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(54) **LUBRICATION PASSAGE AND NOZZLE FOR SWASH PLATE TYPE COMPRESSOR**

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(52) **U.S. Cl.** **417/269**; 417/222.2; 92/153
(58) **Field of Search** 417/269, 270, 417/271, 222.2; 92/153, 156; 184/6.17

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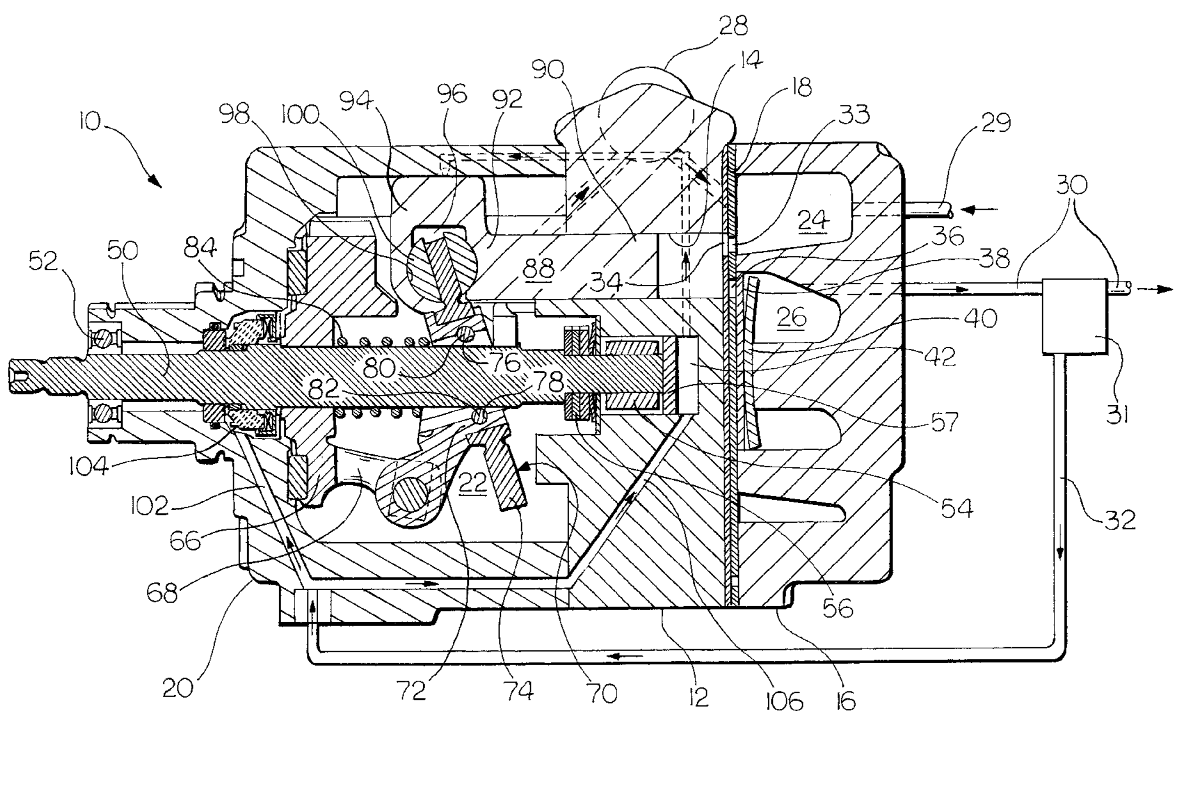
(57) **ABSTRACT**

A variable displacement swash plate type compressor which incorporates a lubrication passage formed in a cylinder block and crankcase, and a spray nozzle disposed at the crankcase end of the lubrication passage. The lubrication passage provides fluid communication between an oil sump and the spray nozzle, and the spray nozzle causes lubricating oil to be efficiently distributed as a fine mist or spray to the crank chamber. The lubrication passage and spray nozzle maximize the flow of refrigerant gas and lubricating oil to the crank chamber under all operating conditions providing cooling and lubrication to the internal moving components within the crankcase.

