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Kvinge et al.

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[54] **NON-ICING QUIET AIR-OPERATED PUMP**

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[73] Assignee: **Graco Inc.**, Minneapolis, Minn.

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[51] **Int. Cl.**[5] **F04B 39/02**

[52] **U.S. Cl.** **417/368**; 417/375; 62/402; 60/412

[58] **Field of Search** 417/375, 368, 396, 402, 417/403; 137/338; 62/82, 402; 60/370, 407, 412

[56] **References Cited**

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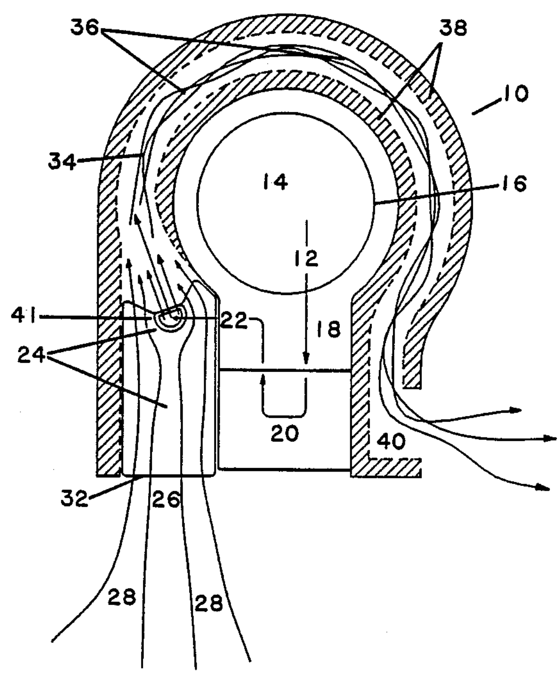
Primary Examiner—Louis J. Casaregola

Assistant Examiner—Robert N. Blackmon

[57] **ABSTRACT**

A silencing system is provided for an air-operated pump which also eliminates icing of the pump at higher cycle rates and humidities. The exhaust from the air motor powers an air flow inducer to induce a flow of relatively warm ambient air. The induced flow of ambient air is drawn across cold components of the air motor, and the mixed (ambient and exhaust air) exit stream routed away from the air motor. The relatively warm mixed air exhaust flow also allows noise reduction by conventional acoustical techniques without suffering performance degradation due to icing.

