Dec. 22, 1959 M. CREVOISIER 2,918,009

INJECTION-COMPRESSOR APPARATUS

Filed Jan. 28, 1958 4 Sheets-Sheet 1

FIG.1

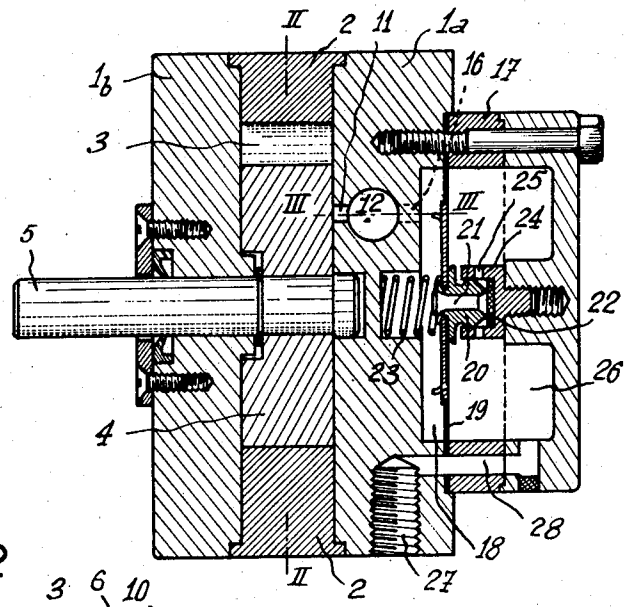


FIG.2

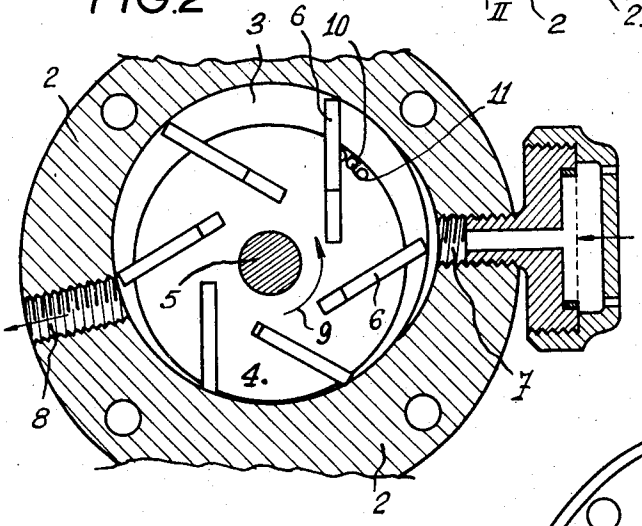


FIG.4

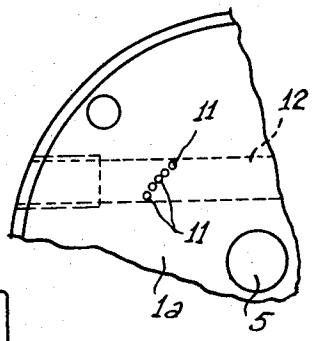
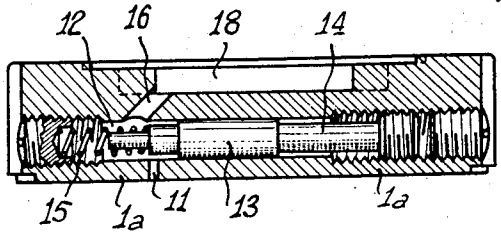


