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

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(52) **U.S. Cl.** **417/222.1**; 417/269; 184/6.17

(58) **Field of Search** 417/222.1, 269; 184/6.17

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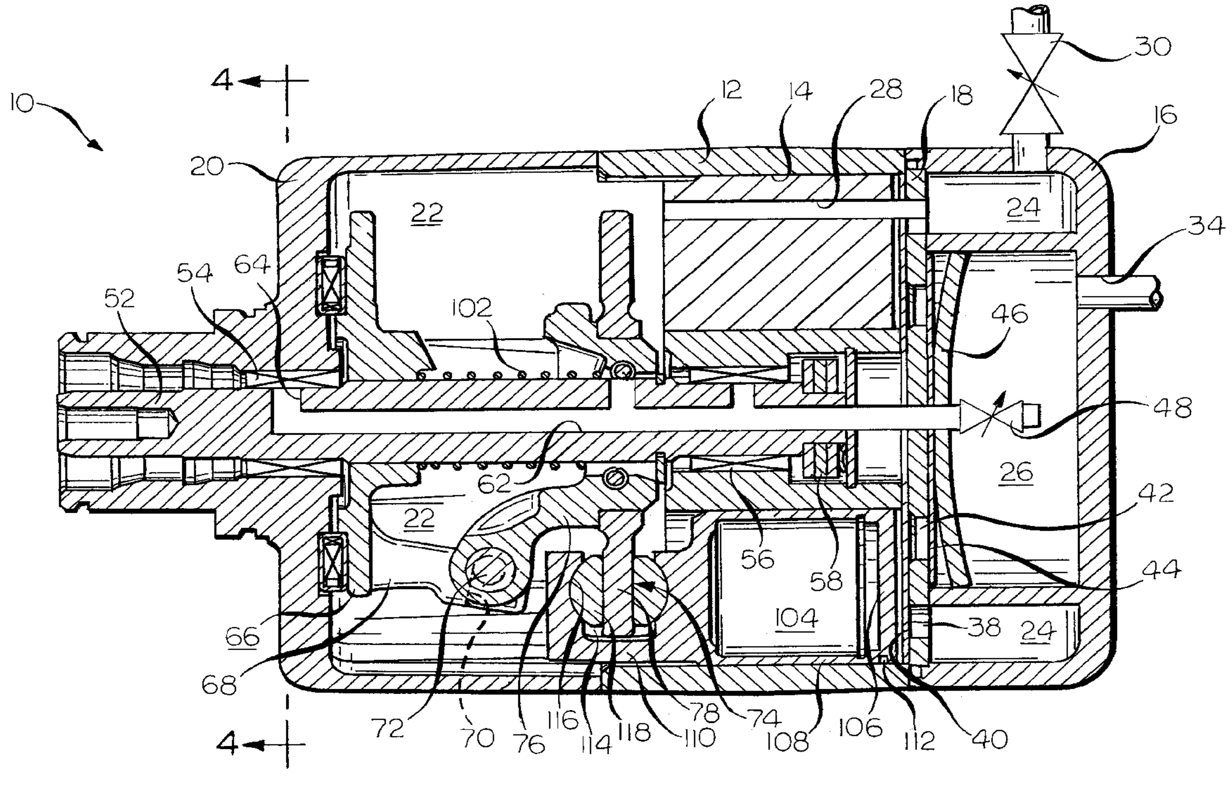
(57) **ABSTRACT**

A variable displacement swash plate type compressor which incorporates a lubrication passage formed in the drive shaft, wherein the lubrication passage provides fluid communication between a discharge chamber and a crank chamber. The lubrication passage maximizes the low of refrigerant gas and lubricating oil to the crank chamber under all operating conditions providing cooling and lubrication to the internal moving components in the crank chamber. The lubrication passage facilitates the efficient flow of lubricating oil from the discharge chamber to the crank chamber.

