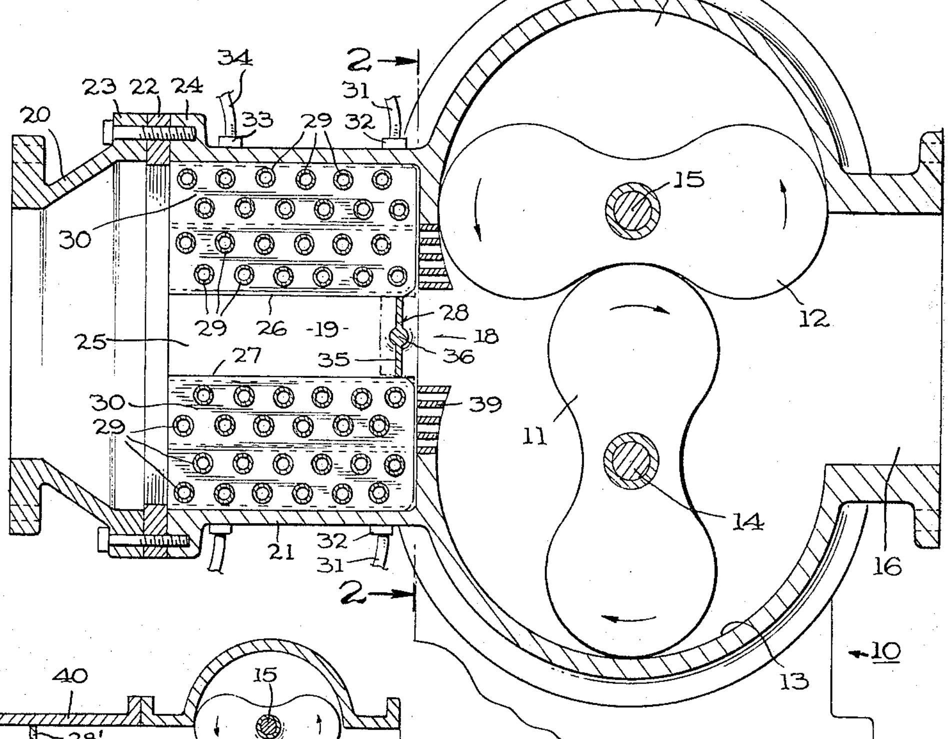
Nov. 15, 1966 D. H. SILVERN 3,285,332

DISCHARGE COOLER ARRANGEMENT FOR ROTARY POSITIVE DISPLACEMENT VACUUM PUMP

Filed Oct. 15, 1964

FIG. 1.



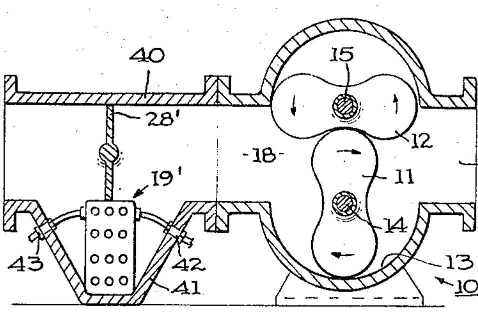


FIG. 3.

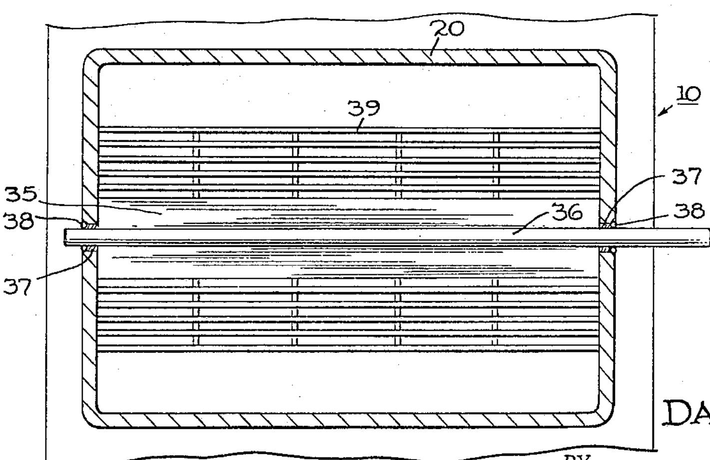


FIG. 2.