FIG.3



Dec. 22, 1959 M. CREVOISIER 2,918,009

INJECTION-COMPRESSOR APPARATUS

Filed Jan. 28, 1958 4 Sheets-Sheet 2

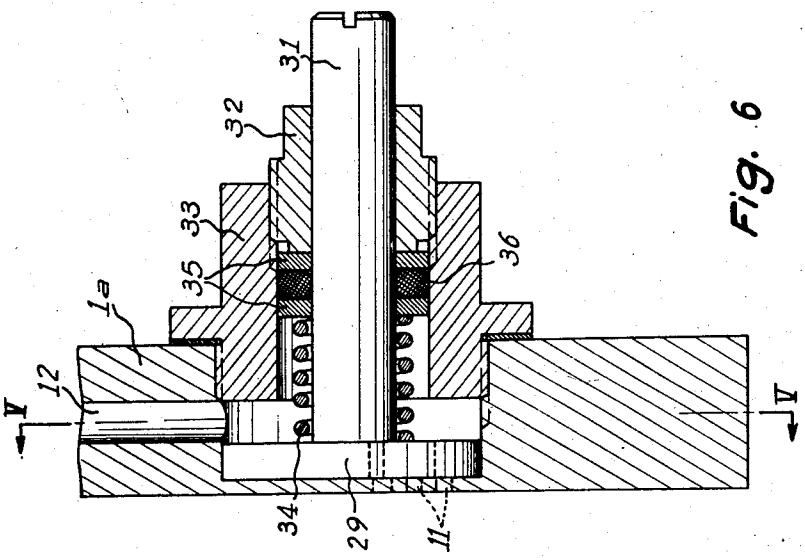


Fig. 6

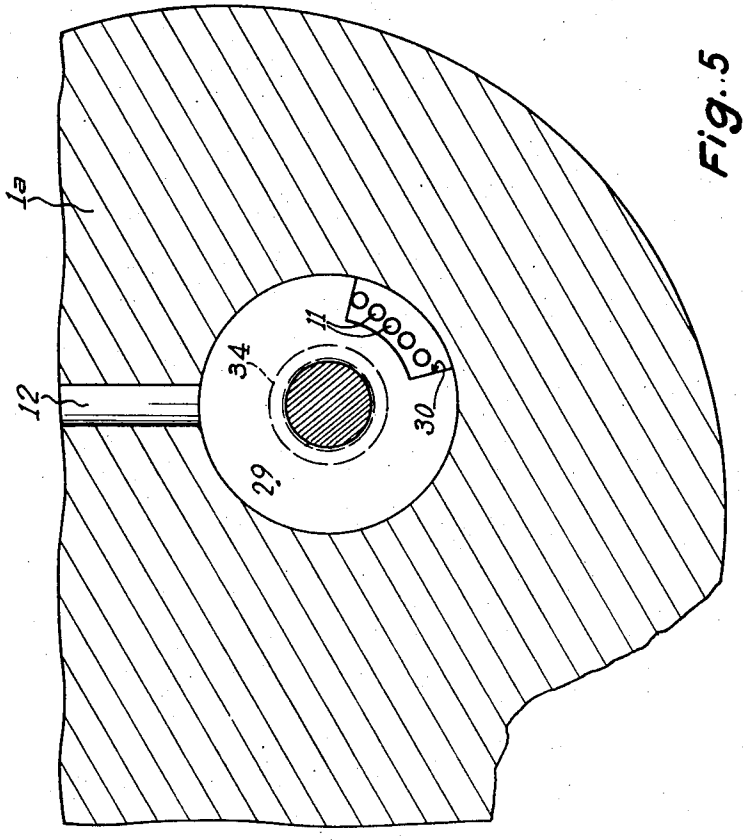


Fig. 5

Fig. 7

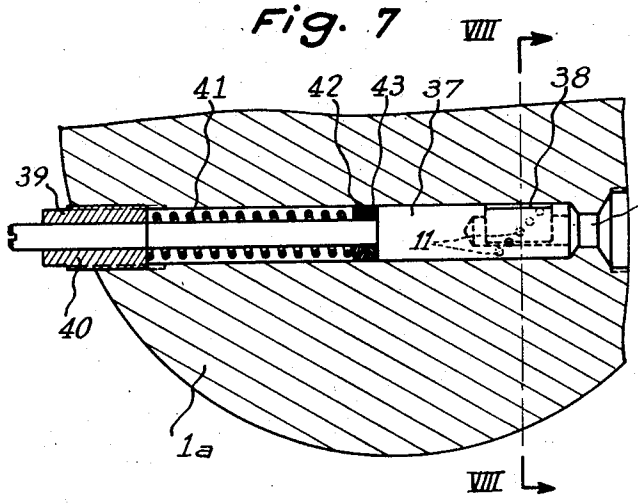


Fig. 8