8 Claims, 2 Drawing Sheets



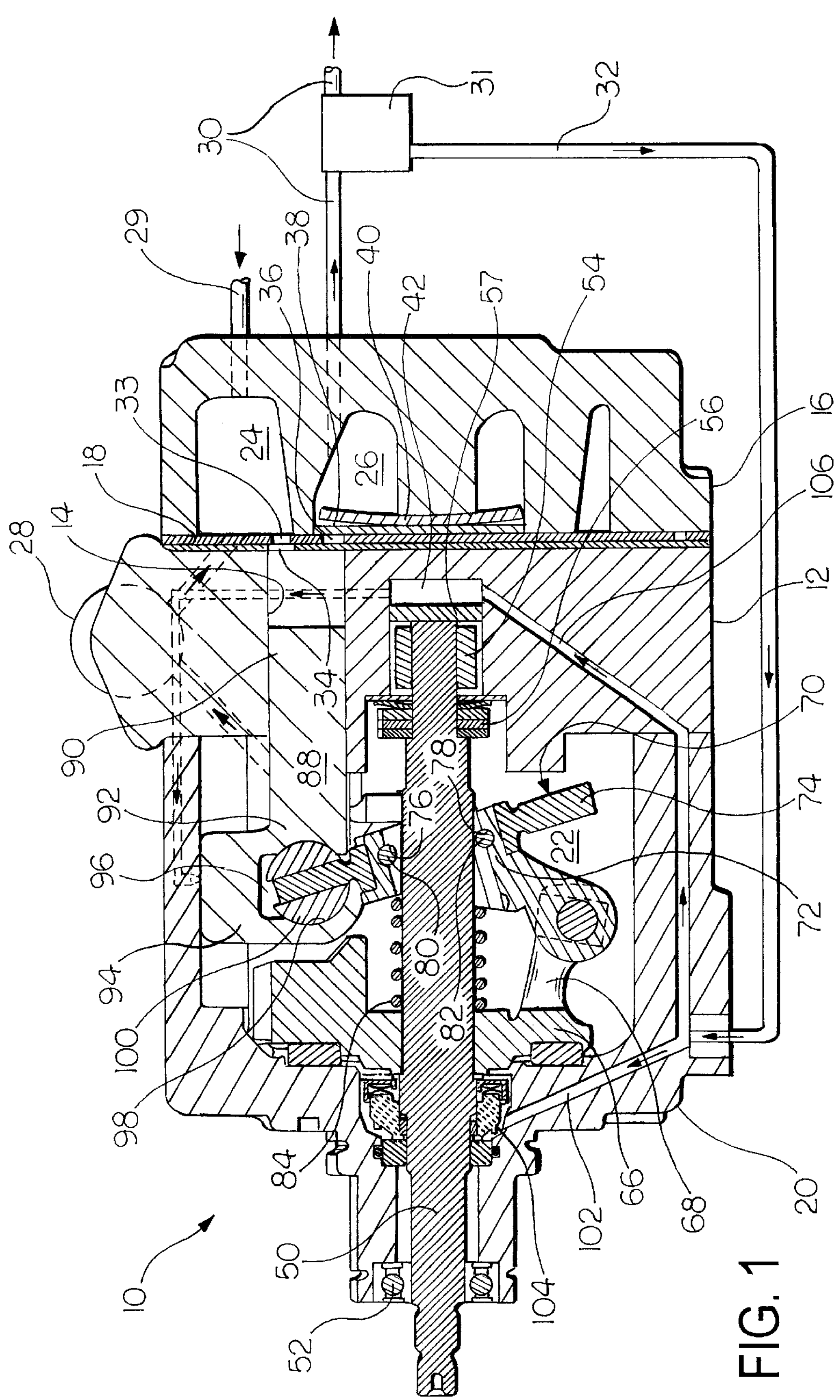

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FIG. 1

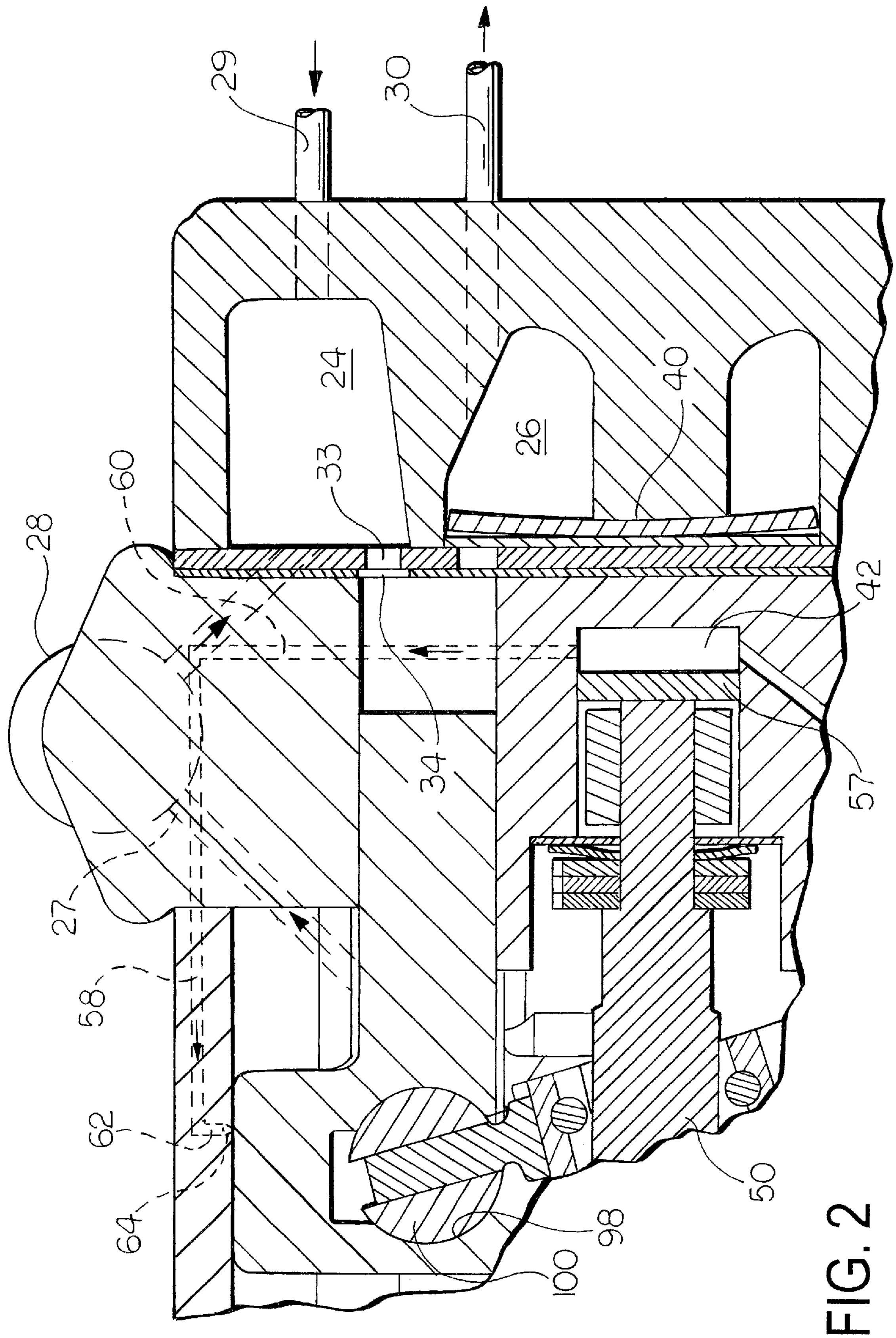

FIG. 2

LUBRICATION PASSAGE AND NOZZLE FOR SWASH PLATE TYPE COMPRESSOR

FIELD OF THE INVENTION

The present invention relates to a variable displacement swash plate type compressor adapted for use in an air conditioning system for a vehicle, and more particularly to a compressor having a passage providing fluid communication between an oil sump and a crank chamber, and a spray nozzle disposed at the crank chamber end of the passage for efficiently distributing a fine mist or spray of lubricating oil to the crank chamber.