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United States Patent Office 3,285,332
Patented Nov. 15, 1966

3,285,332

DISCHARGE COOLER ARRANGEMENT FOR ROTARY POSITIVE DISPLACEMENT VACUUM PUMP

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Filed Oct. 15, 1964, Ser. No. 404,140
7 Claims. (Cl. 165—122)

This invention relates generally to fluid pumps of the rotary positive displacement type, and more particularly to the provision of an improved means for cooling the fluid discharge of such devices.

Inasmuch as the invention is especially well adapted for embodiment in mechanical vacuum booster pumps of the rotary impeller type, the following disclosure will be directed primarily to this specific application of the inventive concept. By so doing, however, it is not intended to limit the scope of the invention or its application.

In prior vacuum pump installations, it has been customary to provide a cooler for the system on the discharge side of a mechanical vacuum booster pump so as to cool the discharged gas and increase the efficiency of the pump. However, such systems operate under two completely disparate conditions. When operating under low vacuum conditions, that is, at pressures in the millimeter range, the percentage of the pressure drop through the heat exchanger is relatively low in relation to the total pressure drop, while the temperature drop across the cooler is high. Under high vacuum conditions, that is, when the pump is operating in a micron pressure range, the percentage of the pressure drop across the heat exchanger becomes relatively high in relation to the total pressure drop, even though the amount of cooling required is negligible. This problem is particularly significant when the heat exchanger is made integral with the pump to permit cooling of the back-flow.

Accordingly, it is a principal object of the present invention to provide a novel discharge cooler arrangement for a rotary positive displacement vacuum pump wherein the stream of gas discharged from the pump may be selectively maintained either in or out of contact with the cooler.

Another object is to provide an improved cooler for a vacuum booster pump or similar device which is adapted to cool the discharged gas in accordance with the particular operating condition of the pump.

These and other objects of the invention will appear more fully upon consideration of the following detailed description of the mechanical structure and mode of operation of two embodiments thereof. While the specification concludes with claims particularly pointing out and distinctly claiming the subject matter of the present invention, it will be described with reference to the accompanying drawing wherein two specific forms of cooler are illustrated. However, it is to be expressly understood that this drawing is for the purpose of illustration only and is not intended to represent the full scope of the invention, which is defined by the appended claims.

In the drawing, wherein like reference characters indicate like parts throughout the several views:

FIG. 1 is a side elevational view, partly in cross section, of one form of discharge cooler embodying the invention as used in conjunction with a well known type of mechanical vacuum pump;

FIG. 2 is a transverse view taken along line **2—2** of FIG. 1; and

FIG. 3 is a side elevational view, partly in cross section, of another embodiment of the invention.

Referring to the drawing, there is illustrated a rotary positive displacement pump **10** of the type comprising

two multilobed impellers **11** and **12** rotating within a surrounding casing **13**. The impellers **11** and **12** are mounted on parallel shafts **14** and **15**, respectively, which are geared together so that the impellers rotate in opposite directions, as indicated by the arrows. The contour and finish of the impellers and the accuracy of cut of the gears is such that a small, substantially gas-tight operating clearance of a few thousandth of an inch is maintained between the impellers as they rotate. The surrounding casing **13** has semicylindrical sides conforming to the path described by the ends of the impeller lobes and is otherwise so constructed that a small, substantially gas-tight operating clearance of a few thousandths of an inch or less is provided between the sides and the ends of the casing and the rotating impellers.