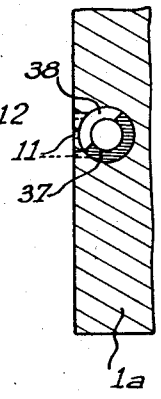
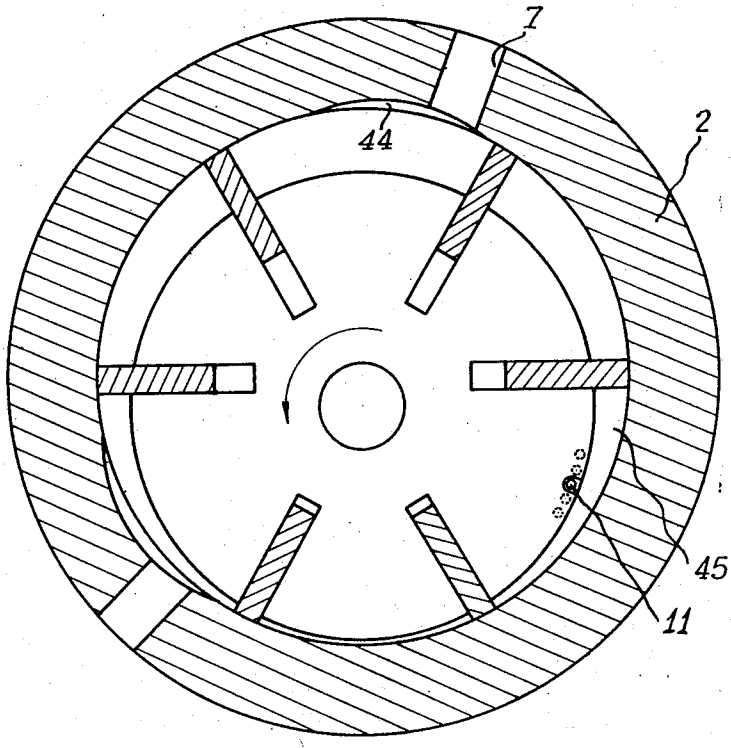


Fig. 9



Dec. 22, 1959 M. CREVOISIER 2,918,009

INJECTION-COMPRESSOR APPARATUS

Filed Jan. 28, 1958 4 Sheets-Sheet 4

FIG.10

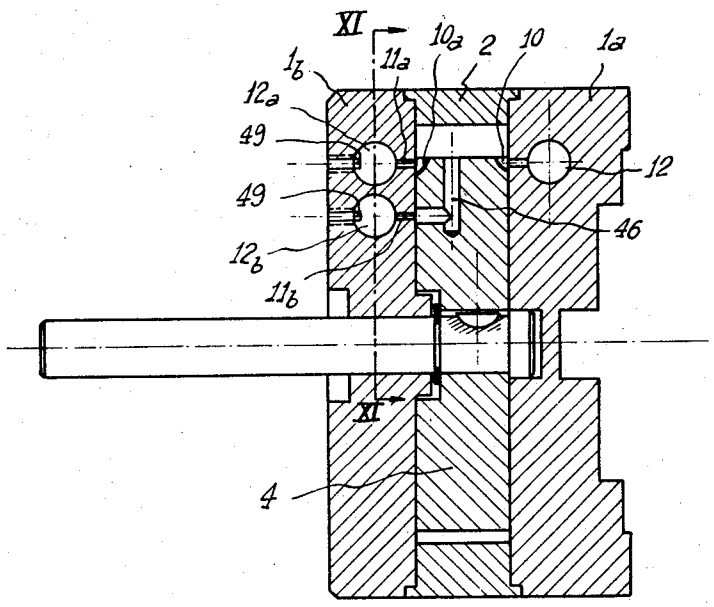
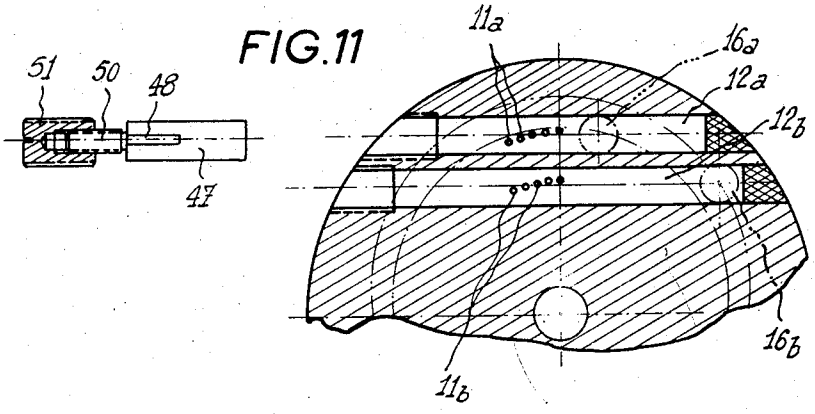