BACKGROUND OF THE INVENTION

A typical conventional variable displacement swash plate type compressor includes a cylinder block provided with a number of cylinders, a piston disposed in each of the cylinders of the cylinder block, a crankcase sealingly disposed on one end of the cylinder block, a cylinder head sealingly disposed on the other end of the cylinder block, a rotatably supported drive shaft, and a swash plate. The swash plate is adapted to be rotated by the drive shaft. Rotation of the swash plate is effective to reciprocatively drive the pistons. The length of the stroke of the pistons is varied by the inclination of the swash plate. Inclination of the swash plate is varied by controlling the pressure differential between a suction chamber and a crank chamber. Lubrication of components within the crankcase is typically provided by circulating refrigerant gas mixed with lubricating oil within the internal refrigerant circuit of the compressor. Typical conventional variable displacement swash plate type compressors may also use carbon dioxide ($CO2$) as the refrigerant gas.

Another conventional lubricating system disclosed in the prior art employs lubricating oil passageways separately arranged from the refrigeration circuits. The separately arranged oil passageways avoid reduction in the refrigerating efficiency of a refrigeration circuit in a vehicle caused by an attachment of the lubricating oil to an evaporator of an air conditioning system. For example, lubricating oil may be pumped by a gear pump through a lubrication passage and radial branch passageways within the drive shaft to lubricate the moving components within the crank chamber.

The compressor arrangements in the prior art described above in which $CO2$ is used as the refrigerant gas have several disadvantages. First, because conventional lubricating oil is not soluble in $CO2$, the lubricating oil cannot be effectively distributed with the $CO2$ as the $CO2$ is circulated within the internal refrigeration circuit, resulting in ineffective lubrication of the close tolerance moving parts within the crank chamber. Second, in a compressor having separately arranged lubrication passages, the lubricating oil is subjected to a gradual pressure drop while flowing inside the lubrication passages. The volume of the oil flowing out of the branch passageways furthest from the gear pump is caused to become less than the volume of oil flowing out of the branch passageways nearest the gear pump. In such an arrangement lubricating oil is not efficiently and effectively distributed within the crank chamber.

An object of the present invention is to produce a swash plate type compressor wherein oil flow to the crankcase during both minimum and maximum operating conditions is improved to result in efficient lubrication of the compressor components.

Another object of the present invention is to produce a swash plate type compressor wherein lubricating oil can be efficiently and evenly distributed within the crank chamber.

SUMMARY OF THE INVENTION

The above, as well as other objects of the invention, may be readily achieved by a variable displacement swash plate type compressor comprising: a cylinder block having a plurality of cylinders arranged radially therein; an oil sump for containing lubricating oil; a piston reciprocatively disposed in each of the cylinders of the cylinder block; a cylinder head attached to the cylinder block; a crankcase attached to the cylinder block to define a crank chamber; a drive shaft rotatably supported by the crankcase and the cylinder block; a swash plate adapted to be driven by the drive shaft, the swash plate having a central aperture for receiving the drive shaft; a pump for distributing the lubricating oil from the oil sump to the crank chamber; a lubrication passage providing fluid communication between the oil sump and the crank chamber; and a spray nozzle disposed at the crank chamber end of the lubrication passage for facilitating distribution of lubricating oil to the crank chamber.

BRIEF DESCRIPTION OF THE DRAWINGS

The above, as well as other objects, features, and advantages of the present invention will be understood from the following detailed description of the preferred embodiment of the present invention with reference to the accompanying drawings, in which:

FIG. **1** is a cross sectional elevational view of a variable displacement swash plate type compressor incorporating the features of the invention, showing a lubrication passage in the cylinder block and the crankcase in fluid communication with the oil sump and the crank chamber, and a spray nozzle disposed at the crank chamber end of the lubrication passage; and

FIG. **2** is a fragmentary enlarged cross sectional view of the compressor illustrated in FIG. **1**, a phantom line showing the features of the lubrication passage and nozzle of the invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring now to the drawings, and particularly FIG. **1**, there is shown generally at **10** a variable displacement swash plate type compressor incorporating the features of the invention. The compressor **10** includes a cylinder block **12** having a plurality of cylinders **14**. A cylinder head **16** is disposed adjacent one end of the cylinder block **12** and sealingly closes the end of the cylinder block **12**. A valve plate **18** is disposed between the cylinder block **12** and the cylinder head **16**. A crankcase **20** is sealingly disposed at the other end of the cylinder block **12**. The crankcase **20** and cylinder block **12** cooperate to form an airtight crank chamber **22**.

