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Grant

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[54] VARIABLE CAPACITY ROTARY SCREW COMPRESSOR

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[52] **U.S. Cl.** **62/196,** 62/226, 62/510

[51] **Int. Cl.** **F25b 1/00**

[58] **Field of Search** 62/196, 510, 199, 200, 62/226, 228; 418/201, 281

[56] **References Cited**

UNITED STATES PATENTS

3,568,466	3/1971	Brandin	62/510
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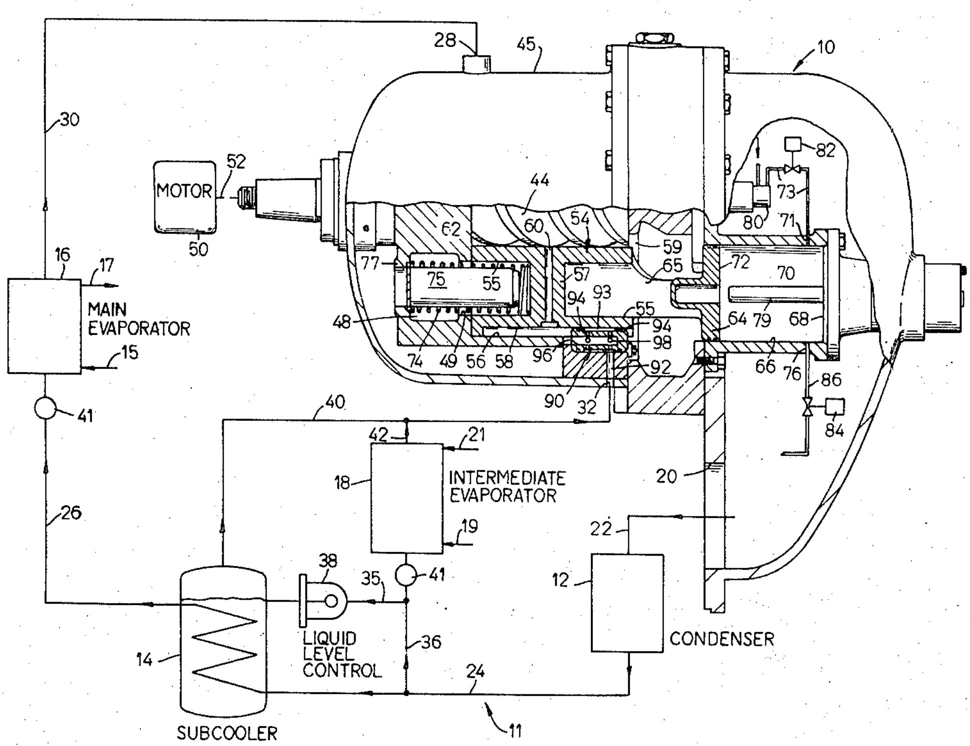
Primary Examiner—Meyer Perlin

Attorney, Agent, or Firm—James E. Nilles

[57] **ABSTRACT**

A variable capacity rotary screw compressor for a refrigeration system which includes a high pressure condenser, a subcooler, a main evaporator and an intermediate evaporator, the compressor including a primary inlet connected to receive low pressure vapor from the main evaporator, a secondary or intermediate inlet connected to receive high pressure vapor from the subcooler and/or intermediate evaporator, and a high pressure discharge port connected to the condenser, the compressor including a pair of oppositely rotating constant mesh helical lobe rotors and a slide valve to vary the capacity of the compressor by changing the points of admission of the low pressure vapor and the high pressure vapor to the rotors of the compressor, the points of admission of low pressure vapor and high pressure vapor being maintained in a fixed relation as the capacity of the compressor is varied.