9 Claims, 4 Drawing Sheets



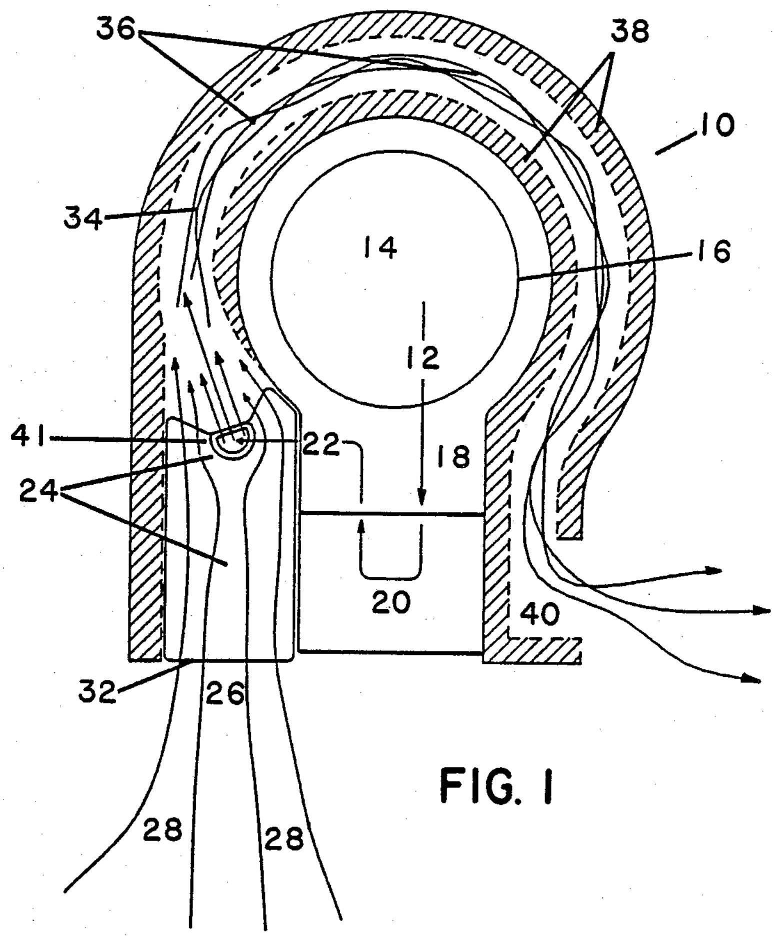


FIG. 1

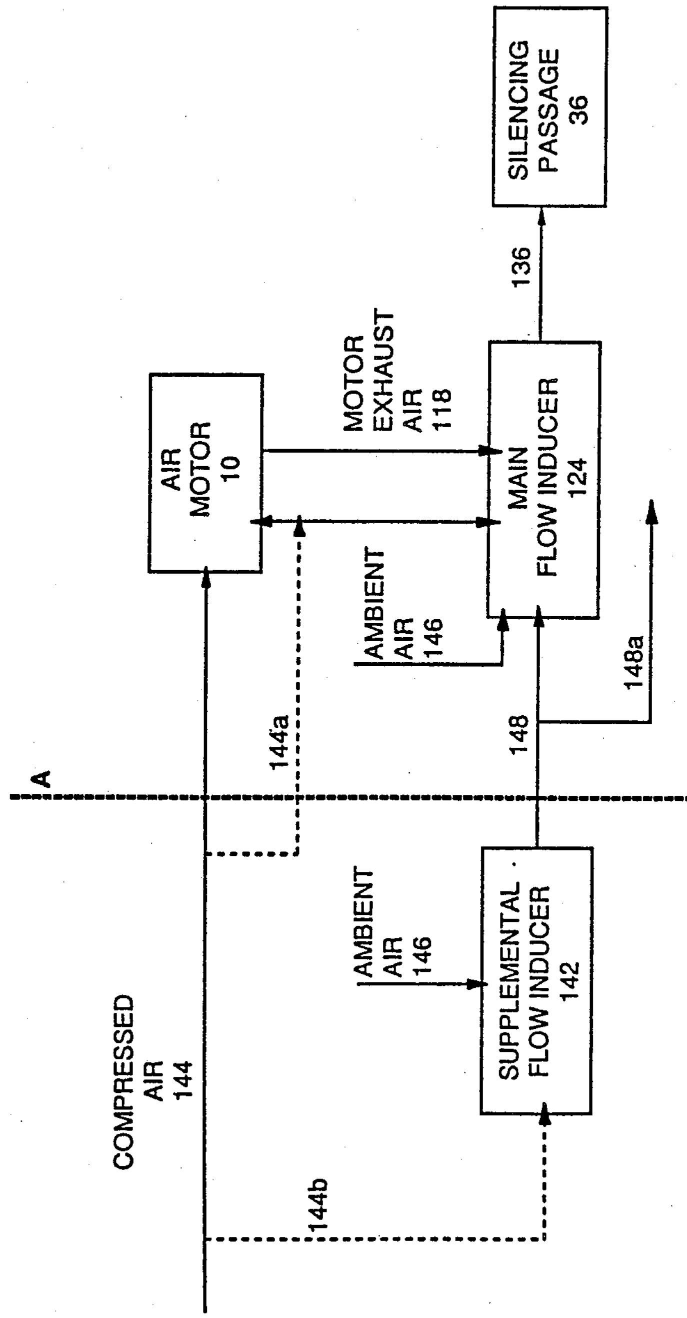

SILENCING PASSAGE 36
136
AIR MOTOR 10
MOTOR EXHAUST AIR 118
MAIN FLOW INDUCER 124
AMBIENT AIR 146
148a
148
144a
A
AMBIENT AIR 146
SUPPLEMENTAL FLOW INDUCER 142
COMPRESSED AIR 144
144b

