


FIG.3A

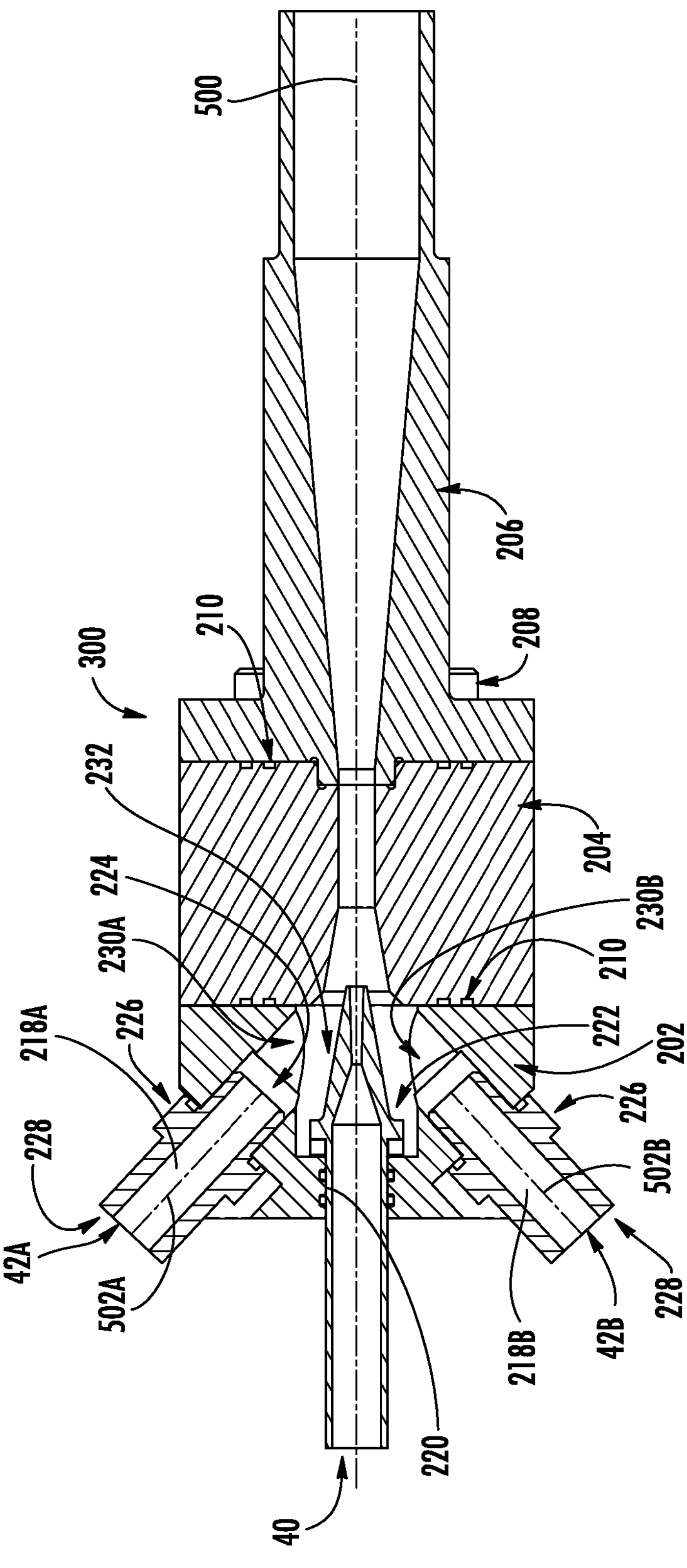
500
206
208
210
300
204
232
224
230A
230B
210
218A
226
222
202
228
42A
502A
226
502B
220
40
218B
42B
228