FIG.11



United States Patent Office 2,918,009 Patented Dec. 22, 1959

2,918,009

INJECTION-COMPRESSOR APPARATUS

Marcel Crevoisier, Paris, France, assignor to Societe Nouvelle Dieny & Lucas, Paris, France, a French society

Application January 28, 1958, Serial No. 711,727

Claims priority, application France February 1, 1957

8 Claims. (Cl. 103—7)

This invention relates to fluid compressors or pumps of the type wherein auxiliary inlet means are provided for injecting into the main or primary stream of fluid being compressed, an additional or secondary fluid required to be intimately mixed and compressed with the main fluid.

In the past such devices have had only limited application to situations wherein the secondary fluid injected into the main fluid stream was sometimes a coolant fluid and sometimes a lubricating fluid, such as oil. It is a general object of this invention to extend the range of usefulness of injection-compressors of the specified type by the provision of novel and improved features therein whereby such apparatus will be applicable to many fields in which the use of such apparatus was not heretofore feasible.

The injection-compressors or pumps contemplated herein are of the vane-type generally comprising a stator or body with a cylindrical chamber having inlet and outlet means for the main fluid connected therewith, and a rotor mounted in excentric relation within the chamber and having a set of slidable vanes projecting in a generally radial direction from the rotor periphery into engagement with the wall of the stator chamber so that, on rotation of the rotor, the vanes will sweep the fluid from said inlet to said outlet while simultaneously compressing said fluid owing to the separate fluid-tight compartments of decreasing capacity defined between adjacent vanes. One or more secondary inlet orifices are formed in an end wall of the stator chamber and a slot or aperture is provided in the periphery of the rotor at a suitable point between two adjacent vanes thereof and is adapted, during each revolution of the rotor, to register with said secondary inlet to inject secondary fluid into the stream of primary fluid undergoing compression.

It is an object of this invention to provide improved apparatus for mixing two or more fluids in accurately metered proportions and to compress the resulting mixture. It is a related object to provide a novel and improved injection-compressor system particularly useful in connection with the supplying of fuel to internal combustion engines.

In accomplishing the above objects of my invention I provide improved means, in an injection-compressor of the type described, for accurately and smoothly adjusting the effective cross-sectional area of the secondary fluid inlet means. A related object which my invention accomplishes is the provision of such adjusting means which can conveniently and efficiently be operated automatically by means of a servo-system of any appropriate kind.