FIG. 2

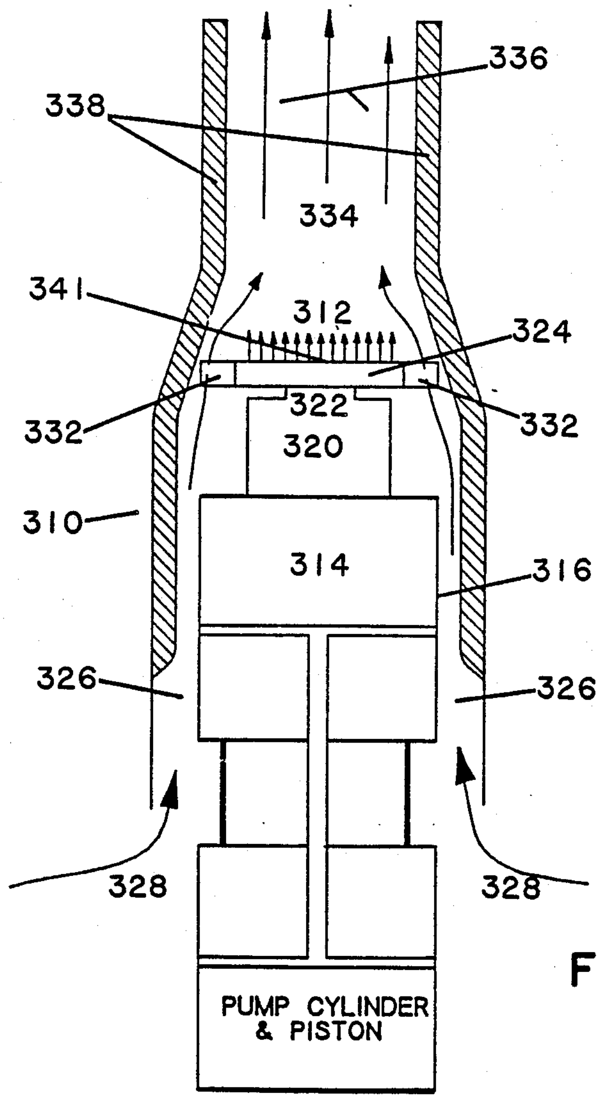

336
338
334
341
312
324
332
322
332
320
310
314
316
326
326
328
328
PUMP CYLINDER & PISTON

FIG. 3

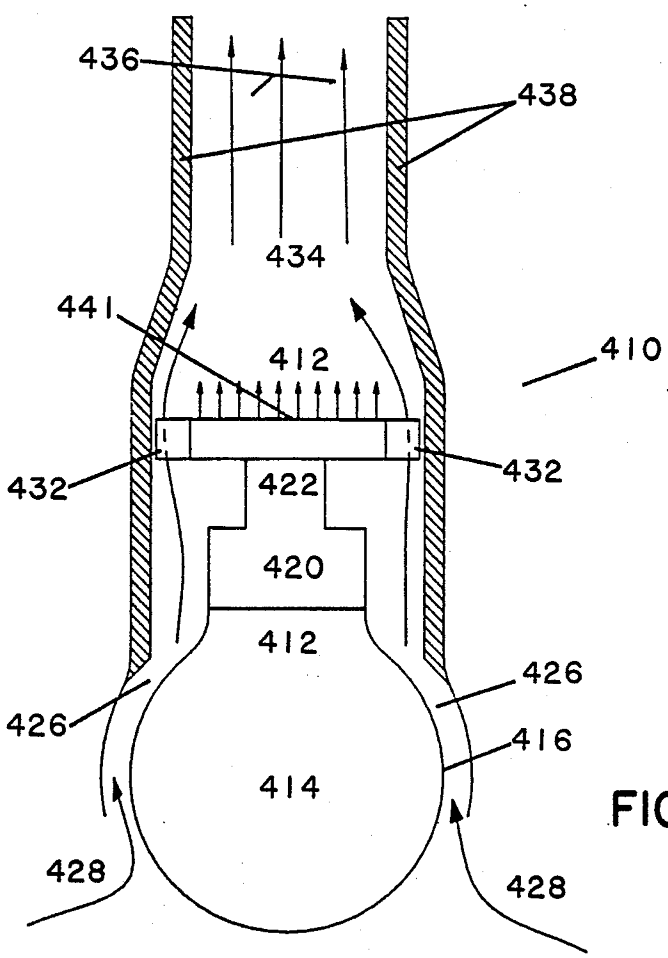

436
438
434
441
412
410
432
432
422
420
412
426
426
416
414
428
428

FIG. 4

NON-ICING QUIET AIR-OPERATED PUMP

BACKGROUND OF THE INVENTION

Air-operated reciprocating piston pumps are in general well known and have been in widespread operation for many years. Such pumps have traditionally suffered from two problems which are closely interrelated to the point where the solution of one problem typically exacerbates the other. First, in the normal operation of such pumps, the expanding air in the air motor becomes quite cold and, as it exhausts, cools the valve and exhaust passages tending to build up ice in the valve and exhaust passages. If the pump should be operated at relatively high cycle rates and/or high pressures for an extended period of time, the ice build-up can be sufficient to slow or completely stall operation of the pump. Once the pump has stalled, it may need anywhere from one to several hours to thaw the blockage from the passages noted.

Such pumps have also typically produced relatively high noise levels in normal operation. Attempts to muffle the noise by restricting the exhaust of such motors using conventional muffling technology has typically led to substantially decreased performance, efficiency and increased ice build-up due to the increased restriction in the exhaust stream.

It is therefore an object of this invention to produce an air motor which is substantially quieter than existing state of the art machines.

It is yet a further object of this invention to produce an air-operated pump which is capable of operating for extended periods at high cycle rates, high pressures without icing or other decrease in performance.

It is yet a further object of this invention to provide such an air-operated pump which operates efficiently by virtue of low back pressure compared to conventionally muffled air motors.

It is yet a further object of this invention to provide an air-operated pump which may be easily and inexpensively manufactured.

SUMMARY OF THE INVENTION