The cylinder head **16** includes a suction chamber **24** and a discharge chamber **26**. A conduit **27** is disposed to provide fluid communication between the crank chamber **22** and the suction chamber **24**. An electronic control valve **28** is disposed in the conduit **27** for controlling the flow of refrigerant gas from the crank chamber **22** to the suction chamber **24**. The valve **28** can be of any conventional type such as, for example, a ball type valve. The valve **28** is designed to receive an electrical control signal from a remote microprocessor (not shown). The microprocessor monitors the discharge pressure of the compressor, the RPM of the vehicle engine, the cabin temperature and humidity, and the like, to control valve **28** which, in turn, controls the flow of refrigerant gas from the crank chamber **22** to the suction chamber **24**. An inlet port **29** provides fluid communication between an evaporator (not shown) of the cooling portion of an air conditioning system for a vehicle and the suction chamber **24**. An outlet conduit **30** provides fluid communication between the discharge chamber **26** and the cooling portion of the air conditioning system for a vehicle. An oil separator **31** is disposed in the conduit **30**. An orifice tube **32** provides fluid communication between the oil separator **31** and the crank chamber **22**.

Suction ports **33** provide fluid communication between the suction chamber **24** and each cylinder **14**. Each suction port **33** is opened and closed by a flap valve **34** which may be formed as an integral part of the valve plate **18**. Discharge ports **36** provide fluid communication between each cylinder **14** and the discharge chamber **26**. Each discharge port **36** is opened and closed by a discharge valve **38**. A retainer **40** restricts the opening of the discharge valve **38**. An oil sump **42** is formed in the cylinder block **12**.

A drive shaft **50** is centrally disposed in and arranged to extend through the crankcase **20** to the cylinder block **12**. One end of the drive shaft **50** is rotatably supported by a bearing **52** mounted in the crankcase **20**, and the other end of the drive shaft **50** is rotatably supported in a bearing **54** mounted in the cylinder block **12**. Longitudinal movement of the drive shaft **50** is restricted by a thrust bearing **56** mounted in the cylinder block **12**. A drive shaft driven gear pump **57** is disposed within the oil sump **42**.

Referring now to FIG. **2**, a longitudinally extending lubrication passage or bore **58** is formed within the cylinder block **12** and the crankcase **20**. The bore **58** communicates with radially extending bores **60**, **62**. Bore **62** includes a spray nozzle **64** having an orifice opening into the crank chamber **22**. The lubrication passage **58** and the bores **60**, **62** provide fluid communication between the oil sump **42** and the nozzle **64**. The nozzle **64** is arranged to evenly distribute lubricating oil to the crank chamber **22**. The nozzle **64** can be of any conventional type such as, for example, a nozzle in which the orifice has a smaller diameter than the diameter of the bore **62**, and in which an internal vane causes controlled turbulence of the oil within the nozzle **64**. Such a nozzle structure thereby causes the oil to be discharged through the orifice in a fine mist or spray.

A rotor **66** is fixedly mounted on an outer surface of the drive shaft **50** adjacent one end of the crankcase **20** within the crank chamber **22**. An arm **68** extends outwardly from a surface of the rotor **66** opposite the surface of the rotor **66** that is adjacent the end of the crankcase **20**.

A swash plate **70** is formed to include a hub **72** and an annular plate **74**. The arm **68** is hingedly connected to the hub **72**.

A pair of spaced apart holes **76**, **78** are formed in the hub **72** and are adapted to receive pins **80**, **82**, respectively which are typically press fit therein. The outer surfaces of the pins **80**, **82** are formed to extend inwardly within the hub **72**.

The hub **72** is press fit in a suitable central aperture of the annular plate **74**. In the assembled form the drive shaft **50** is adapted to extend through the central aperture of the hub **72**.

A helical compression spring **84** is disposed to extend around the outer surface of the drive shaft **50**. One end of the spring **84** abuts the rotor **66**, while the opposite end abuts the hub **72** of the swash plate **70**. The spring **84** tends to urge the swash plate **70** away from the rotor **66**.