5 Claims, 3 Drawing Figures



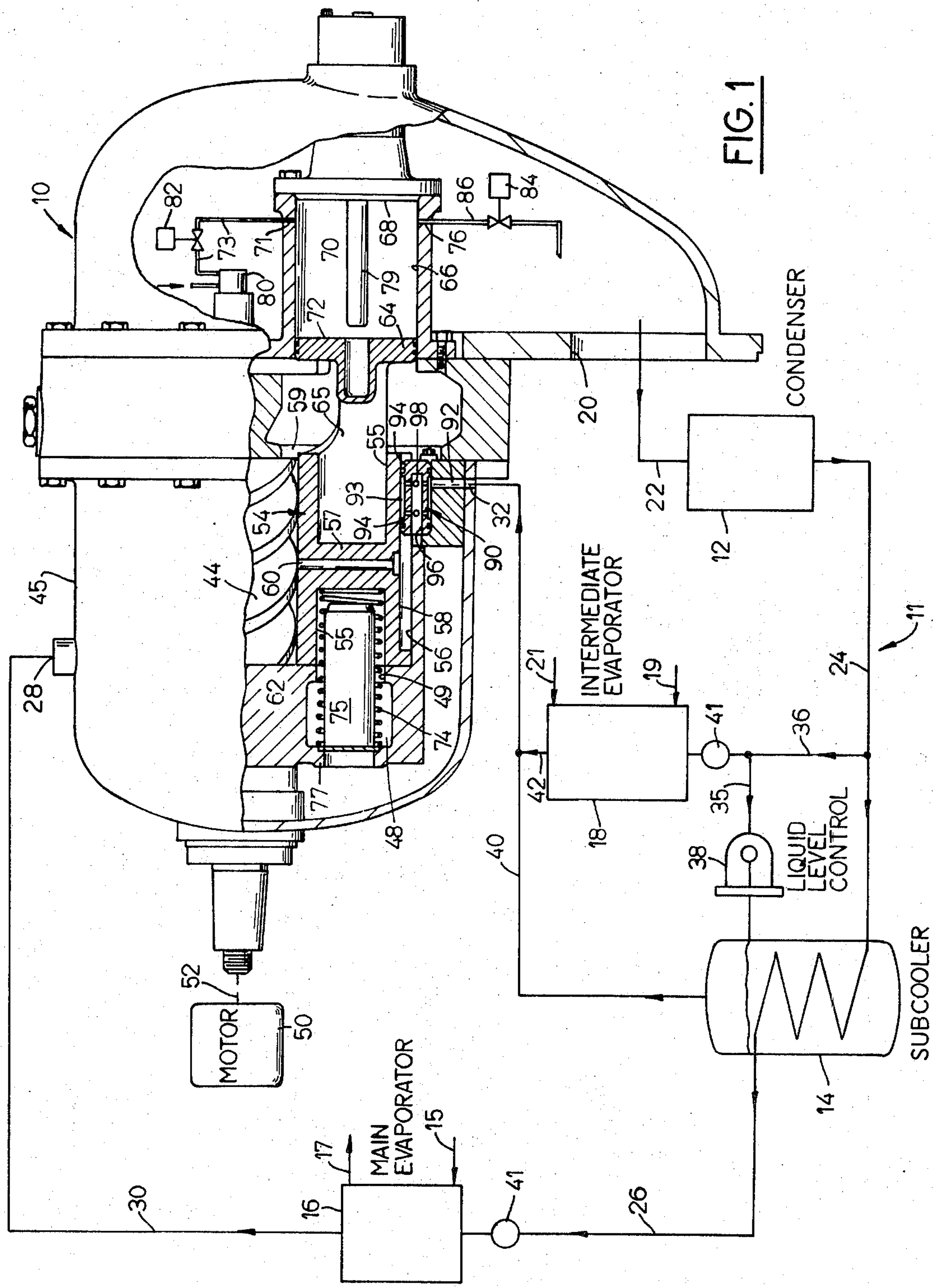


FIG. 1
CONDENSER
INTERMEDIATE EVAPORATOR
LIQUID LEVEL CONTROL
SUBCOOLER
MOTOR
MAIN EVAPORATOR