An air-operated reciprocating piston pump is provided where an exhaust passage from the valve is connected to the primary fluid (or high velocity fluid) input of an air flow inducer which may be of the Coanda type. The secondary (or low velocity) fluid input of the air flow inducer is arranged so as to induce warm (room temperature) ambient air to be drawn through the flow inducer. The mixed air stream has a velocity substantially lower and temperature higher than that of the motor exhaust. The mixed air stream can be directed around the air motor, axially, radially or otherwise away from the air motor, the passage through which the mixed air stream passes being lined with sound deadening material.

The temperature of the mixed fluid stream is above freezing and serves to prevent the exhaust path downstream from the air flow inducer from falling below freezing thus preventing icing. The input air (which is drawn into the secondary fluid inlet of the air flow inducer) is drawn over a finned heat exchanger or other heat transfer mechanism which is attached to the air motor valve and exhaust nozzle block thus allowing heat transfer to the valve and exhaust nozzle block and preventing ice from forming therein. As can be appreciated, in order to keep the cold surfaces warm, the area of the heat exchanger which is exposed to the warm ambient air should be maximized compared to the area of the valve, heat exchanger and exhaust nozzle block which are exposed to the cold air stream present in the exhaust.

The warm ambient air and cold exhaust air mixture is above freezing, but may still be colder than the air motor metal temperatures. Since the mixture is above freezing, acoustical foam can be used to absorb the noise without experiencing degradation due to ice. Also, the acoustical foam can serve to insulate the air motor metal surfaces from the colder mixed air flow when the muffler exhaust passage is configured to surround the air motor.

Optionally, a second or supplemental air flow inducer may be connected to the ambient air input of the main flow inducer so as to provide additional induced flow for mixing with the cold exhaust air, and for purposes of additional warming of the valve, heat exchanger and exhaust nozzle block. The supplemental air flow inducer is operated by a small amount of compressed air which can enhance heat transfer to the heat exchanger and raise the temperature of the mixed air stream.

