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[54] **CAM DRIVE PUMP REFRIGERATORS**

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[51] **Int. Cl.²** **F25D 9/00**

[58] **Field of Search** 62/401, 403, 498

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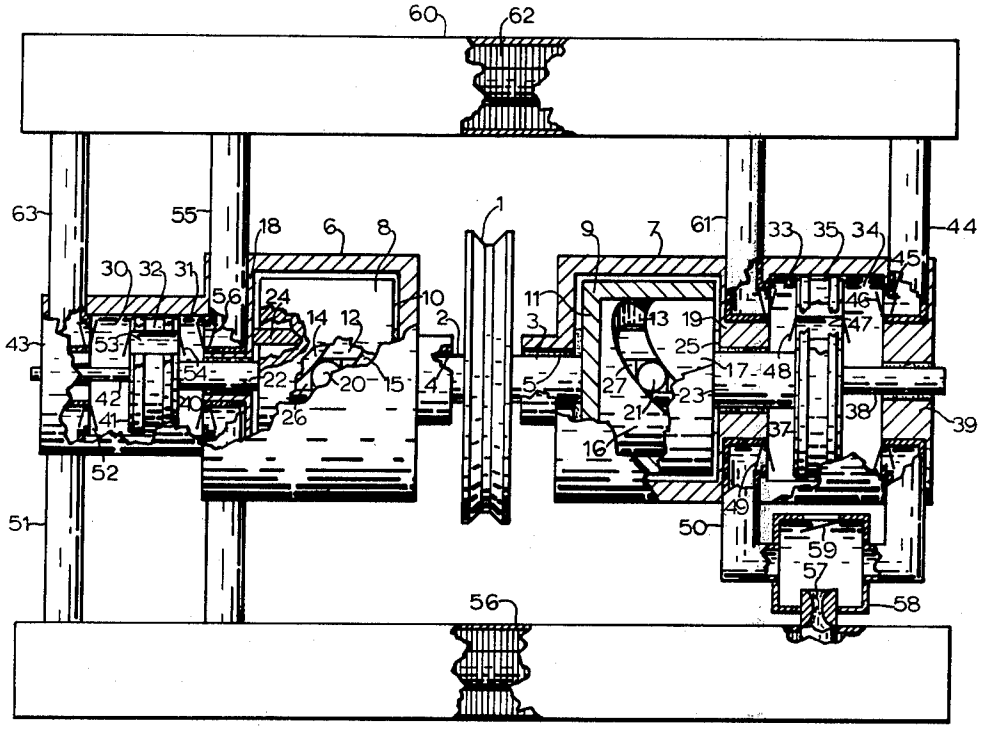
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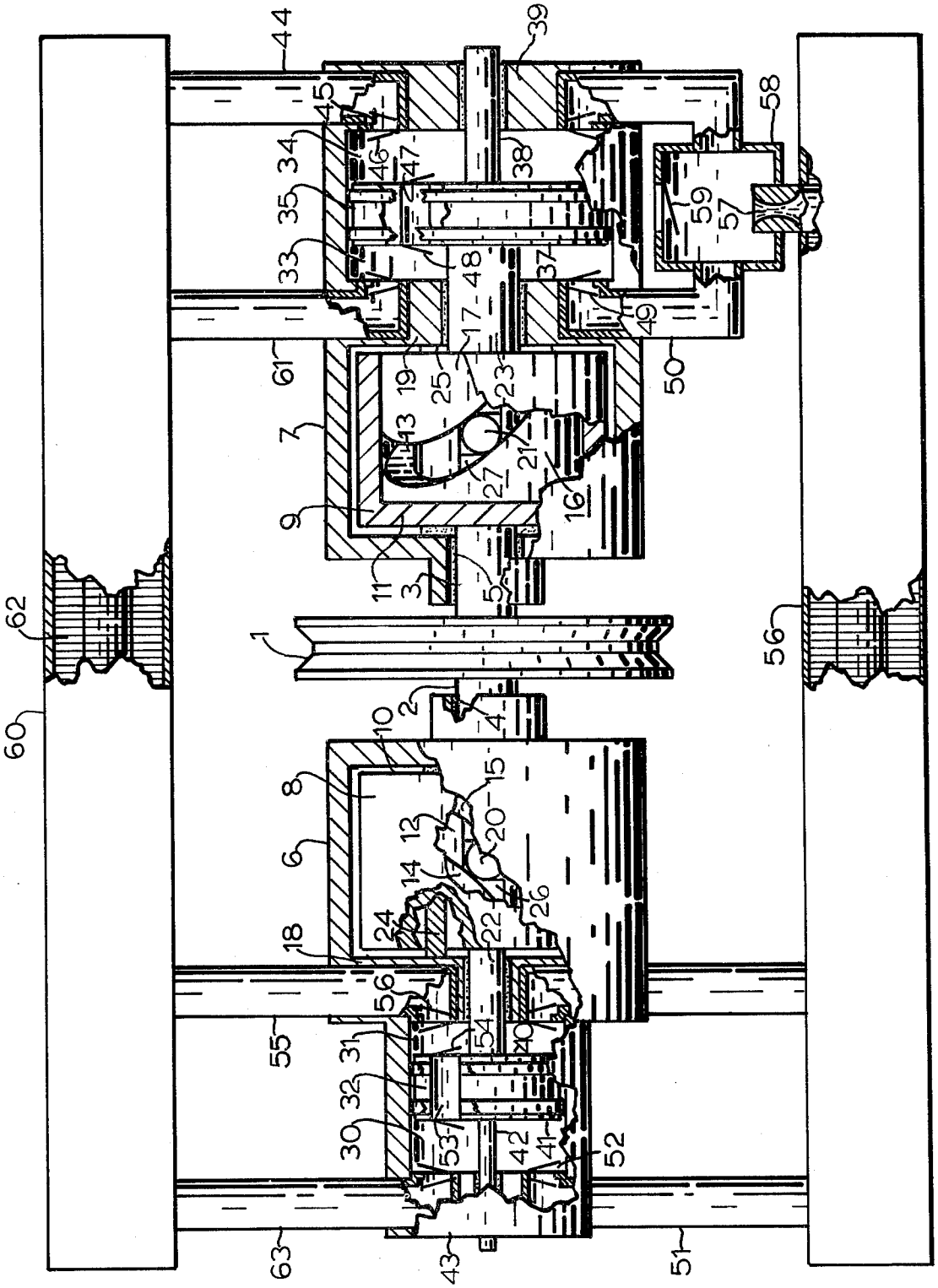
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[57] **ABSTRACT**