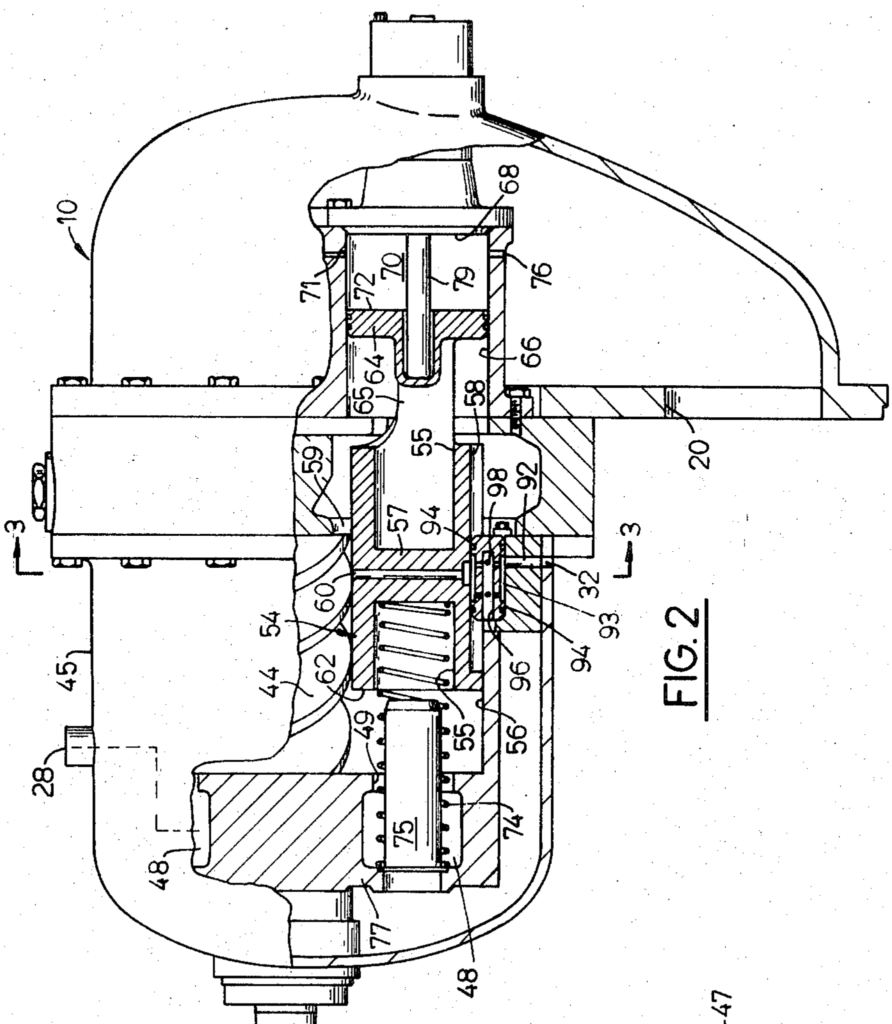

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FIG. 2

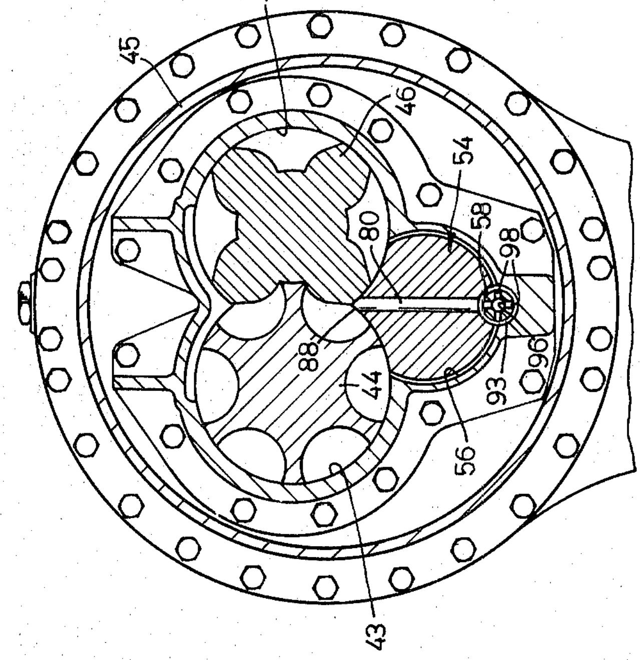
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FIG. 3