4 Claims, 5 Drawing Sheets



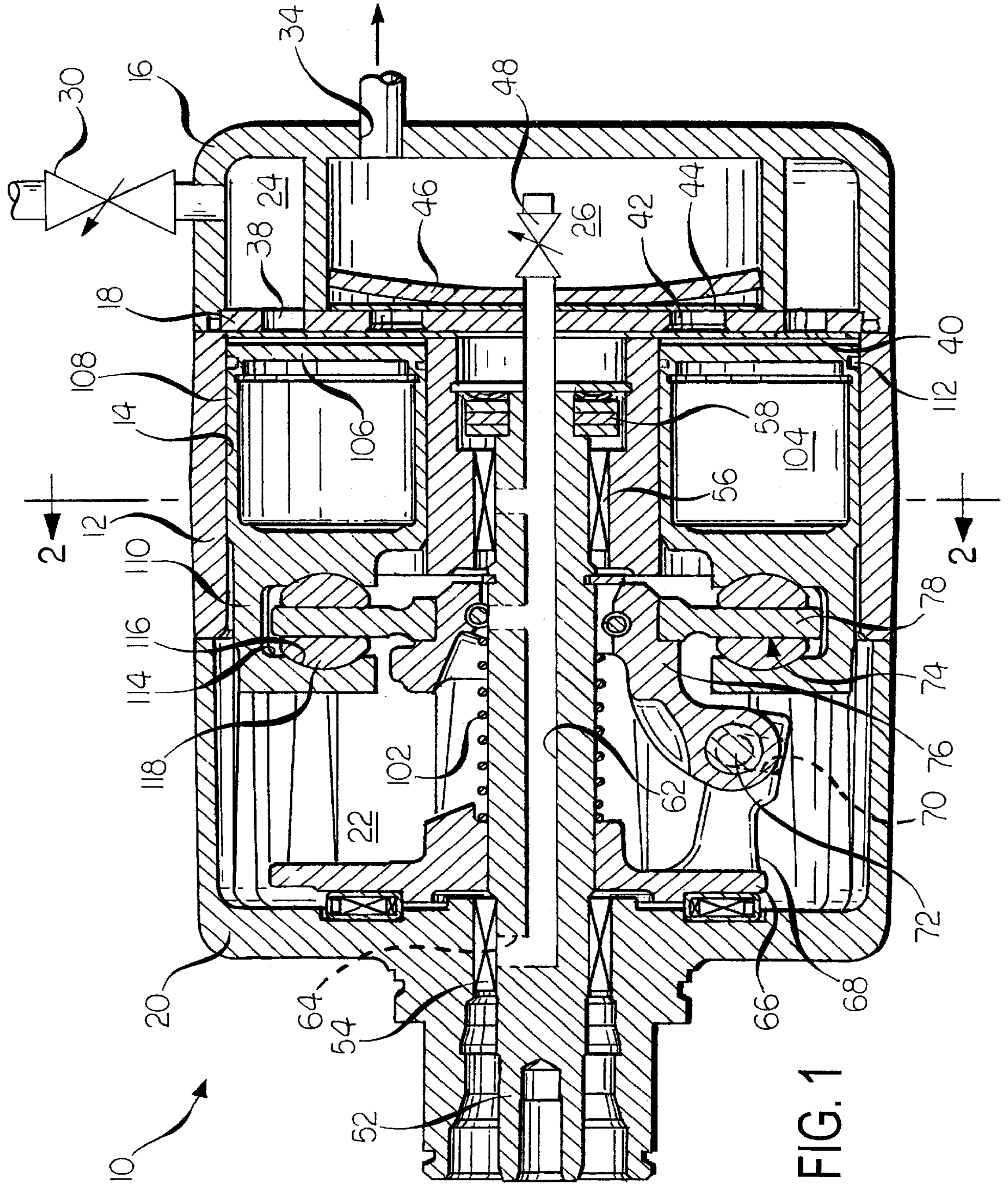

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FIG. 1