A piston **88** is slidably disposed in each of the cylinders **14** in the cylinder block **12**. Each piston **88** includes a head **90**, a middle portion **92**, and a bridge portion **94**. The middle portion **92** terminates in the bridge portion **94** defining an interior space **96** for receiving the annular plate **74**. Spaced apart concave pockets **98** are formed in the interior space **96** of the bridge portion **94** for rotatably containing a pair of semi-spherical shoes **100**. The spherical surfaces of the shoes **100** are disposed in the shoe pockets **98** with a flat bearing surface disposed opposite the spherical surface for slidable engagement with the opposing sides of the annular plate **74**.

In operation, the compressor **10** is actuated by the rotation of the drive shaft **50** which is typically an associated internal combustion engine of a vehicle. Rotation of the drive shaft **50** causes the simultaneous rotation of the rotor **66**. The hub **72** of the swash plate **70** is hingedly connected to the arm **68** of the rotor **66**. Rotation of the rotor **66** causes the swash plate **70** to rotate. During rotation, the swash plate **70** is disposed at an inclination. The rotation of the swash plate **70** is effective to reciprocatively drive the pistons **88**. The rotation of the swash plate **70** further causes a sliding engagement between the annular plate **74** and the cooperating spaced apart shoes **100**.

The reciprocation of the pistons **88** causes refrigerant gas to be introduced from the suction chamber **24** into the respective cylinders **14** of the cylinder head **16**. The reciprocating motion of the pistons **88** then compresses the refrigerant gas within each cylinder **14**. When the pressure within each cylinder **14** reaches the pressure within the discharge chamber **26**, the compressed refrigerant gas is discharged into the discharge chamber **26**.

The capacity of the compressor **10** can be changed by changing the inclination of the swash plate **70** and thereby changing the length of the stroke for the pistons **88**.

The valve **28** is arranged to monitor the suction and crank chamber pressures of the compressor **10**, and control the flow of refrigerant gas from the crank chamber **22** to the suction chamber **24**. When an increase in thermal load occurs, the valve **28** is caused to open, thereby causing refrigerant gas to flow through the valve **28** to the suction chamber **24**. The pressure differential between the crank chamber **22** and the suction chamber **24** is then equalized. As a result of the decreased backpressure acting on the pistons **88** in the crank chamber **22**, the swash plate **70** is moved against the force of the spring **84**, the inclination of the swash plate **70** is increased, and as a result, the length of the stroke of each piston **88** is increased.

Conversely, when a decrease in thermal load occurs, the valve **28** is caused to close, thereby reducing the flow of refrigerant gas from the crank chamber **22** to the suction chamber **24**. Because the flow of pressurized refrigerant gas to the crank chamber **22** from the discharge **26** is larger than the flow of refrigerant gas from the crank chamber **22** to the suction chamber **24**, the backpressure acting on the pistons **88** in the crank chamber **22** is increased. As a result of the increased backpressure in the crank chamber **22**, the swash plate **70** yields to the force of the spring **84**, the inclination of the swash plate **70** is decreased, and as a result, the length of the stroke of each piston **88** is reduced.

Lubricating oil is introduced into the orifice tube **32** from the oil separator **31**, and caused to flow through a passage **102** to a shaft seal **104**, and through a passage **106** to the oil sump **42**. Rotation of the drive shaft **50** causes the pump **57** to pump lubricating oil from the oil sump **42** into the passage **58**. The pressurized lubricating oil within the passage **58** is caused to flow through the nozzle **64**. The internal vane within the nozzle **64** causes controlled turbulence of the oil within the nozzle, thereby causing the oil to be evenly discharged into the crank chamber **22** in the form of a fine mist or spray.