VARIABLE CAPACITY ROTARY SCREW COMPRESSOR

BACKGROUND OF THE INVENTION

Multiple suction variable capacity screw compressors are well known as shown in the Kocher U.S. Pat. No. 3,577,742, issued May 4, 1971. This type of a compressor has been further improved by using a slide valve to vary the capacity of the compressor from a minimum to a maximum level as shown in Edstrom U.S. Pat. No. 3,738,780, issued June 12, 1973. In compressors of this type the injection point for the secondary or high pressure vapor remains constant. The slide valve for the primary suction inlet is moved to change the capacity of the compressor from a maximum to a minimum producing a continuing change in the pressure of the intermediate vapor. At minimum capacity, the intermediate vapor pressure will be virtually at the same pressure level as the primary vapor pressure from the main evaporator. This continually changing intermediate vapor pressure level reduces the effect of the multiple suction arrangement such that maximum efficiency occurs only at maximum load conditions. There is virtually no increase in efficiency at minimum capacity because the pressures at the primary and secondary inlets are the same. Since the intermediate vapor pressure is continually varying in this type of a compressor, it is not suitable for use with intermediate evaporators.

SUMMARY OF THE INVENTION

The variable capacity screw compressor of the present invention provides for the admission of secondary vapor at high pressure throughout the full stroke of the slide valve. The point of injection of the secondary high pressure vapor is maintained constant with respect to the point where the vapor begins to compress in the rotors. The secondary high pressure vapor is always introduced into the rotors at a fixed distance from the start of compression in the rotors. A relatively constant or fixed pressure relationship is maintained between the main evaporator suction inlet and the intermediate evaporator pressure level. Since the pressure relation between the primary and secondary gas is maintained constant, the compressor can be used with an intermediate evaporator and still obtain the advantages of desuperheating and subcooling.

DRAWINGS

FIG. **1** is a schematic view of a refrigeration system of the two suction pressure level type connected to a multiple suction screw compressor which has been partly broken away to show the slide valve of the present invention;

FIG. **2** is an elevation view of the multiple suction screw compressor partly broken away to show the slide valve in the minimum capacity position;

FIG. **3** is a section view taken on line **3—3** of FIG. **2** showing the slide valve.

DESCRIPTION OF THE INVENTION

The multiple suction screw compressor **10** of the present invention as shown in FIG. **1** is connected to a refrigeration system **11** which generally includes a condenser **12**, a subcooler **14**, a main evaporator **16** and an intermediate evaporator **18**. In this regard, the condenser **12** is connected to the discharge outlet **20** of the compressor **10** by a high pressure discharge conduit **22**. High pressure liquid from the condenser **12** is conducted to the subcooler **14** through a high pressure liquid conduit **24**. The cooled liquid from the subcooler **14** is conducted to the main evaporator **16** through a conduit **26**. The main evaporator **16** is connected to the low pressure vapor inlet port **28** in the compressor **10** through a conduit **30**.

The level of liquid refrigerant in the subcooler **14** is maintained at a predetermined level by a liquid level control **38** connected to the high pressure liquid conduit **24** through conduits **35** and **36**. High pressure gas or vapor from the subcooler **14** is conducted to a fixed secondary or intermediate high pressure vapor inlet port **32** in the compressor **10** through a conduit **40**.

Additional high pressure gas or vapor is provided by means of the intermediate evaporator **18**. The evaporator **18** is connected across the subcooler **14** by conduits **36** and **42**. The high pressure vapor from the subcooler **14** and intermediate evaporator **18** is drawn into the compressor through conduit **40**.

The evaporators **16** and **18** are conventional and can be of the shell and tube brine cooler type in which brine is introduced into and taken out of the evaporators through conduits **15, 17** and **19, 21**, respectively. The intermediate evaporator **18** provides vapor at a higher pressure than the main evaporator **16**. This difference in pressure should normally be at least 15 psi. Control valves **41** can be provided in each of the evaporators **16** and **18** to control the flow of refrigerant to these evaporators. The control valves function to reduce the pressure of the liquid to the required evaporator pressure as is generally understood.