As the impellers revolve, gas flows through the pump inlet **16** into pockets formed by the impeller lobes and the surrounding casing. One such pocket is indicated at **17** in FIG. 1. The gas is trapped in the pockets thus formed and is carried therein to the outlet **18** at the side of the pump casing opposite inlet **16** where it is forced positively through a cooler **19** into a fitting **20** which is adapted to be connected to the discharge line. During each complete revolution of the impellers, this action is repeated a number of times equal to the total number of impeller lobes.

Since vacuum pumps of this type operate without valves, the full difference in pressure between the pump inlet **16** on the suction side and the outlet **18** on the pressure side continuously loads impellers **11** and **12**. With each rotation of the impellers, the gas column on the pressure side undergoes four pressure strokes at the times when the gas trapped in the pockets is freed towards outlet **18**. Gas at the higher pressure then rebounds from the pressure side into the opening pocket and thereby undergoes heating.

To overcome this heating effect, it has been proposed to provided cooling means built into the outlet port of the pump casing. One such cooling arrangement is shown in U.S. Patent No. 2,667,046. However, while such an arrangement provides an effective means for cooling gas leaving the pump, the cooler serves to introduce a relatively high pressure drop into the system when operating in the micron pressure range, at which time cooling is not actually needed.

In accordance with the present invention, the objectionable features of previously known discharge coolers are overcome by providing a novel cooling arrangement which effectively cools the gas when the pump is operating in the millimeter pressure range, but may be readily bypassed by the discharged gas stream when the pump is operating in the micron pressure range. Such an arrangement permits straight-through flow of the discharged gas when the pressure drop is particularly critical, thus minimizing system losses. Vacuum pumps constructed in accordance with the present invention are able to work continuously against a higher pre-vacuum pressure, and at higher compression ratios for a given pressure level, than vacuum pumps without such cooling arrangements.

When reference is made to the millimeter pressure range, it is intended to refer to pressures above approximately 1–20 torr, while the micron pressure range refers to pressures below approximately 1–20 torr. It will be appreciated that there is no sharply defined cut-off point between operation in the millimeter pressure range and operation in the micron pressure range, and that the range of 1–20 torr represents the area in which the characteristics identifying operation in the millimeter pressure range blend with the characteristics identifying operation in the micron pressure range. A torr is defined as the pressure equal to 1 mm. Hg at 0° C. and standard gravity.

In the embodiment of the invention illustrated in

FIGS. 1 and 2, the rotary positive displacement pump **10** is provided with an extended outlet section **21** which is advantageously constructed as part of the pump casing to form an integral unit, but may be formed separately as a conduit or pipe connected to the outlet of the pump. The discharge cooler **19** is supported within the outlet section **21** between the discharge fitting **20** and the outlet **18** of the pump. To this end, the cooler **19** is provided with a retaining flange **22** which is bolted or otherwise suitably secured between flanges **23** and **24** of the fitting **20** and outlet section **21**, respectively.

The discharge cooler **19** comprises a plurality of cooling units which are supported adjacent the pump outlet **18** and arranged to provide a central passage **25** in communication with the outlet **18** and the discharge fitting **20**. In the illustrated embodiment, the outlet section **21** is rectangular in cross section and a pair of cooling units **26** and **27**, also rectangular in cross section, are mounted in the upper and lower portions thereof so as to form the passage **25** between them. However, it should be readily apparent that other configurations can be utilized as long as provision is made to allow the discharged gas stream to bypass the cooling units when the pump is operating in the micron pressure range and to direct the gas stream through the cooling units when the pump is operating in the millimeter pressure range.

To effect selective control over the direction of flow of the discharged gas stream, a valve **28** is provided adjacent the pump outlet **18**, preferably at the point of entrance of the discharged gas into the passage **25**. In the form shown, valve **28** is a butterfly valve arranged to selectively open and close the entrance to passage **25** in accordance with the operating conditions of the pump, whereby the path of the gas stream discharged through outlet **18** may be directed either through the cooling units **26** and **27** when the valve is in the closed position illustrated, or straight through the passage **25** to bypass the cooling units when the valve is rotated 90° from said position.