This is a counter-bevelled cam drive piston pump with optional multiple stages of compression and vacuum pumping for use in compression pumping, vacuum pumping and open or closed cycle refrigeration.

7 Claims, 1 Drawing Figure




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CAM DRIVE PUMP REFRIGERATORS

Objects of this invention are to provide a plunger-type pump with highly efficient conversion of rotary motion to reciprocating travel.

Another object of this invention is to provide the high efficiency of a multiple-staged plunger-type pump with a highly efficient means of obtaining reciprocating travel from rotary motion in conjunction with the advantageous sealing made possible by a piston-type pump.

Another object of this invention is to provide a multiple-staged pump capable of extremely high use life and low weight.

Another advantage of this invention is to provide a combination compressor pump and vacuum pump with extremely high efficiency, low weight, and long use life for open or closed cycle refrigeration systems.

Most current compressors or vacuum pumps which utilize plunger action require crank-shaft-type conversion of rotary power to reciprocating action. The weight is approximately as much as the engine which drives them. The counter-bevelled cam drive compressor and vacuum pump described in this application can be made to weigh as little as five to ten per cent of this proportionate amount.

High output per weight of pumps usually requires the use of turbine blades, impellers, or some form of rotary vaned or rotary piston pump. These rotary pumps sacrifice sealing efficiency or actual compression efficiency to obtain efficient rotary motion.

This device, however, provides high output per weight in conjunction with high efficiency for the means of both compression and utilizing rotary motion.

This invention is illustrated in the accompanying drawing.