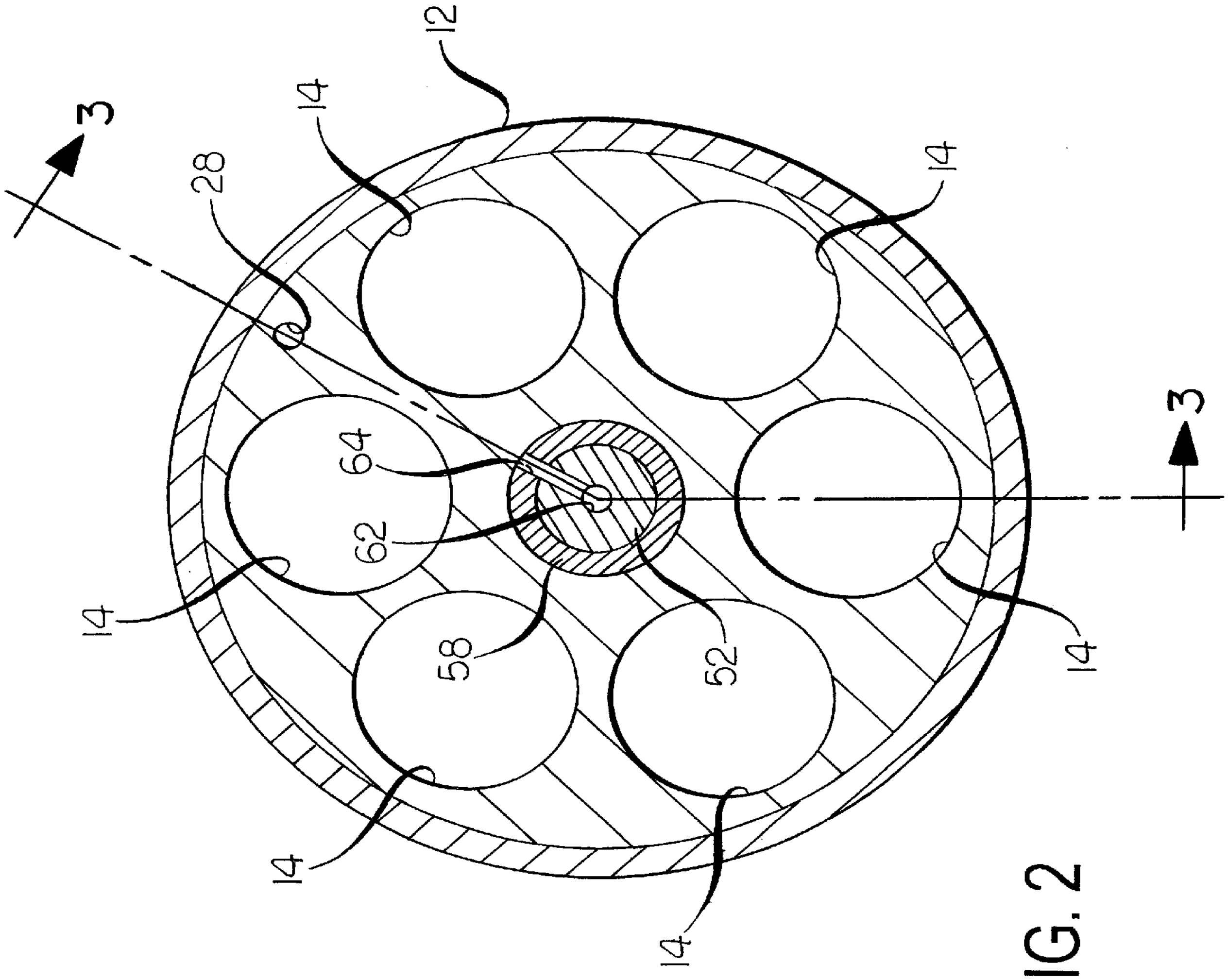

FIG. 2

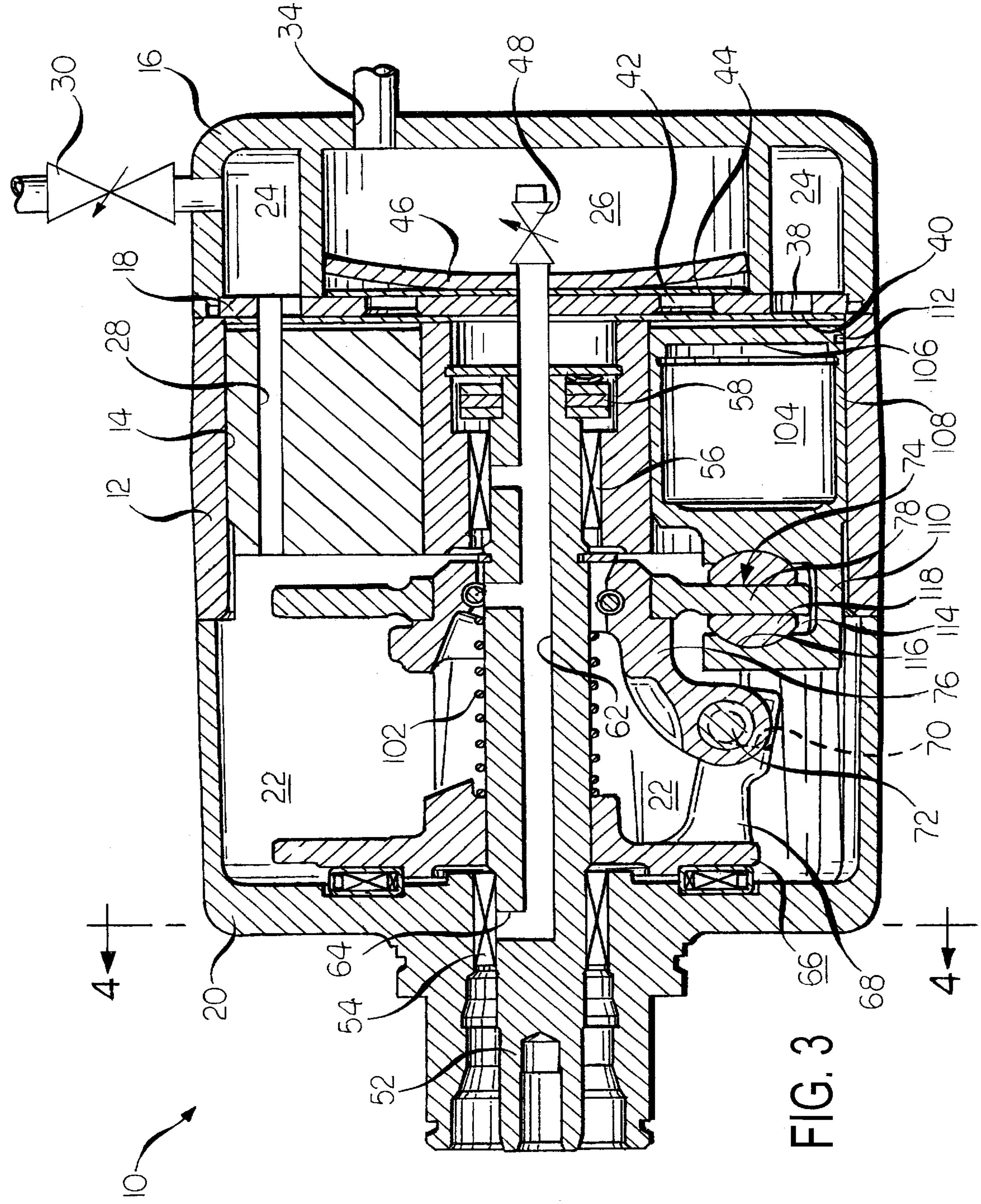
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FIG. 3