As shown in FIG. 1, the cooler **19** comprises a pair of cooling units **26** and **27** which are identical in construction and of a type well known in the art. Each unit comprises a bundle of cooling tubes **29** having a plurality of spaced cooling fins **30** secured thereto in any suitable manner, as by brazing, welding, crimping, or the like. The cooling fins are advantageously spaced about one-eighth to one-sixteenth inch apart to allow a free flow of discharged gas therebetween when the gas is directed through the cooling units, and to provide the maximum cooling effect. The cooling tubes **29** may be connected individually, in series, or in any desired combination to a suitable source of coolant (not shown) by means of conduits or pipes **31**. To this end, each cooling unit is provided at its sides with a coolant jacket having suitable inlet and outlet couplings **32** and **33** for establishing the proper flow connections. After flowing through the cooling tubes **29** and extracting heat from the discharged gas, the coolant is removed through discharge conduits **34** connected to outlet couplings **33**, after which it may be recooled and recirculated through the cooling units.

The valve **28** which controls the flow of the discharged gas stream comprises a rectangular plate **35** which is mounted on a rotatable shaft **36** and extends across the outlet **18** between the cooling units to close off the passage **25** when in the position shown in the drawing. The ends of shaft **36** extend outwardly through the sides of the pump casing. Teflon bearings **37** being provided for supporting the shaft and sealing being effected through O rings **38**. The valve may be suitably actuated, either manually or automatically through a servo mechanism, in accordance with indications of either pressure or temperature of the air at the blower outlet ahead of the cooler. Alternatively, the valve may be operated on a time basis, for a given installation, either manually or automatically through a timer and a servo mechanism.

In operation, when the pump is operating at inlet pressures in the millimeter range, i.e., from atmospheric down to a suitable low pressure in the range from 1–20 torr, and cooling of the discharge is desired, the valve is rotated to the position shown in FIG. 1 to close the bypass passage **25**. This causes the discharged gas to flow through the cooling units **26** and **27**, between the fins **30** and over the outsides of the tubes **29**. When operating at pressures in the micron range, however, the valve **28** is rotated 90° from the position shown to open the passage **25** between the cooling units **26** and **27** so that the gas flows straight through the passage from pump outlet **18** to the discharge fitting **20**. Although the valve may be operated at any point within the 1–20 torr range, the point of operation is preferably set for approximately 5 torr. However, operation anywhere within said range provides the necessary cooling and at a satisfactory pressure drop at the higher pressures, while at lower pressures the pressure drop is still maintained satisfactory with elimination of the cooling, since cooling is not required at the lower pressure levels.

It will be readily apparent that various modifications may be made in the construction illustrated. For example, the valve **28** may be positioned closer to or further from outlet **18** than shown, the exact position being dependent on the particular type of cooling units and pump utilized. Also, suitable baffles may be provided at the outlet **18** for directing the path of the gas discharged from the pump. Furthermore, if desired, outlet **18** may be provided with suitable grid or vane structures **39** so that puff-back air will pass through the coolers and not around them. Such grid structures may be separately fabricated in the form of aluminum castings or the like, and secured to the ends of the cooling units.

Referring now to FIG. 3, an alternative embodiment of the invention is shown wherein the discharge cooler **19'** is arranged externally of the pump in a separate pipe or line **40** connected to the pump outlet **18**. The pipe is arranged to provide a suitable offset supporting enclosure **41** for the cooler, including inlet and outlet connections **42** and **43**, respectively, for the coolant. Valve **28'** is supported above the cooler **19'** so that, when the valve is open, the gas discharged from the pump passes straight through the pipe **40**, but when the valve is closed, the gas is forced through the cooler **19'**. Such an arrangement requires the use of only a single cooling unit and may be effectively used where, due to physical limitations of the installation, a discharge cooler integral with the pump housing cannot be utilized. Also, this alternative construction can be utilized in existing pump installations merely by connecting the pipe **40** to the existing gas pump outlet.