The operation of these improvements in pump and refrigeration systems is described in the following manner. Rotational power is provided through a rotational power source **1.** This power source is illustrated as a belt-driven wheel but could be any other power conveyance source or prime mover, including a centrally positioned prime mover or electric motor with a power output shaft at both ends.

A left drive shaft **2,** and a right drive shaft **3** are attached at opposite sides of the power source and extended in rotational contact through left and right bearings **4** and **5** in left and right housings **6** and **7** respectively at opposite sides of the power source.

The drive shafts are attached to left and right drive shaft sleeves **8** and **9** by means of left and right plates **10** and **11.**

Left and right counter-bevelled grooves **12** and **13** are formed around the inside periphery of left and right sleeves **8** and **9** by two pairs of two identical counter-bevelled end cams **14, 15, 16,** and **17** in the sleeves.

The end cams are separated to form the counter-bevelled cam drive grooves **12** and **13** between them.

Left and right drive teeth **20** and **21** are extended radially into the groove from left and right shafts **22** and **23.** Transverse guides **24** and **25** are rigidly attached to the housing at baseplates **18** and **19** and are provided with channels **26** and **27** in which the radially extended drive teeth are caused to reciprocate when the power source and drive sleeve are rotated.

The reciprocating shafts are extended in slidable contact through the baseplates **18** and **19** into compressor cylinders **30** and **31** at opposite sides of compressor

piston **32** and similarly into cylinders **33** and **34** at opposite sides of compressor piston **35.**

Various modes of operation can be achieved by varying the sizes and proportions of the components and by varying the fluid circuitry with appropriate valves and conveyance means within the system. One such mode is a four-staged compressor.

A four-staged compressor is achieved by first constructing one side **36** of one piston **35** with a larger surface area than the other side **37.** This difference in size can be obtained by using a larger shaft **23** on one side than the shaft **38** on the other side. Alternatively, the shaft **38** can be omitted along with the slidable contact with the outside head **39** of cylinder **34.**

Cylinders **30** and **31** are then constructed smaller in diameter than cylinders **33** and **34.** Piston **32** is constructed proportionately smaller and side **40** is made smaller than side **41** by having shaft **22** made smaller in diameter than shaft **42** or by omitting shaft **42** and its slidable contact through cylinder head **43.**

Four-stage compressor mode utilizes inward travel of piston **35** to draw air or other fluid into cylinder **34** through conveyance **44** at port **45** while valve **46** is open. The fluid is directed through conveyance **47** into smaller cylinder **33** when valve **48** is open. The return travel of piston **35** further compresses the fluid past open valve **49** into conveyance **50** and then into conveyance **51** where it is directed into still smaller cylinder **30** past valve **52** when piston **32** is caused to travel inwardly for a third stage of compression. A fourth stage of compression is achieved at side **40** of piston **32.** Fluid is directed from cylinder **30** through conveyance **53** and past valve **54** into cylinder **31.** There it is compressed into a final stage by the return travel of piston **32** and directed out through conveyance **55** past valve **56** when it is open.

The variation of the piston surface areas, with their respective cylinders, can be much greater than is illustrated for obtaining extremely high compression ratios. The use of multiple stages to achieve high compression has the advantage of increased sealing capacity in addition to higher pressure per surface area of plunger piston.

A two-stage compressor is achieved by terminating the above process at conveyance **51** after utilizing only piston **35** in cylinders **33** and **34.**

An equal or unequal stage capacity of the double-stage compressor can be provided at each side of the power source **1** by terminating each stage at second outlets **55** and **50** respectively.

The device can be single-staged by making both sides of the pistons with equal surface areas through use of the same diameter shafts at either side of the piston.

A vacuum pump can be provided by utilizing the inlet conveyance means to the cylinders as the vacuum pump lead line.

A particularly useful mode of operation for this device is that of a refrigeration system. It can be made to utilize both the compression and the vacuum aspects of the device simultaneously, or either separately.

Employing compression and vacuum modes in a single refrigeration system makes possible the use of working media gasses that are more plentiful but are not as compressible and expandable as freon or other refrigerants in common use. Air, in particular, can be used in either closed or open cycle refrigeration with high efficiency and low cost with this device.

