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DISCHARGE COOLER FOR ROTARY POSITIVE DISPLACEMENT VACUUM PUMP

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FIG. 1.

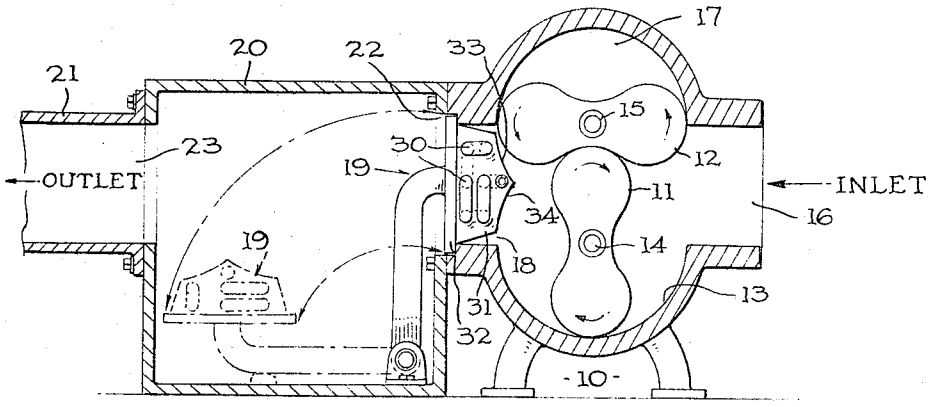
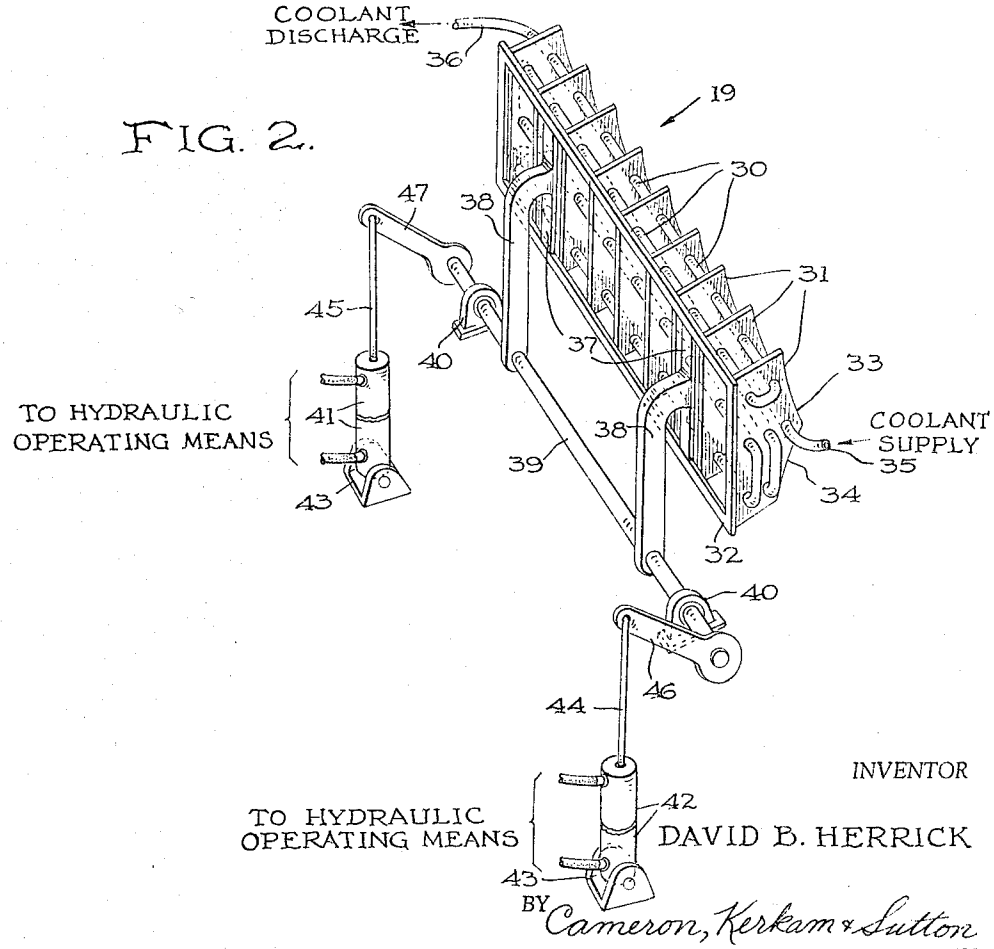


FIG. 2.