Also, optionally, a relatively small amount of compressed air may be bled into the valve or the exhaust nozzle to further assist in warming the exhaust stream.

These and other objects and advantages of the invention will appear more fully from the following description made in conjunction with the accompanying drawings wherein like reference characters refer to the same or similar parts throughout the several views.

A BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** shows a schematic cross section of a typical air motor showing the air path of the preferred embodiment of the instant invention.

FIG. **2** discloses another embodiment of the instant invention when additional air flow inducer adds a supplemental effect.

FIG. **3** shows a side cross sectional view of another embodiment of the instant invention having an axial configuration.

FIG. **4** shows a top cross sectional view of another embodiment of the instant invention having an axial configuration.

DESCRIPTION OF THE PREFERRED EMBODIMENT

A cross section of an air-operated reciprocating piston pump air motor is shown in FIG. **1**. Such air motors are in general well known in the art and the internal detailed construction need not be shown here. The motor, generally designated **10**, exhausts cold exhaust air **12** from chamber **14** in the air cylinder **16**. Air **12** is exhausted through first exhaust passage **8** and into air valve **20** (which may be of any conventional design) whereupon the exhaust air is passed to the primary fluid input **22** of main air flow inducer **24** and exits via the exhaust nozzle block **41**.

Air flow inducer **24** may be of the venturi type, vortex type or the type generally known as a Coanda effect air amplifier, the construction of which is well known as typified by U.S. Pat. No. 2,052,869, the contents of which are hereby incorporated by reference. The secondary or low velocity fluid input **26** of flow inducer **24** receives relatively warm ambient air **28** which is drawn through the heat exchanger **32**.

Heat exchanger **32** is attached in a heat conducting relationship with air cylinder **16**, valve **20** and exhaust nozzle block **41**, so as to extract heat from the ambient air **28** and transfer the heat into the cold exhaust nozzle block **41**, air valve **20** and air cylinder **16**. The expansion of exhaust gas in air cylinder **16** causes exhaust gas in passage **18** to be extremely cold (average temperatures of −30 degrees centigrade or less) which tends to lower temperatures of any contacted air motor parts below freezing and, due to the humidity in the compressed air, causes icing in air valve **20**, first exhaust passage **18**, exhaust nozzle block **41**, air exit stream **34** or other exhaust passages.

Also, the exhaust air **12** exiting from air cylinder **16** exits at extremely high velocity. As the exhaust air **12** and ambient air **28** are mixed in air flow inducer **24**, they form a mixed flow in exit stream **34**. Exit stream **34** has a substantially lower velocity and higher temperature than the air leaving the exhaust nozzle block **41**. The exit stream **34** passes through a silencing passage **36** which is lined with sound deadening or absorbing material such as acoustical foam **38**. This reduced velocity and increased temperature serves to substantially reduce noise at the point **40** where the mixed exhaust air exits without allowing ice to form. The noise is greatly reduced compared to the traditional unmuffled air motor.

By directing passage **36** around substantially the circumference of air cylinder **16**, a compact package is produced. Of course, other packaging configurations (linear, etc.) are well within the scope of this invention.

FIG. **2** shows schematically another embodiment of the instant invention wherein further induced air flow may be obtained by the use of compressed air. A source of compressed air **144*b*** is connected to the primary fluid input of a supplemental air flow inducer **142**. The secondary fluid input of supplemental flow inducer **142** is left open to the ambient air **146**. The exit stream **148** of flow inducer **142** is thence focused via line **148*a*** on those areas requiring additional heat or can be connected to the secondary fluid inlet of main flow inducer **124** which, as in the FIG. **1** embodiment, has its primary fluid inlet connected to the exhaust air **118** of the air motor. In the ambient air induction process, the ambient air warms the critical air motor components. As in FIG. **1**, the mixed air exit stream **136** is directed about the air motor for silencing.

Compressed air source **144** may also be plumbed to power the air motor **10** and a portion **144*a*** of compressed air source **144** may be bled into the main flow inducer **124** to induce further air flow over portions of air motor **10** to produce an additional warming effect.