It will be apparent from the foregoing description that there has been provided by the present invention a simple and effective discharge cooling arrangement for a rotary positive displacement pump wherein the discharge gas stream may be effectively controlled so as to either pass through or bypass the cooling elements of the cooler, in accordance with the operating conditions of the pump. Such an arrangement allows the gas to bypass the cooler when the pump is operating in the micron pressure range, while maintaining the necessary cooling when the pump is operating in the millimeter pressure range. This results in an increase in the efficiency of the pump by avoiding the high pressure drop which would occur if the cooler remained in the path of the gas when the pump is operating in the micron pressure range, and allows use of the pump at a higher than customary compression ratio for a given pressure level.

Although only two specific embodiments of the invention have been described and illustrated, it will be obvious to those skilled in the art that various modifications may be made in the mechanical structure of the cooler and the means by which the path of the discharged gas stream is controlled. Reference should therefore be had to the appended claims for a definition of the scope of the invention.

What is claimed is:

1. A gas pump of the rotary positive displacement type adapted for operation at inlet pressures above and below the range of 1 to 20 torr comprising a casing having a gas inlet and a gas outlet, a pair of multilobed impellers rotatably mounted in said casing and adapted to displace gas from said gas inlet to said gas outlet, cooling means mounted in said gas outlet, said gas outlet including a passage free of said cooling means to allow unrestricted flow of discharge gas past said cooling means, valve means disposed in said passage for actuation to a first position at a predetermined inlet pressure within the range of 1 to 20 torr to close said passage and thereby cause the discharge gas to flow through the cooling means when said pump is operating at inlet pressures above said predetermined inlet pressure and to a second position when said pump is operating at inlet pressures below said predetermined inlet pressure within the range of 1 to 20 torr to open said passage and thereby cause the discharge gas to bypass said cooling means.

2. A gas pump of the rotary positive displacement type as set forth in claim 1, wherein said valve means is actuated to its first position when said pump is operating at an inlet pressure of above approximately 5 torr and to its second position when said pump is operating at an inlet pressure below approximately 5 torr.

3. A gas pump of the rotary positive displacement type as set forth in claim 1 wherein said gas outlet comprises an extension integral with said casing, said extension having an inlet and an outlet, said inlet being aligned with said gas outlet to allow straight-through flow of discharge gas from said outlet when said valve means is actuated to its second position.

4. A gas pump of the rotary positive displacement type as set forth in claim 3, wherein said extension includes an offset portion, said cooling means being mounted in said offset portion, said valve means being mounted in said extension above said cooling means to thereby form a bypass passage within said extension and integral with said cooling means.

5. A gas pump of the rotary positive displacement type as set forth in claim 1, wherein said casing adjacent the gas outlet includes a grid portion forming a plurality of channels for directing puff-back gas through the coolers.

6. A gas pump of the rotary positive displacement type adapted for operation above and below the range of 1 to 20 torr comprising a casing having a gas inlet and a gas outlet, a pair of multilobed impellers rotatably mounted in said casing and adapted to displace gas from said gas inlet to said gas outlet, cooling means mounted in gas outlet, said cooling means including a plurality of spaced cooling units forming a gas passage therebetween to allow an unrestricted flow of gas past said cooling units, valve means disposed in said gas passage for actuation between a first position at a predetermined inlet pressure within the range of 1 to 20 torr to close said gas passage and cause the discharge gas to be directed through the cooling units when said pump is operating at inlet pressures above said predetermined inlet pressure and a second position when said pump is operating at inlet pressures below said predetermined inlet pressure within the range of 1 to 20 torr to cause the discharge gas to flow unrestricted through said passage.

7. A gas pump of the rotary positive displacement type as set forth in claim 6 wherein said valve means is actuated to its first position when said pump is operating at inlet pressures above approximately 5 torr, and to its second position when said pump is operating at inlet pressures below approximately 5 torr.

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