Refrigeration mode, with compression and vacuum pumping employed in combination, employs a heat exchanger **56** in fluid communication between the left and right cylinders or pairs of cylinders. Air or other fluid coolant media is compressed into the heat exchanger where heat of compression in the fluid is transferred outside the system. The coolant media is then vacuum-pumped out of the heat exchanger by the opposite pump from the one which was employed to compress it.

The direction of coolant flow from left to right in the illustration demonstrates the practice of using a larger piston for the vacuum pump than for the compressor pump. The size ratio is highly exaggerated, however, just to make use of the same illustration for the refrigerator mode of operation as for the four-stage compressor mode.

The valves can be reversed for the reverse flow of fluid. Thus, there is illustrated a schematic one-way valve at the opposite side of each port from that called out for the four-stage compressor. These valves can be simple one-way compressor valves as common to the compressor art.

A heat exchange exit restriction **57** is used to retain pressure within the heat exchanger at a sufficiently high pressure ratio and to allow for high expansion ratio in the cylinder. The restriction means can be a pressure valve or an appropriately sized venturi as illustrated, depending on the application requirements.

A collector box **58** can be employed to provide constant pressure to the vacuum cylinders to compensate for fluctuation of vacuum pressure from the piston system.

An inlet safety valve **59** is provided to allow air, if it is used as the coolant, to be drawn into the vacuum pump prior to possible excessive build-up of pressure in the heat exchanger.

The collector box can be used as a first-stage cooler for some applications of the device. It can serve as a freezer unit while a main cooler **60** can be employed in cooling relationship to objects or areas being cooled.

A closed loop refrigeration system is provided by directing the expanded coolant from the vacuum pump through conveyances **44** and **61** into a radiation tube or tubes **62** in the cooler. The coolant is then recirculated back through the compressor portion of the device, illustrated at the left side, through conveyances **55** and **63.**

An open cycle is provided when the conveyances **44,** 61, 55, and **63** are not connected in fluid conveyance communication through conveyance **62,** nor cooler between them. Instead, conveyances **44** and **61** are extended directly into the area being cooled. Conveyances **55** and **63,** the compressor inlets would be extended into the same area if recirculation from the cooled area is desired in open refrigeration cycle. The compressor inlets can also be constructed to obtain part or all of the coolant from inside or outside of the cooled area.

Other variations of this device include construction with all piston surfaces substantially the same area. All four pistons can then be used for one compressor or for one vacuum pump or a combination of two compressors and two vacuum pumps with or without a heat exchange unit, and with or without a cooling unit between them.

Another variation is a single phase pump utilizing just one side of the device illustrated. A coolant can be pumped from one side of a piston to the other through outside tubes for refrigeration cycle in this mode. A cooler could be used for closed cycle or an open cycle could be employed in the same working relationship as described above for the staged compressor and vacuum pump system. This is shown at the right side of the illustration by utilizing piston **35** as both a compressor and a vacuum pump. The valves and channels through the piston would be removed. The heat exchanger **56** would be in the place of the collector box **58.** The cooler **60** would be positioned between conveyances **44** and **61** if a closed cycle were used. Valves at ports, restrictions and safety valves would be used as described above and in present art pump and refrigeration practices.

Another variation of the device is to construct the shaft sleeves **8** and **9** as one sleeve and attach the power source **1** to the outside of the sleeve. This eliminates the bearing flange section of the housing. The transverse guides **24** and **25** are then combined as one unit.

For greatest balance, reliability and efficiency in utilizing the counter-bevelled cam drive as described above, it has been found best to utilize three or more drive teeth and to have the drive angle of the end cams over sixty degrees from the shaft axis.