VARIABLE CAPACITY COMPRESSOR

The variable capacity compressor **10** of the invention generally includes a housing **45** having a pair of oppositely rotating constant mesh helcial lobe rotors **44** and **46** positioned within bores **43** and **47** within the housing **45**. The rotors **44** and **46** cooperate to provide a pumping and compressing action in a known manner. The rotors define lobe chambers which close off low pressure vapor from chamber **48** provided at the end of the rotors. These lobe chambers become progressively smaller to compress the low pressure gas or vapor trapped therein. The low pressure vapor is drawn via conduit **30** from the main evaporator **16** to the primary low pressure suction inlet **28** and then into chamber **48** at the end of bores **43** and **47**.

The compressor **10** includes a discharge port **20** for discharging high pressure refrigerant which has been compressed between the rotors to the condenser **12** through the conduit **22**. The condenser **12** is conventional and functions to receive the high-pressure vapor from the compressor discharge port **20**. The compressor **10** is driven by means of an electric motor **50** which is connected directly to the rotors **44** and **46** by a drive shaft **52**.

SLIDE VALVE

In accordance with the invention, the fixed intermediate pressure inlet port **32** is connected to the lobe chambers between the rotors **44** and **46** by means of slide valve **54**. The slide valve **54** is positioned for axial movement in a bore **56** provided in the housing **45** in a parallel relation to the rotor lobes **44** and **46** and is connected to chamber **48** through opening **49**. The slide valve **54** forms a movable wall for a portion of the wall of the bores 43 and 47 in the housing 45 and is axially movable in the bore 56 from the maximum capacity position shown in FIG. 1 to a minimum capacity position shown in FIG. 2. The mass of the valve 54 can be reduced by providing a recess 55 in each end of the valve which terminate at a center section 57.

The slide valve 54 is biased to the minimum capacity position by means of a spring 74. The spring 74 is mounted on a guide rod 75 which extends into the recess 55 on one end of the valve 54. The spring 74 is seated on a fixed plate 77 and bears against the center section 57 of the valve.

The point of admission of low pressure vapor into the cavity or chamber between the rotors is determined by the position of the face or end 62 of the slide valve 54. In this regard and referring to FIG. 2, it should be noted that in the minimum capacity position of the slide valve 54, a portion of the bores 43 and 47 for rotors 44 and 46 will be opened to the bore 56. The rotor lobes therefore cannot close until the lobes pass the end 62 of the slide valve 54. The stroke of the compressor at the minimum capacity position will be equal to the distance from the end 62 of the valve 54 to the discharge end 59 of the rotors 44 and 46.

Means are provided in the slide valve 54 for connecting the fixed intermediate inlet port 32 with the cavities formed in the rotors 44 and 46. Such means is in the form of an arcuate slot 58 provided in the side wall of the valve 54 and a passage 60 which extends through the center section 57 of the valve from the slot 58 to the cavity in the rotors.

The location of the point of introduction of the high pressure vapor through the passage 60 into the rotors is preferably at the beginning of the compression of the vapor trapped in the cavity of the rotors at suction inlet cut-off. This high pressure vapor is introduced in the cavity between the rotors at a point after the low pressure vapor cut-off and preferably prior to the point where any appreciable compression has taken place in the compressor. In this regard, the distance of the passage 60 from the face 62 of the slide valve should be equal to or slightly greater than the length of the cavity or chamber closed by the rotors 44 and 46 at suction inlet cut-off.

The position of the slide valve 54 in the bore 56 is controlled by means of a piston 64 which is axially slideable in a bore 66 in housing 45. The piston 64 includes a face 72 and is connected to the valve 56 by means of flanges 65. The bore 66 is closed by an end plate 68 to form a chamber 70 for receiving pressure liquid through a port 71.

Means are provided to control the amount of movement of the piston 64 in the form of an adjustable pin 79 secured to a plate 68.