In conventional injection-compressors it is generally necessary to reduce the output pressure of the compressor below the nominal value that is attainable therewith in order to make a predetermined amount of negative pressure available within the compressor for effectively drawing-in the secondary fluid. It is also an object of the invention to eliminate this objectionable limitation and make it possible to operate an injection-compressor at full nominal pressure while still providing for efficient injection of the secondary fluid. With this object in view my invention may provide (as known per se) a recess in the wall of the stator chamber adjacent the primary or main fluid inlet in order to ensure that each rotor compartment is properly filled with the main or primary fluid as it sweeps past said inlet, but such recess, in accordance with the invention, is of reduced circumferential extent so as to define a zone of vacuum sealed off from the main fluid inlet, and an outlet and the secondary fluid inlet means are position in that vacuum zone. In this way the negative pressure is held at a uniform value regardless of the rate at which the primary fluid is pumped, and hence the secondary fluid is injected under conditions that do not depend on the rate of delivery of the compressor.

The above, and further objects, features and advantages of the invention, will appear in the following detailed description of embodiments thereof, given for purposes of illustration but not of limitation, with reference to the accompanying drawings wherein:

Fig. 1 is an axial sectional view of a first embodiment.

Fig. 2 is a sectional view on line II—II of Fig. 1.

Fig. 3 is a detail section through a flange of the compressor, on line III—III of Fig. 1.

Fig. 4 is a fragmentary elevational view of the compressor flange shown in section of Fig. 3.

Fig. 5 is a transverse sectional view on line V—V of Fig. 6, and showing another embodiment of a compressor according to the invention.

Fig. 6 is an axial sectional view of the secondary inlet control arrangement in the embodiment of the invention shown in Fig. 5.

Fig. 7 is a sectional view of an arrangement for controlling the cross-sectional area of a secondary inlet in a third embodiment of the invention.

Fig. 8 is a section on line VIII—VIII of Fig. 7.

Fig. 9 is a cross sectional view generally similar to that of Fig. 2, but illustrating another feature of the invention.

Fig. 10 is a cross sectional view generally similar to that of Fig. 1, but illustrating still another embodiment of the invention.

Fig. 11 is a sectional view taken along the line XI—XI of Fig. 10.

Referring first to Figs. 1–4, it will be seen that the vane-type pump or compressor there illustrated comprises a stator assembly made up of spaced flanges **1***a* and **1***b* retained in assembled relationship by an intermediate spaced member **2** which is formed with a cylindrical recess **3** therein. Rotatably mounted in the stator assembly is a shaft **5** which is off center with respect to the recess **3** and is journalled in the flanges **1***a* and **1***b*. Secured on shaft **5** is a cylindrical rotor member **4** which is coaxial with the shaft and arranged to be substantially tangent with the wall of recess **3** at one point, the lowermost point of said recess as shown in the drawings. Formed in the rotor member **4** are a plurality of slots in which vanes **6** are slidable. While the slots and vanes might extend radially with respect to the rotor, and such an arrangement, is shown in Fig. 9 later described, in the embodiment now being described the slots and the vanes are directed angularly as shown. An inlet for primary fluid, e.g. air, is provided in spacer member **2** at **7** for connection with a source of the fluid, and an outlet **8** is provided in spacer member **2** and is connectable with equipment in which the compressed fluid mixture is to be utilized. The rotor **4** is assumed to be rotatably driven in the counterclockwise direction, as viewed in Fig. 2, as indicated by the arrow **9**.

A cylindrical metering chamber **12** is formed in the stator flange **1***a* in a direction normal to the axis of rotor

rotation and is connected at one side, through duct **16** (Figs. 1 and 3), with a recess **18** formed in the outer face of the flange **1***a*, while the other side of chamber **12** is connected, by way of a row of small orifices **11**, with the stator chamber **3** at a point somewhat beyond the primary fluid inlet **7**, considered in the direction of rotor rotation. A slot **10** (Fig. 2) is cut in a point of the periphery of the rotor **4** to register with the orifices **11** during every revolution of the rotor. As will be later described, the recess **18** is adapted, during operation of the system, to be filled with secondary fluid which is to be injected into the primary fluid through bore **12** and inlet orifices **11**.