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DISCHARGE COOLER FOR ROTARY POSITIVE DISPLACEMENT VACUUM PUMP

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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 the 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 cooler may be readily positioned either in or out of the stream of gas discharged from the pump.

Another object is to provide an improved cooler for vacuum booster pumps and similar devices 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 from the following detailed description of the mechanical structure and mode of operation of one embodiment 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 one specific form of pump and 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; and

FIG. 2 is a perspective view of the discharge cooler of FIG. 1, including the hydraulic operating means by which the cooler may be moved into and out of the path of the gas discharged from the pump.

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 thousandths 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 the discharge cooler **19** and associated housing **20** into a discharge pipe **21**. During each complete revolution of the impellers, this action is repeated a number of times equal to the total number of impeller lobes.

As shown in FIG. 1, housing **20** comprises an inlet **22** and an outlet **23** and is supported adjacent the outlet side of pump casing **13** in any suitable manner. Inlet **22** mates with the outlet **18** of the pump **10** to allow a straight-through flow of the discharged gas when the cooler **19** is swung out of the path of the gas flow in the manner hereinafter described.

Since vacuum pumps of this type operate without valves, the full difference in pressure between the inlet **16** on the suction side and outlet **18** on the pressure side continuously loads the 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 the 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 provide 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 featues of previously known discharge coolers are overcome by providing a novel cooling device which effectively cools the gas when the pump is operating in the millimeter pressure range, but may be readily moved out of the path of the discharged gas stream when the pump is operating in the micron pressure range so as to allow the gas to bypass the cooler. To this end, the discharge cooler **19** is so constructed and arranged that it may be selectively moved into and out of the path of the gas stream discharged through outlet **18**, depending upon the operating conditions then existing.

As shown in FIGS. 1 and 2, the cooler **19**, which is normally positioned in the outlet **18** when the pump is operating in the millimeter pressure range, comprises a bundle of cooling tubes **30** having a plurality of spaced cooling fins **31** fixed thereto in any well-known manner, as by brazing, welding, or the like. The cooling fins **31** are also fixed to and supported by a rectangular frame **32** which is open to allow the passage of gas therethrough, and is so dimensioned as to fit into and seat against a groove in the pump casing around the outer end of out-

let 18. Cooling fins 31 are made of any suitable heat conductive material and are preferably shaped to provide a profile having dimensions which allow the fins 31 to extend into the outlet 18 to positions closely adjacent the impellers 11 and 12. As shown, the inner edge of each fin is provided with a pair of symmetrical concave surfaces 33 and 34 which, when the cooler 19 is in cooling position at the outlet 18 of the pump, lie closely adjacent the paths of the tips of the impellers 11 and 12 as they rotate past the outlet. In this manner, the maximum cooling effect is obtained.

The cooling tubes 30 may be connected individually, in series, or in any desired combination to a suitable source of coolant (not shown), as by a flexible conduit or hose 35 of rubber, plastic or the like. After flowing through the tubes 30 and extracting heat from the discharged gas, the coolant is discharged through another flexible conduit 36.