FIG.4

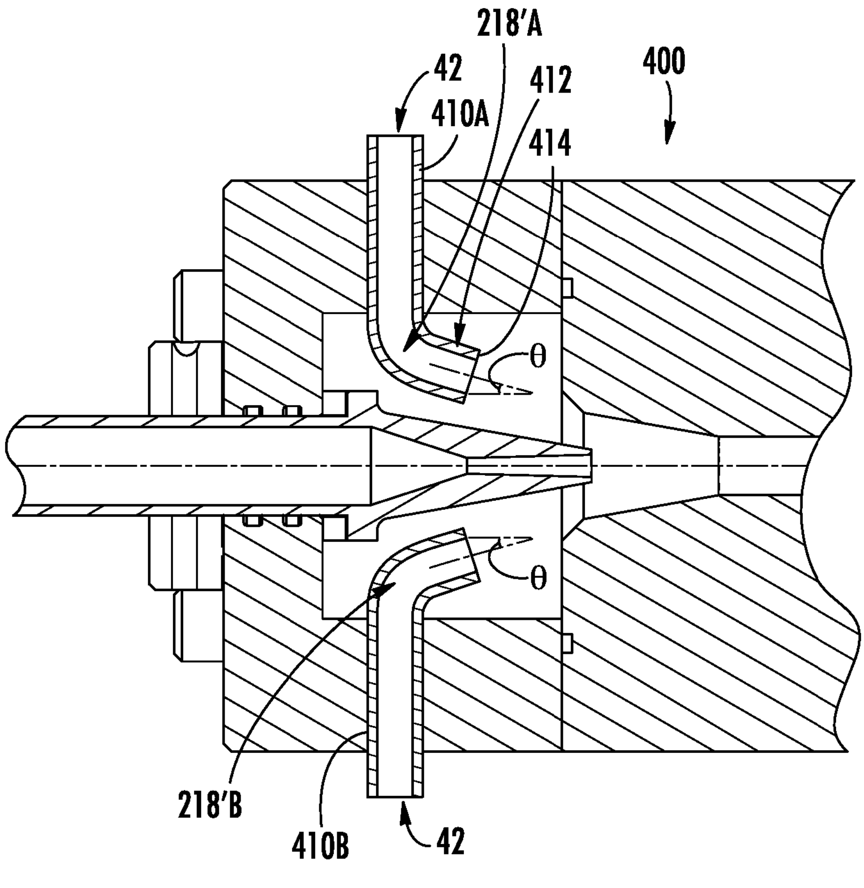


FIG.5

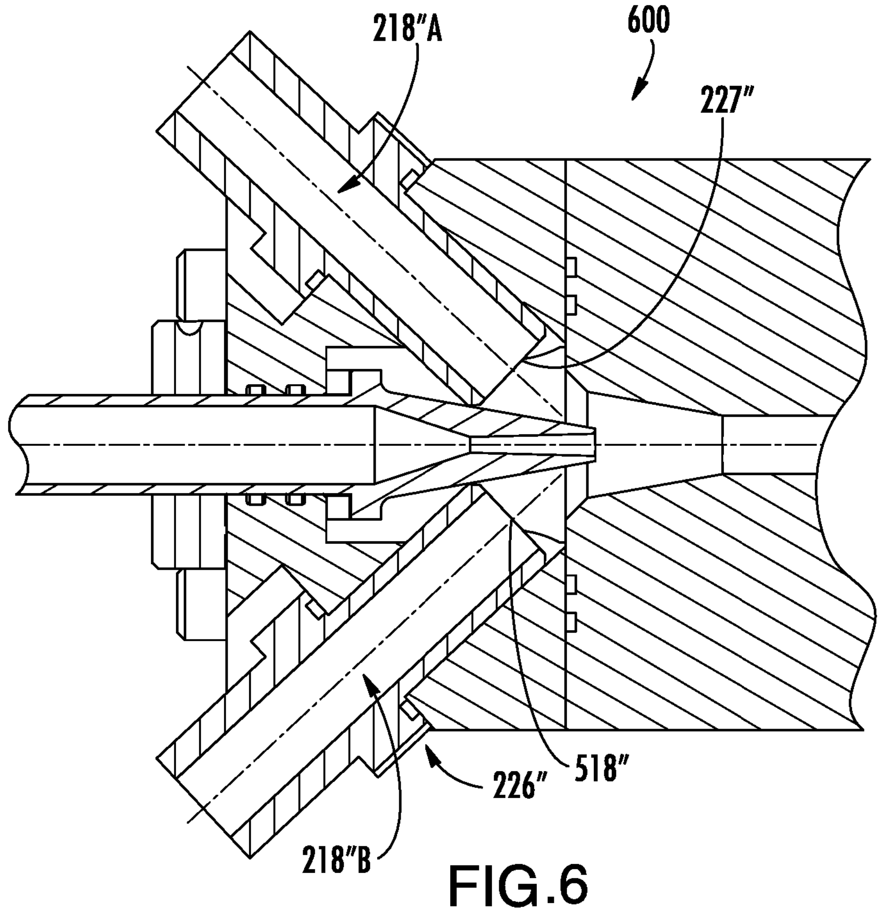


FIG.6

## REFERENCES CITED IN THE DESCRIPTION



### Patent documents cited in the description


- US 1836318 A **[0002]**
- US 3277660 A **[0002]**
- EP 2194280 A2 **[0008]**
- US 2008060378 A1 **[0009]**
- US 2009232665 A1 **[0010]**
- JP 2008202812 A **[0011]**