The metering chamber **12** has means therein for adjusting the total effective cross-sectional area of the secondary inlet orifices **11**. In the embodiment being described, said adjusting means comprises a plunger **13** fitting closely in the cylindrical chamber **12** and adjustable therein by means of a set screw **14** acting in opposition to a spring **15** so as to uncover a desired number of the orifices **11**.

Secured with screws to the outer side of flange **1***a* and extending over the recess **18** is a two-part valve casing **17**, and a flexible diaphragm **19** is clamped across the recess **18** between the periphery of the casing **17** and the flange, so as to define a chamber **26** in the valve casing. The chamber **26** is connected by way of a duct **28** with an inlet **27** formed in the flange **1***a* and connectable with a source of secondary fluid, e.g. liquid fuel. Secured centrally of the diaphragm **19** is a valve element **20** having an axial bore **21** and seatable against a seat **22** supported in a bushing member **24** screwed into the center of the outer part of casing **17**. Radial ducts **25** extend through the sides of the bushing member **24**. A spring **23** tends to apply the valve element **20** against its seat **22**. In this seated condition it will be seen that the recess **18** communicating with the metering chamber **12**, is sealed off from the outer chamber **26** which communicates with the inlet **27** and is at all times filled with secondary fluid.

In operation, rotation of the rotor **4** in the counterclockwise direction, as viewed in Fig. 2, results in drawing primary fluid into chamber **3** through the inlet **7** and compressing it in the compartments defined between the successive vanes **6** while said fluid is swept towards and into the discharge outlet **8**. As the slot **10** is brought into registry with those orifices **11** which are uncovered by the plunger **13**, a negative pressure is communicated by way of said orifices to the recess **18** so that the diaphragm **19** and valve element **20** are drawn leftward (as viewed in Fig. 1), thereby establishing communication between recess **18** and the outer chamber **26** whereby secondary fluid is drawn into chamber **12** by way of ducts **25**, axial bore **21**, recess **18** and duct **16** and an accurately metered amount of this fluid is drawn from chamber **12** into chamber **3** through orifices **11** every time said orifices are uncovered by the slot **10** in the rotor. This secondary fluid is then intimately mixed with the primary fluid undergoing compression within the rotor compartment in which the slot **10** is provided. Therefore, a compressed mixture of primary and secondary fluid in accurately predetermined proportions is discharged by way of outlet **8**.

In the embodiment partly illustrated in Figs. 5 and 6, the plunger-type metering device formed by the plunger **13** of the first described embodiment is replaced by a rotatable disc-type metering device which includes a disc **29** formed with an arcuate cutout **30** adapted to uncover a variable number of the orifices **11**. The disc **29** is rotatable in the flange **1***a* about an axis parallel to the rotor axis. An actuating rod **31** projecting axially from the disc **29** is operable manually or mechanically for adjusting the total effective cross-sectional area of the orifices. As shown, rod **31** is journaled in a bushing **32** which is screwed in an outer bushing **33** screwed in turn into a bore of the flange **1***a*, and a spring **34** acts between the disc **29** and a dual sealing assembly including washers **35** and an intermediate seal **36**, for applying the disc **29** against the orifices. The chamber defined at the right of the disc **29**, as viewed in Fig. 6, is herein connected, by way of the duct **12**, with the recess **18** and remaining structure for admitting secondary fluid which structure may be similar to that shown in Figs. 1 to 4.

In Figs. 7 and 8, the means for adjusting the total effective cross-sectional area of the orifices **11** comprises a valve member **37** rotatable in a bore **37***a* formed in flange **1***a* normal to the rotor axis as in the first embodiment described, with the orifices **11** opening from bore **37***a* into the stator chamber. The inner end of bore **37***a* communicates with the duct **12** for admitting the secondary fluid and the rotatable valve member **37** is hollow and is slotted at **38** so as to uncover a variable number of the orifices **11** disposed in a row at an angle to the axis of the valve member **37**. The uncovered orifices **11** communicate with the duct or bore **12** by way of the slot **38** and hollow interior of valve member **37**. An operating shank **39** secured to member **37** is journalled in a guide bushing **40** screwed in the flange **1***a*. A spring **41** acting between bushing **40** and a spring seat **42** applied against member **37** through a seal ring **43** biasses the valve member toward the right, as viewed in Fig. 7. Shank **39** may be actuated manually or mechanically.