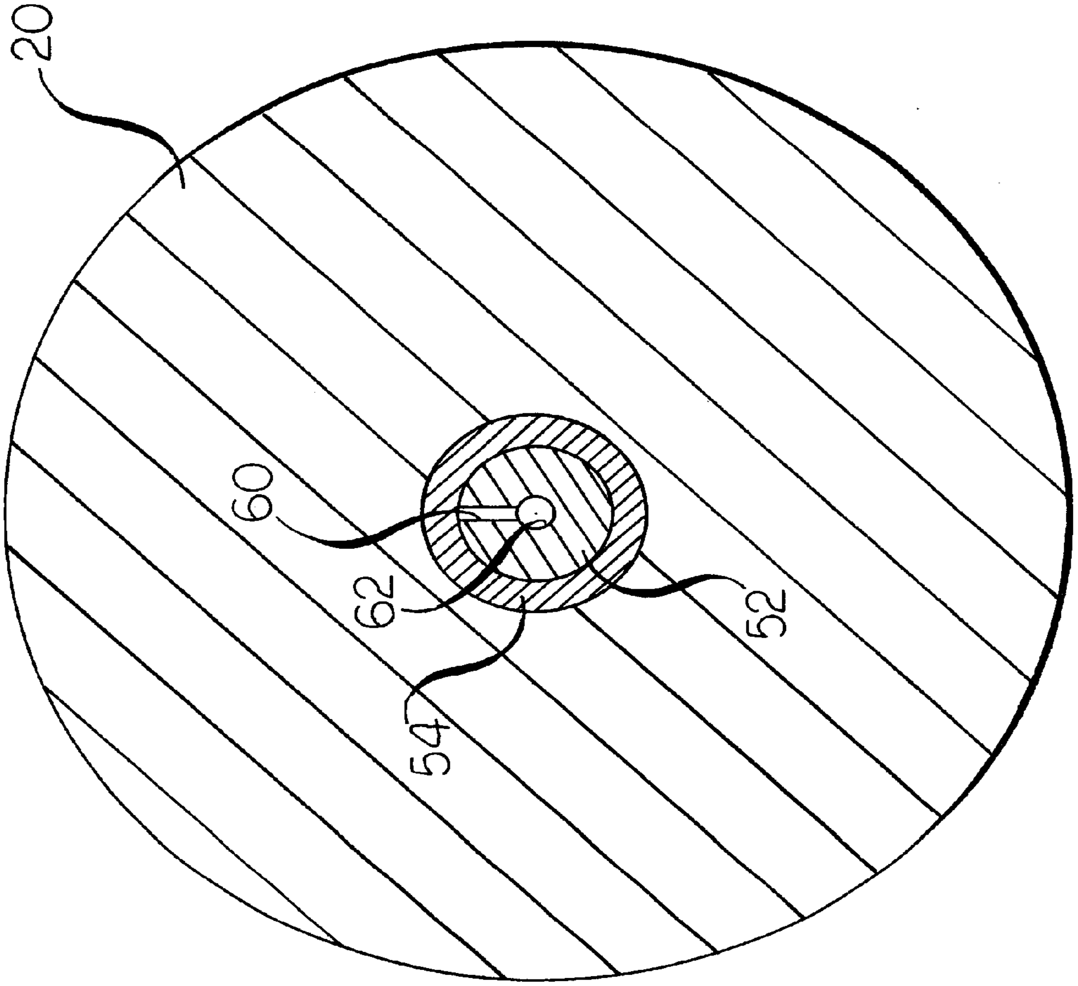

FIG. 4

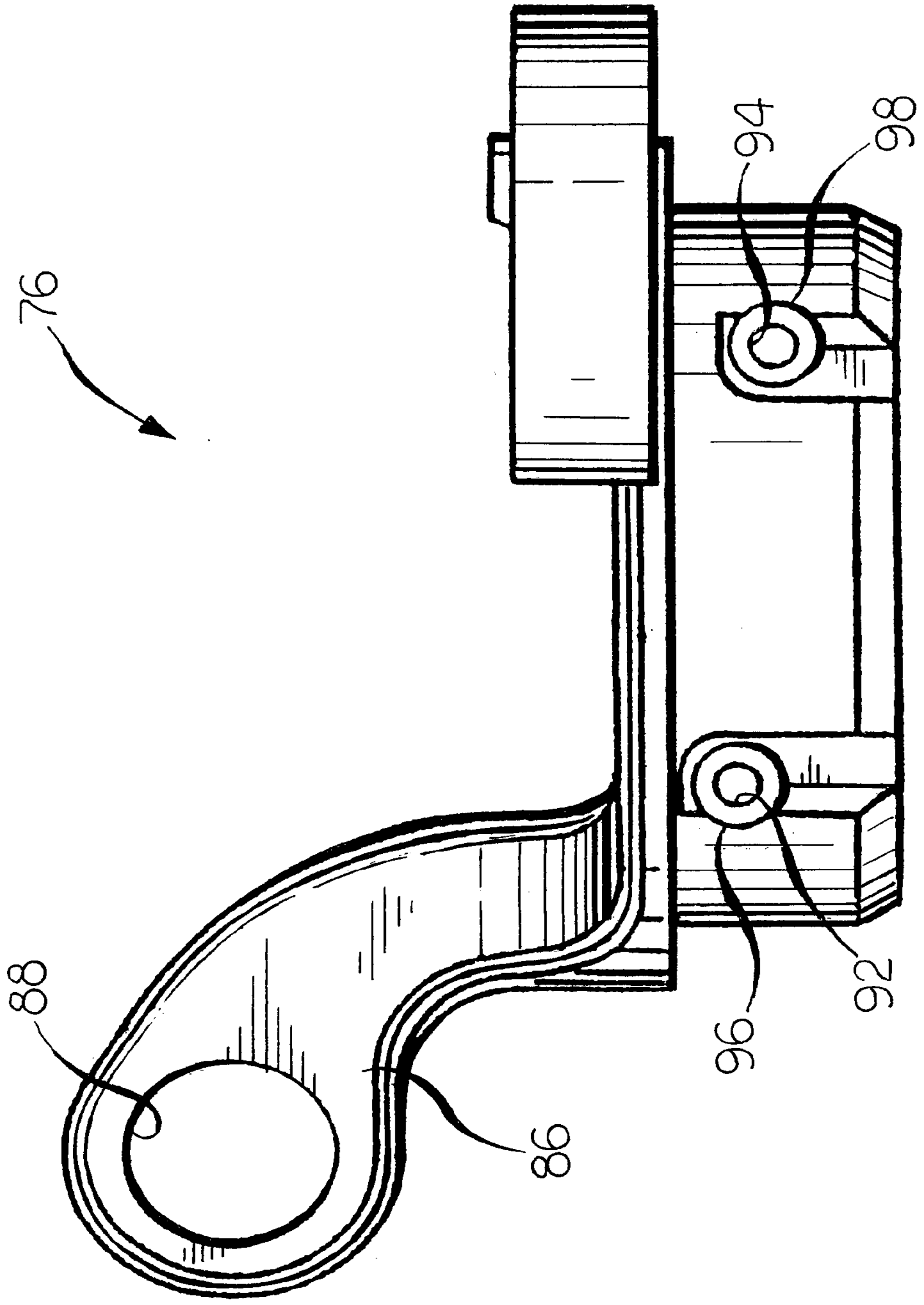

FIG. 5

LUBRICATION PASSAGE 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 in a drive shaft for providing lubricating oil to the crankcase.

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 cylinder 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. The pressure differential is typically controlled using a control valve and a conduit formed within the cylinder block which provides fluid communication between a discharge chamber and the crank chamber to convey compressed gases from the discharge chamber to the crank chamber based on the pressure in the suction chamber. The conduit also typically provides communication for lubricating oil between the discharge chamber and the crank chamber to achieve lubrication of the moving components within the crank chamber.