In order to support the cooler 19 and to enable movement thereof into and out of cooling position, frame 32 is provided with one or more cross straps 37 each of which is fixed to one end of an arm 38. The other end of each arm 38 is secured to an operating shaft 39 which is rotatably supported in housing 20 by means of combined bearing and seal members 40 through which the ends of shaft 39 project outwardly of the housing. The shaft 39 is adapted to be oscillated in the bearings 40, so as to impart a swinging or pivotal movement to cooler 19 which brings it into or out of the path of the gas stream, by means of a pair of hydraulic cylinders 41 and 42. These cylinders are pivotally mounted on suitable supports 43 outside the housing 20 and have their piston rods 44 and 45 connected to lever arms 46 and 47, respectively, which are in turn fixed to the outer ends of shaft 39. Cylinders 41 and 42 are adapted to be actuated by hydraulic operating means of any suitable character (not shown) which may be controlled either manually or automatically in accordance with the operating conditions of the pump.

When the pump is operating at pressures in the millimeter range and cooling of the discharge is desired, hydraulic cylinder 41 and 42 are so energized as to force piston rods 44 and 45 and lever arms 46 and 47 upwardly. This causes shaft 39 to rotate about its axis which in turn swings the discharge cooler 19 into place in the outlet 18 of the pump casing 13. The positive action of the hydraulic cylinders, in addition to pivoting the cooler into position, also serves to firmly hold the cooler in place and to prevent it from vibrating or being otherwise affected by the pulse of the vacuum pump. When the pump is operating in the micron pressure range and cooling is unnessary, the hydraulic cylinders are actuated in reverse so as to move the cooler out of the path of the discharged gas and back to the non-cooling position indicated in broken lines in FIG. 1.

It will be apparent from the foregoing description that there has been provided by the present invention a simple and effective discharge cooler arrangement for a rotary positive displacement pump wherein the cooling element may be readily swung into and out of the path of the discharge gas stream. 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.

Although only one particular embodiment of the invention has been described and illustrated, it will be obvious to those skilled in the art that various modifications may be made in the mechanical construction of the cooler and the means by which it is moved into and out of cooling position. Reference should therefore be had to the appended claims for a definition of the scope of the invention.

What is claimed is:

1. A vacuum pump of the rotary positive displacement type comprising a casing having a gas inlet and a gas outlet, a pair of multilobe impellers rotatably mounted in said casing and adapted to displace gas from said gas inlet to said gas outlet, a housing integral with said casing and having an inlet opening and an outlet opening, said inlet opening of said housing being aligned with said gas outlet, a heat exchanger movably supported within said housing and means operatively connected to said heat exchanger and adapted to be hydraulically actuated for moving said heat exchanger into and out of the path of the gas discharge from said gas outlet, said means upon actuation to move said heat exchanger into the path of the gas discharge from said gas outlet serving to position the heat exchanger in said gas outlet in close proximity to the maximum extent of travel of the lobes of the impellers as they rotate past the gas outlet and to positively hold said heat exchanger in position to prevent vibration due to gas pulsation.

2. A vacuum pump as set forth in claim 1 wherein said heat exchanger comprises a bundle of cooling tubes having a plurality of spaced cooling fins fixed thereto, each of said cooling fins when said heat exchanger is positioned in said gas outlet having a portion extending into said casing, said portion having a profile complimentary to the path of movement of the tips of the lobes of the impellers as they rotate past the gas outlet.

3. A vacuum pump of the rotary positive displacement type comprising a casing having a gas inlet and a gas outlet, a pair of multilobe impellers rotatably mounted in said casing and adapted to displace gas from said gas inlet to said gas outlet, a housing integral with said casing and having an inlet opening mating with said gas outlet and an outlet opening, a heat exchanger pivotally supported within said housing, hydraulic actuating means connected to said heat exchanged and adapted to be actuated for moving said heat exchanger into and out of the path of gas discharge from said gas outlet and positively position the heat exchanger in said gas outlet to prevent vibration due to gas pulsation, said heat exchanger comprising a bundle of cooling tubes having a plurality of spaced cooling fins supported thereto and said cooling fins having a profile such that when said heat exchanger is positioned in said gas outlet a portion of said cooling fins extend into the casing closely adjacent the maximum extent of travel of the tips of the lobes of the impellers as they rotate past the gas outlet.

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