By introducing lubricating oil from the oil sump **42** into the crank chamber **22** through the lubrication passage **58** and the nozzle **64** the lubricating efficiency of the compressor **10** is maximized. In the preferred embodiment of the invention, the flow of lubricating oil between the oil sump **42** and the crank chamber **22**, through the lubrication passage **58** and nozzle **64** is provided during both minimum and maximum operating conditions of the compressor **10** by the drive shaft driven pump **57**. The use of the nozzle **64** at the crank chamber **22** end of the passage **58** facilitates efficient and even distribution of lubricating oil into the crank chamber **22**. The lubricating oil introduced into the crank chamber **22** through the passage **58** and the nozzle **64** provides lubrication to the close tolerance moving components within the crank chamber **22** such as bearings **56**, the swash plate **70**, the shoe pockets **98**, and the shoes **100**. The introduction of lubricating oil to the crank chamber **22** improves the durability of the compressor **10**.

From the foregoing description, one ordinarily skilled in the art can easily ascertain the essential characteristics of this invention and, without departing from the spirit and scope thereof, can make various changes and modifications to the invention to adapt it to various usages and conditions.

What is claimed is:

1. A variable displacement swash plate type compressor comprising:

a cylinder block having a plurality of cylinders arranged radially therein;

an oil sump for containing lubricating oil;

a piston reciprocatively disposed in each of the cylinders of said cylinder block;

a cylinder head attached to said cylinder block, said cylinder head having an inlet and an outlet;

a crankcase attached to said cylinder block to define a crank chamber;

a drive shaft rotatably supported by said crankcase and said cylinder block;

a rotor fixedly mounted on said drive shaft;

a swash plate adapted to be driven by said rotor, said swash plate having a central aperture for receiving said drive shaft;

a hinge means disposed between said rotor and said swash plate to hingedly connect said rotor and said swash plate;

a pump for distributing the lubricating oil from said oil sump to the crank chamber;

a lubrication passage providing fluid communication between said oil sump and the crank chamber; and

a spray nozzle disposed at the crank chamber end of said lubrication passage for facilitating distribution of lubricating oil to the crank chamber.

2. The compressor according to claim **1**, wherein said oil sump is formed in said cylinder block.

3. The compressor according to claim **2**, wherein said pump is a gear pump driven by said drive shaft.

4. The compressor according to claim **3**, wherein said lubrication passage is formed within said cylinder block and said crankcase.

5. Lubrication means for a variable displacement swash plate type compressor, the compressor having a cylinder head, a cylinder block having an oil sump formed therein, a crankcase forming a crank chamber therein, an inlet and an outlet, and a plurality of pistons:

an oil separator adapted to be installed in the outlet of the compressor, said separator removing a lubricating oil from a refrigerant and supplying the oil to the oil sump;

a lubrication passage providing fluid communication between the oil sump and the crank chamber, said lubrication passage formed within the cylinder block and the crankcase; and

a spray nozzle disposed at the crank chamber end of said lubrication passage for facilitating distribution of the lubricating oil to the crank chamber.

6. A variable displacement swash plate type compressor comprising:

a cylinder block having a plurality of cylinders arranged radially therein;

an oil sump for containing lubricating oil formed within said cylinder block;

a piston reciprocatively disposed in each of the cylinders of said cylinder block;

a cylinder head attached to said cylinder block and having a suction chamber and a discharge chamber formed therein;

a crankcase attached to said cylinder block and cooperating with said cylinder block to define a crank chamber;

a drive shaft rotatably supported by said crankcase and said cylinder block and adapted to be coupled to an auxiliary drive means;

a rotor fixedly mounted on said drive shaft;

a swash plate adapted to be driven by said drive shaft and having a central aperture for receiving said drive shaft, radially outwardly extending side walls, and a peripheral edge;

a gear pump for distributing the lubricating oil from said oil sump to the crank chamber, said gear pump driven by said drive shaft;

hinge means disposed between said rotor and said swash plate to hingedly connect said rotor and said swash plate;

a lubrication passage formed within said cylinder block and said crankcase providing fluid communication between said oil sump and the crank chamber; and

a spray nozzle disposed at the crank chamber end of said lubrication passage for facilitating distribution of lubricating oil to the crank chamber.

7. The compressor according to claim **1**, including an oil separator disposed in the outlet of said cylinder head, the separator removing the lubricating oil from a refrigerant and supplying the lubricating oil to said oil sump.

8. The compressor according to claim **7**, wherein the refrigerant is CO_2.

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