Another conventional lubricating system disclosed in the prior art employs a forced lubrication system including an oil pump provided at one end of the drive shaft and driven by the drive shaft to lubricate the moving components within the crank chamber. The forced lubrication system typically causes lubricating oil to be pumped from an oil sump, through a pump chamber, a lubrication passage and radial branch passageways within the drive shaft, to the crank chamber.

The compressor arrangements in the prior art described above have several disadvantages. First, when a compressor having a conduit within the cylinder block is operating at minimum capacity, ineffective lubrication of the close tolerance moving parts within the crank chamber occurs due to the lack of consistent flow of refrigerant gas from the discharge chamber to the crank chamber. Second, in a compressor having a forced lubrication system, the compressor may include an oil sump, a pump chamber, and an oil pump operatively connected to the drive shaft adding expense.

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 the oil sump, the pump chamber, and the drive shaft driven oil pump of the prior art can be eliminated.

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; a piston reciprocatively disposed in each of the cylinders of the cylinder block; a cylinder head attached to said cylinder block and having a discharge chamber formed therein; 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 and having a central aperture for receiving the drive shaft, radially outwardly extending side walls, and a peripheral edge; and a lubrication passage formed within the drive shaft providing fluid communication between the discharge chamber and 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, schematically showing a lubrication passage in the drive shaft in fluid communication with the discharge chamber and the crank chamber;

FIG. **2** is a cross-sectional view of the compressor illustrated in FIG. **1** taken along line **2**—**2** thereof, showing a first radial bore of the lubrication passage, and an orifice tube in the cylinder block in fluid communication with the crank chamber and the suction chamber;

FIG. **3** is a cross sectional elevational view of the compressor illustrated in FIGS. **1** and **2** taken along line **3**—**3** of FIG. **2**, schematically showing a lubrication passage in the drive shaft in fluid communication with the discharge chamber and the crank chamber, and an orifice tube in the cylinder block in fluid communication with the crank chamber and the suction chamber;

FIG. **4** is a cross-sectional view of the compressor illustrated in FIG. **3** taken along line **4**—**4** thereof, showing an additional radial bore of the lubrication passage; and

FIG. **5** is a elevational view of the hub of the swash plate illustrated in FIGS. **1** and **3** showing the features thereof.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring now to the drawings, and particularly FIGS. **1** and **3**, 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**. An orifice tube **28** is disposed to provide fluid communication between the crank chamber **22** and the suction chamber **24**. A shut-off valve **30** provides selective fluid communication between an evaporator (not shown) of the cooling portion of the air conditioning system for a vehicle and the suction chamber **24**. An outlet port **34** provides fluid communication between the discharge chamber **26** and the cooling portion of the air conditioning system for a vehicle. Suction ports **38** provide fluid communication between the suction chamber **24** and each cylinder **14**. Each suction port **38** is opened and closed by a flap valve **40** which may be formed as an integral part of the valve plate **18**. Discharge ports **42** provide fluid communication between each cylinder **14** and the discharge chamber **26**. Each discharge port **42** is opened and closed by a discharge valve **44**. A retainer **46** restricts the opening of the discharge valve **44**.

An electronic control valve **48** is disposed in the discharge chamber **26** and arranged to monitor the discharge pressure of the compressor **10**, the RPM of the vehicle engine, the humidity in the vicinity of the evaporator, and the like, to control the flow of refrigerant gas from the discharge chamber **26** to the crank chamber **22**. The shut-off valve **30** is arranged to be actuated by the electronic control valve **48** through a fluid pressure channel (not shown), for example. In the embodiment shown, a mechanical shut-off valve is illustrated, but it is understood that other types of valves can be used.

A drive shaft **52** is centrally disposed in and arranged to extend through the crankcase **20** to the cylinder block **12**. One end of the drive shaft **52** is rotatably supported by a bearing **54** mounted in the crankcase **20**, and the other end of the drive shaft **52** is rotatably supported in a bearing **56** mounted in the cylinder block **12**. Longitudinal movement of the drive shaft **52** is restricted by a thrust bearing **58** mounted in the cylinder block **12**.

A longitudinally extending lubrication passage or bore **62** is formed within the drive shaft **52**. The bore **62** communicates with a plurality of spaced apart radially extending bores **64**. The lubrication passage **62** and the bores **64** provide fluid communication between the discharge chamber **26** and the crank chamber **22**.

A rotor **66** is fixedly mounted on an outer surface of the drive shaft **52** 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 slot **70** is formed in the distal end of the arm **68**. A pin **72** has one end slidingly disposed in the slot **70** of the arm **68** of the rotor **66**.