Fig. 9 illustrates another advantageous feature of the invention. As there shown a recess **44** is formed in the cylindrical wall of the stator chamber adjacent to the primary inlet **7**. Such a recess is also shown to be present in the embodiment of Fig. 1, and its primary purpose is to provide an extended area filled with primary fluid in contact with the rotor so as to facilitate the filling of each rotor compartment as it sweeps past the inlet. However, it will be noted that in Fig. 9 the angular extent of recess **44** is substantially smaller than the angular extent of each rotor compartment, e.g. recess **44** may have an extent of 30° where the rotor compartments are 60° in extent as shown. In this way there is provided a zone **45** which is at no time in communication with the inlet **7** or with the outlet. The secondary inlet orifices **11** are formed in this zone **45**. Since the degree of negative pressure obtained in the zone **45** remains substantially constant at all times during rotation of the rotor regardless of the volume of fluid it will be seen that the amount of secondary fluid drawn in can be made substantially independent of the rate of delivery of the primary fluid.

In the embodiment illustrated in Figs. 10 and 11, the rotor is formed with radial slots **10** and **10***a* at the peripheries of its opposite side walls. The flange **1***a* has orifices **11** therein cooperating with slot **10**, as in the previous described embodiments. Moreover, the flange **1***b* has orifices **11***a* formed in the path of the slot **10***a* and which communicate with a conduit **12***a* formed in the flange **1***b* in a direction normal to the rotor axis.

Moreover, the rotor **4** has a bent conduit **46** extending through it, said conduit opening at one end into the suction zone of the compressor and, at its other end, at the side wall of the rotor opposite the flange **1***b*. Said flange **1***b* has orifices **11***b* formed in it, which are located in the path of the end of the conduit **46** opening at the side surface of rotor **4**, and which communicate with a conduit **12***b* parallel to the conduit **12***a*.

Conduits **12***a* and **12***b* are arranged in the same manner as the conduit **12**, i.e. each conduit communicates with a source of auxiliary fluid through a conduit **16***a* or **16***b* respectively, and they are provided with means for metering or varying the total effective cross-sectional area of the orifices **11***a* or **11***b*.

Said metering means may comprise for example the plunger **13** of the embodiment of Figs. 1–4 or the rotatable valve member **37** of the embodiment of Figs. 8 and 9. In the embodiment of Fig. 11 a micrometric plunger

47 has been provided which is slidably mounted in each of the conduits 12*a* or 12*b* and has a radially opening, longitudinally extending groove 48 adapted to receive a finger or set screw 49 screwed in the flange 1*b*. The plunger 47 is thus prevented from rotating within the conduit. The plunger 47 has secured to it a threaded member 50 which is screwed in a plug or cap member which is also threaded externally and is screwed in the conduit 12*a* or 12*b*. The internal and external threadings of the cap 51 are slightly different so that on screwing said cap into the conduit, the member 50 of the plunger 47 will be displaced longitudinally by a distance which is a function of the difference in pitch of the cap threadings.

In the embodiment of Figs. 10 and 11, it is possible to inject into the main compressed fluid, three different auxiliary or secondary fluids, the rates of flow of the fluids delivered through the conduits 12*a* and 12*b* being regulated by means of the related caps 51.

It is found that an injection-compressor embodying the improvements of my invention is suitable for many useful purposes. Thus, in combustion-engine fuel supply systems the novel apparatus may be used for mixing combustion air, serving as the primary fluid, with liquid fuel constituting the secondary fluid. The resulting combustible mixture has extremely desirable combustion characteristics in view of the intimate mixing obtained and furthermore it is inherently pre-heated owing to the temperature elevation generated by the compression. Liquid fuels of comparatively high viscosity, e.g. an Engler viscosity of 7° at 20° C., have been successfully used in a fuel supply system embodying the injection-compressor of the invention.