The slide valve 54 can be controlled by the admission of pressure liquid from any source such as oil pump 80 into chamber 70 through passage 71. In the embodiment shown in FIG. 1, a schematic circuit is shown for the control liquid which is controlled by means of a high pressure oil solenoid valve 82 provided in the oil line 73 between the oil pump 80 and the chamber 70. The build up of pressure liquid in the chamber 70 will move the slide valve toward the maximum capacity position against the bias of spring 74. Pressure is relieved in the chamber 70 by means of an oil drain solenoid 84 provided in a discharge line 86 connected to the port 76. Opening of the oil drain solenoid 84 will relieve the pressure in the chamber 70 allowing the spring 74 to move the slide valve towards the minimum capacity position.

The slide valve 54 can be positioned anywhere between the maximum capacity position and the minimum capacity position by the proper control of the solenoids 80 and 84. In the maximum capacity position of the slide valve 54, the stroke will now be equal to the full length of the rotors since the end 62 of the valve 54 is located at the inlet end of the rotors. In the maximum and minimum capacity positions of the valve 54 the secondary vapor will be admitted at a fixed distance from the end 62 of the valve 54.

Means are provided for guiding the slide valve 54 in the housing in order to maintain the alignment of the crest edge 88 of the slide valve 54 between the rotors 44 and 46. Such means is in the form of a pin 90 provided in a groove 92 in housing 45 which is axially aligned with the slot 58. The pin 90 includes a reduced diameter center section 93 and a piston head 94 at each end of the center section 93. The piston heads 94 have outer diameters substantially equal to the diameter of the grooves 92 and slot 58.

Fluid communication is provided through the guide pin 90 by means of an open passage 96 and transverse ports 98. Fluid entering the groove 92 around the center section 93 will flow through ports 98 into passage 96 and out into groove 58.

In operation, the slide valve 54 in the maximum capacity position shown in FIG. 1 provides for the admission of high pressure vapor at a fixed distance from the low pressure vapor inlet chamber 48. This distance is equal to the length of the compression chamber immediately after low pressure suction cut-off and preferably at the beginning of compression before the pressure builds up in the chambers. When the slide valve 54 is in the minimum capacity position as seen in FIG. 2, the low pressure suction inlet will be at a point corresponding to the face 62 of the slide valve 54. The end face 62 of the slide valve 54 will determine the point of low pressure suction inlet cut off.

High pressure vapor will still be introduced into the cavities between the rotors at the same distance from low pressure vapor inlet cut off as in the maximum capacity position. Maximum efficiency will, therefore, be maintained through the full stroke of the slide valve since the same pressure relationship will always be present between low pressure vapor inlet and high pressure vapor inlet.

I claim:

1. In a refrigeration system including a high pressure condenser, a subcooler for receiving condensed refrigerant from the condenser, a main evaporator for receiving liquid from said subcooler, said subcooler forming some high pressure refrigerant vapor, and a variable capacity multiple inlet compressor having a pair of oppositely rotating constant mesh rotors defining chambers having a primary inlet cut off and which rotors cooperate to provide a pumping and compressing action, a primary inlet for receiving low pressure vapor from said main evaporator, a secondary inlet for receiving high pressure vapor from said subcooler, and a discharge port for discharging high pressure vapor to said condenser, the improvement comprising: a slide valve mounted for movement relative to said rotors, said valve including low pressure vapor cut-off means for controlling the point of cut-off of admission of low

pressure vapor to said rotors and the begining of said compression action, and passage means for providing fluid communication between said secondary inlet and said rotors, said passage means being located a fixed distance from said low pressure vapor cut-off means and means for moving said slide valve to vary said cut-off of admission of low pressure vapor and consequently vary the capacity of the compressor.

2. The system according to claim **1** wherein said passage means is located a distance from said low pressure vapor cut-off means greater than the length of the chambers formed by said rotors at primary inlet cut-off.

3. The system according to claim **1** wherein said passage means is located a distance from said low pressure vapor cut-off means less than the distance from the primary inlet cut-off and the point where the pressure of the vapor trapped in said chambers between the rotors starts to increase.

4. The system according to claim **1** including means for maintaining the slide valve in a fixed position with respect to the rotors during axial movement of the valve.

5. The system according to claim **1** including an intermediate evaporator connected between the condenser discharge and secondary inlet to provide high pressure vapor to the secondary inlet to the compressor.

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