A swash plate **74** is formed to include a hub **76** and an annular plate **78**. Referring now to FIG. **5**, the hub **76** includes a centrally disposed aperture formed therein and an arm **86** that extends outwardly and perpendicularly from the surface of the hub **76**. An aperture **88** is formed in the distal end of the arm **86** of the hub **76**. One end of the pin **72** is slidingly disposed in the slot **70** of the arm **68** of the rotor **66**, while the other end is fixedly disposed in the aperture **88** of the arm **86**.

A pair of spaced apart holes **92**, **94** are formed in the hub **76** and are adapted to receive pins **96**, **98**, respectively which are typically press fit therein. The outer surfaces of the pins **96**, **98** are formed to extend inwardly within the hub **76**.

The hub **76** is press fit in a suitable central aperture of the annular plate **78**. In the assembled form the drive shaft **52** is adapted to extend through the central aperture of hub **76**.

A helical compression spring **102** is disposed to extend around the outer surface of the drive shaft **52**. One end of the spring **102** abuts the rotor **66**, while the opposite end abuts the hub **76** of the swash plate **74**. The spring tends to urge the swash plate **74** away from the rotor **66**.

A piston **104** is slidably disposed in each of the cylinders **14** in the cylinder block **12**. Each piston **104** includes a head **106**, a middle portion **108**, and a bridge portion **110**. A circumferential groove **112** is formed in an outer cylindrical wall of the head **106** to receive piston rings (not shown). The middle portion **108** terminates in the bridge portion **110** defining an interior space **114** for receiving the annular plate **78**. Spaced apart concave pockets **116** are formed in the interior space **114** of the bridge portion **110** for rotatably containing a pair of semi-spherical shoes **118**. The spherical surfaces of the shoes **118** are disposed in the shoe pockets **116** with a flat bearing surface disposed opposite the spherical surface for slidable engagement with the opposing sides of the annular plate **78**.

In operation, the compressor **10** is actuated by the rotation of the drive shaft **52** which is typically an associated internal combustion engine of a vehicle. Rotation of the drive shaft **52** causes the simultaneous rotation of the rotor **66**. The swash plate **74** is connected to the rotor **66** by a hinge mechanism formed by the pin **72** slidingly disposed in the slot **70** of the arm **68** of the rotor **66** and fixedly disposed in the aperture **88** of the arm **86** of the hub **76**. As the rotor **66** rotates, the swash plate **74** is caused to rotate. During rotation, the swash plate **74** is disposed at an inclination. The rotation of the swash plate **74** is effective to reciprocatively drive the pistons **104**. The rotation of the swash plate **74** further causes a sliding engagement between the annular plate **78** and the cooperating spaced apart shoes **118**.

The reciprocation of the pistons **104** causes refrigerant gas and lubricating oil to be introduced from the suction chamber **22** into the respective cylinders **14** of the cylinder head **16**. The reciprocating motion of the pistons **104** 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 **74** and thereby changing the length of the stroke for the pistons **104**. The inclination of the swash plate **74** is changed by controlling the pressure differential between the crank chamber **22** and the suction chamber **24**. The pressure differential is controlled by controlling the net flow of refrigerant gas from the discharge chamber **26** to the crank chamber **22** through the lubrication passage **62**. As the piston **104** is caused to move toward a bottom dead center position, the pressure within the cylinder **14** is less than the pressure within the suction chamber **24**. The suction valve **40** is opened causing refrigerant gas to flow into the cylinder **14** through the suction port **38**. As the piston **104** is moved toward a top dead center position, the refrigerant gas within the cylinder **14** is compressed until the pressure within the cylinder **14** exceeds the pressure within the discharge chamber **26**. The discharge valve **44** is then opened and refrigerant gas flows through the discharge port **42** to the discharge chamber **26**.

The valve **48** controls the capacity of the compressor **10** by adjustably changing the flow of refrigerant gas and lubricating oil from the discharge chamber **26** to the crank chamber **22** through the lubrication passage **62** in the drive shaft **52**. When an increase in thermal load occurs, the shut-off valve **30** is caused to open and the flow of refrigerant gas to the suction chamber **24** is increased, increasing the pressure therein. The pressure differential between the crank chamber **22** and the suction chamber **24** is therefore increased and the backpressure acting on the pistons **104** in the crank chamber **22** is decreased by bleeding refrigerant gas through the orifice tube **28**. As a result of the decreased backpressure in the crank chamber **22**, the pin **72** connecting the rotor **66** and the swash plate **74** is caused to move slidably and outwardly within the slot **70**. The swash plate **74** is moved against the force of the spring **102**, increasing the inclination of the swash plate **74**, which increases the length of the stroke of each piston **104** and the compressor **10** is caused to operate at a maximum capacity.