What is claimed is:

1. A multiple-staged cam drive pump refrigerator having a housing, a rotational power source, a drive shaft attached to the rotational power source and in rotational contact with the housing, a sleeve attached to the drive shaft, a counterbevelled cam drive groove in separated end cam relationship around the inside periphery of the sleeve, a transverse guide having channels parallel to the drive shaft and rigidly attached to the housing, a double-ended pump cylinder rigidly attached to the housing, a double-ended pump piston in slidable contact with the inside of the cylinder, a piston shaft attached to one side of the piston and extended in slidable contact through the cylinder head at one end of the double-acting cylinder, cam follower teeth extended radially from the shaft in slidable contact with the surfaces of the transverse guide and with the surfaces of the counter-bevelled cam drive, a connecting fluid conveyance in communication between the portion of the cylinder at one head of the piston and the portion of the cylinder at the opposite head of the piston, a fluid conveyance in communication between the inside and the outside of each end of the cylinder, pump valves that are caused to be open when the piston is traveling away from and closed when it is traveling towards the cylinder heat at the conveyance between the inside and the outside of the cylinder at intake end of the cylinder, pump outlet valves that are caused to be closed when the piston is traveling away from and open when it is traveling towards the cylinder head at the conveyance between the inside and the outside of the cylinder at the outlet end of the cylinder, connecting conveyance pump valves that are caused to be closed when the piston is traveling away from and open when it is traveling towards the cylinder head at the intake end of the cylinder, connecting conveyance pump valves that are caused to be open when the piston is traveling away from and closed when it is traveling towards the cylinder heat at the outlet end of the cylinder, and a heat exchanger at the connecting fluid con-

veyance between the intake and outlet ends of the cylinder.

2. A multiple-staged cam drive pump refrigerator as described in claim 1 and having a heat exchanger at the connecting conveyance means between the intake and outlet ends of the cylinder, and a cooler in fluid communication between the intake and outlet ends of the cylinder.

3. A multiple-staged cam drive pump refrigerator as described in claim 1 and having a heat exchanger at the connecting fluid conveyance means between the intake and outlet ends of the cylinder, and a fluid-flow restriction at the outlet end of the heat exchanger upstream of the fluid conveyance into the outlet end of the cylinder.

4. A multiple-staged cam drive pump refrigerator as described in claim 1 and having a heat exchanger at the connecting fluid conveyance between the intake and outlet ends of the cylinder, a fluid restriction at the outlet end of the heat exchanger upstream of entry of the fluid into the outlet end of the cylinder, a collector box in fluid communication between the restriction and the entry of the fluid into the outlet end of the cylinder.

5. A multiple-staged cam drive pump refrigerator having a rotational power source, a housing at each side of the power source, a drive shaft sleeve at each side of the power source in rotatable contact with the respective housings, counter-bevelled cam drive grooves in separated end cam relationship around the inside periphery of each sleeve, transverse guides having channels parallel to the drive shaft and rigidly attached to each of the housings, a double-ended pump cylinder rigidly attached to each housing, double-ended pump pistons in slidable contact with the inside of each cylinder, conveyances in fluid communication between the cylinder at one side of the power source and the cylinder at the other side of the power source, a conveyance in fluid communication into the cylinder at one side of the power source, a conveyance in fluid communication out of the cylinder at the opposite side of the power source, ports with pump valves in one-way working relationship into and out of the cylinder at one side of the power source upstream of entry into the conveyance between said cylinders at opposite sides of said power source, ports with pump valves in one-way working relationship into and out of the cylinder at the opposite side of said power source downstream from the said conveyance between the said cylinders at opposite sides of said power source, conveyances between the portions of the cylinders at the opposite sides of the pistons in each respective cylinder, ports thereat with pump valves in one-way working relationship into and out of the said opposite ends of the said cylinders, and a heat exchanger at the conveyance between the cylinders that are positioned at opposite sides of the power source.

6. A multiple-staged cam drive pump refrigerator as described in claim 5 and having a heat exchanger at the conveyance between the cylinders that are positioned at opposite sides of the power source, and a cooler in fluid communication between the opposite inlet and outlet conveyances to those which are in fluid communication with the heat exchanger between said cylinders.

7. A multiple-staged pump refrigerator as described in claim 5 and having a heat exchanger at the conveyance between the cylinders that are positioned at opposite sides of the power source, a coller in fluid communication between the opposite inlet and outlet conveyances to those which are in fluid communication with the heat exchanger between said cylinders, and a fluid flow restrictor at the outlet end of the heat exchanger.

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