A cross section of an alternate embodiment of the air-operated reciprocating piston pump air motor is shown in FIG. **3**. In this embodiment, the exhaust and mixing air flow paths are arranged along the axial direction of the air motor. The motor, generally designated **310**, exhausts cold exhaust air **312** from chamber **314** in the air cylinder **316**. Air **312** is exhausted through an exhaust passage (detail not shown) and into air valve **320** (which may be of any conventional design) whereupon the exhaust air is passed to the primary fluid input **322** of main air flow inducer **324** (as set forth above) and exits via the exhaust nozzle block **341**.

The secondary or low velocity fluid input **326** of flow inducer **324** receives relatively warm ambient air **328** which is drawn through the heat exchanger **332**. Heat exchanger **332** is attached in a heat conducting relationship with air cylinder **316**, valve **320** and exhaust nozzle block **341**, so as to extract heat from the ambient air **328** and transfer the heat into the cold exhaust nozzle block **341**, air valve **320** and air cylinder **316**. Exit stream **334** has a substantially lower velocity and higher temperature than the air leaving the exhaust nozzle block **341**. The exit stream **334** passes through a silencing passage **336** which is lined with sound deadening or absorbing material such as acoustical foam **338**.

A cross section of another alternate embodiment of the air-operated reciprocating piston pump air motor is shown in FIG. **4**. In this embodiment, the exhaust and mixing air flow paths are arranged along the radial direction of the air motor. The motor, generally designated **410**, exhausts cold exhaust air **412** from chamber **414** in the air cylinder **416**. Air **412** is exhausted through an exhaust passage (detail not shown) and into air valve **420** (which may be of any conventional design) whereupon the exhaust air is passed to the primary fluid input **422** of main air flow inducer **424** (as set forth above) and exits via the exhaust nozzle block **441**.

The secondary or low velocity fluid input **426** of flow inducer **424** receives relatively warm ambient air **428** which is drawn through the heat exchanger **432**. Heat exchanger **432** is attached in a heat conducting relationship with air cylinder **416**, valve **420** and exhaust nozzle block **441**, so as to extract heat from the ambient air **428** and transfer the heat into the cold exhaust nozzle block **441**, air valve **420** and air cylinder **416**. Exit stream **434** has a substantially lower velocity and higher temperature than the air leaving the exhaust nozzle block **441**. The exit stream **434** passes through a silencing passage **436** which is lined with sound deadening or absorbing material such as acoustical foam **438**.

It is contemplated that various changes and modifications may be made to the air-operated pump without departing from the spirit and scope of the invention as defined by the following claims.

What is claimed is:

1. An air motor comprising:

a valve controlling the flow of air in and out of said air motor;

an exhaust passage connected to said valve; and

areas cooled by cold exhaust air,

the improvement comprising means for inducing the flow of ambient atmospheric air over said cold areas, said flow inducing means being operated by exhaust flow through said exhaust passage and mixing said ambient atmospheric air with said exhaust flow to provide an above freezing mixture.

2. The air motor of claim **1** further comprising means to assist in the transfer of heat from said ambient air.

3. The air motor of claim **2** wherein said heat transfer means comprises fins to assist in heat transfer.

4. The air motor of claim **1** further comprising a muffling passage, said muffling passage being connected to said air flow inducer so as to allow the combined flow of said exhaust and said induced flow to mix, lose velocity and maintain the temperature of said combined flow above freezing.

5. The air motor of claim **4** wherein said muffling passage extends around at least a portion of said air motor.

6. The air motor of claim **5** wherein said air motor is generally cylindrical and said muffling passage extends substantially around the circumference thereof.

7. The air motor of claim **1** further comprising a supplemental air flow inducer comprising:

a primary fluid input connected to a source of pressurized air;

a secondary fluid input drawing ambient air; and

an outlet focused on areas of said air motor requiring additional heat.

8. The air motor of claim **7** wherein said supplemental

air flow inducer outlet is connected to said main air flow inducer secondary fluid inlet

9. The air motor of claim **1** further comprising a source of pressurized air connected to said main flow inducer signal input in addition to said exhaust flow from said exhaust passage.

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