Further advantageous uses of the novel injection-compressor is in the mixing and compression of spray-paint mixtures for use in spray-guns and the like, and also in refrigeration systems where the primary fluid is the gaseous cooling medium and the injected secondary fluid is the same medium in liquefied form.

The above applications of the injection-compressors embodying the invention are not exhaustive since many additional useful applications can be found in various fields of engineering wherever a mixture of two or more fluids in accurately predetermined proportions and at superatmospheric pressure is required.

What I claim is:

1. Apparatus for providing a mixture of at least two fluids in metered proportions and under pressure comprising a stator having spaced apart side walls and a cylindrical wall extending between said side walls to define a stator chamber, said stator further having an inlet and an outlet for a primary fluid which open into said stator chamber at circumferentially spaced apart locations, a rotor rotatable in said stator chamber about an axis which is eccentric with respect to said cylindrical wall and fitting closely against said side walls, vanes slidably projecting from the periphery of said rotor into engagement with said cylindrical wall so that separate compartments of varying capacity are defined between the successive vanes to displace primary fluid from said inlet to said outlet while simultaneously compressing the fluid in response to rotation of the rotor, at least one metering chamber in said stator, means for connecting said metering chamber to a source of a secondary fluid,

said stator having at least one series of orifices opening from said metering chamber into said stator chamber at one of said side walls of the latter and being arranged along a substantially arcuate line which is radially inside the periphery of said rotor, said rotor having at least one peripheral cutout opening radially into one of said compartments and also opening against said one side wall of the stator chamber to successively register with said orifices during each revolution of said rotor, and a valve member in said metering chamber being displaceable to open and close said orifices successively, thereby to vary the total effective cross-sectional area of said orifices.

2. Apparatus as in claim 1; wherein said metering chamber has a cylindrical portion arranged with its axis parallel to the axis of said stator chamber and with a flat radial face through which said orifices open; and wherein said valve member is in the form of a circular disc urged axially against said flat radial face and having a peripheral cutout for uncovering said orifices successively upon turning of said disc.

3. Apparatus as in claim 1; wherein said metering chamber is cylindrical and arranged with its axis normal to the axis of said stator chamber, said orifies opening from the cylindrical surface of said metering chamber.

4. Apparatus as in claim 3; wherein said valve member is in the form of a cylindrical plunger movable axially in said metering chamber, and said orifices are spaced apart along the metering chamber to be progressively covered and uncovered in response to axial movement of said plunger.

5. Apparatus as in claim 3; wherein said valve member is in the form of a hollow cylindrical body rotatable in said metering chamber and having a slot extending over a portion of the periphery of said body, and said orifices are spaced in the circumferential direction of said cylindrical surface of said metering chamber so that said slot of the cylindrical body progressively uncovers the orifices upon rotation of said hollow cylindrical body.

6. Apparatus as in claim 1; wherein said stator has at least two metering chambers opening into said stator chamber through respective series of orifices in said opposite side walls of the stator chamber.

7. Apparatus as in claim 1; wherein said cylindrical wall of the stator chamber has an arcuate recess therein connected with said inlet and having an angular extent which is related to the angular extent of said compartments so that said arcuate recess is always out of communication with said orifices.

8. Apparatus as in claim 1; wherein said means for connecting said metering chamber to a source of secondary fluid includes means for conducting the secondary fluid to said metering chamber and having a shut-off valve interposed therein and spring urged to a closed position, and means responsive to a reduced pressure in said metering chamber upon rotation of said rotor to open said shut-off valve and permit the entry of the secondary fluid into said metering chamber.

References Cited in the file of this patent

UNITED STATES PATENTS

1,757,514	Coulombe	May 6, 1930
1,804,604	Gilbert	May 12, 1931