Conversely, when a decrease in thermal load occurs, the shut-off valve **30** is caused to close and the flow of refrigerant gas to the suction chamber **24** is decreased, decreasing the pressure therein. The valve **48** is opened, causing refrigerant gas to flow from the discharge chamber **26** to the crank chamber **22** through the lubrication passage **62**. The pressure differential between the crank chamber **22** and the suction chamber **24** is decreased, and the backpressure acting on the pistons **104** in the crank chamber **22** is increased. As a result of the increased backpressure in the crank chamber **22**, the pin **72** is moved slidably and inwardly within the slot **70**. The swash plate **74** yields to the force of the spring **102**, the inclination of the swash plate **74** is decreased, and as a result, the length of the stroke of each piston **104** is reduced.

When the length of the stroke of each piston **104** is reduced, the compressor **10** is caused to operate at a minimum capacity. When operating at a minimum capacity and with the shut-off valve **30** closed, an internal refrigeration circuit is formed. Within the internal refrigeration circuit, refrigerant gas and lubricating oil are caused to flow serially from the suction chamber **24** to the cylinder **14**, the discharge chamber **26**, the valve **48**, the lubrication passage **62**, and the crank chamber **22**, thus lubricating the component parts within the crank chamber **22**. The refrigerant gas and lubricating oil in the crank chamber **22** is then caused to flow through the orifice tube **28** to the suction chamber **24**, thereby completing the internal refrigeration circuit.

By introducing the refrigerant gas and lubricating oil from the discharge chamber **26** into the crank chamber **22** through the lubrication passage **62**, instead of introducing the refrigerant gas from the discharge chamber **26** into the crank chamber **22** through the conduit of prior art, several benefits are achieved. The lubricating efficiency of the compressor **10** is maximized. The conduit within the cylinder block of prior art compressors causes the discharge chamber **26** to be in continuous fluid communication with the crank chamber **22**. In the preferred embodiment of the invention, the flow of refrigerant gas and lubricating oil between the discharge chamber **26** and the crank chamber **22**, through the lubrication passage **62**, is controlled by the electronic control valve **48**. The use of the electronic control valve **48** efficiently controls the flow of refrigerant gas and lubricating oil from the discharge chamber **26** into the crank chamber **22**. The lubricating oil introduced into the crank chamber **22** through the plurality of spaced apart radial bores **64** provides lubrication to the components within the crank chamber **22**. Further, when the compressor **10** is operating at a minimum capacity, it is not necessary to circulate the refrigerant gas through an external refrigeration circuit such as the air conditioning system for a vehicle. At such a minimum capacity, the electronic control valve **48** is caused to open and the shut-off valve **30** is caused to close, causing the refrigerant gas and lubrication oil to flow within the internal refrigeration circuit, thereby efficiently lubricating moving components such as bearings **54**, **56**, **58**, and the swash plate **74**. The introduction of lubricating oil to the crank chamber **22** improves the durability of the compressor **10**.

Additionally, by introducing the refrigerant gas to the crank chamber **22** through the lubrication passage **62**, as described above, the requirement an oil sump, a pump chamber, and a drive shaft driven oil pump is eliminated, thereby reducing manufacturing and operating costs.

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;
- a piston reciprocatively disposed in each of the cylinders of said cylinder block;
- a cylinder head attached to said cylinder block and having a discharge chamber and a suction chamber formed therein;
- a crankcase attached to said cylinder block to define a crank chamber;
- an orifice tube formed in said cylinder block, said orifice tube providing fluid communication between the crank chamber and the suction chamber;
- a drive shaft rotatably supported by said crankcase and said cylinder block;
- 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; and
- a lubrication passage formed within said drive shaft providing fluid communication between the discharge chamber and the crank chamber, wherein said lubrication passage includes a control valve for selectively opening and closing said lubrication passage.

2. The compressor according to claim **1**, wherein said lubrication passage includes at least a first bore extending longitudinally within said drive shaft.

3. The compressor according to claim **2**, wherein said lubrication passage includes at least one bore extending radially from said first bore portion.

4. A variable displacement swash plate type compressor comprising:

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

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;

an orifice tube formed in said cylinder block, said orifice tube providing fluid communication between the crank chamber and the suction 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;

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

a lubrication passage formed within said drive shaft providing fluid communication between the discharge chamber and the crank chamber, said lubrication passage including at least a fit bore extending longitudinally within said drive shaft, and at least one additional bore extending radially between the first bore and the crank chamber of said crankcase, wherein said lubrication passage includes a control valve for selectively opening and closing said lubrication passage.

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