Nov. 6, 1962 J. H. HEIDORN 3,062,020

REFRIGERATING APPARATUS WITH COMPRESSOR OUTPUT MODULATING MEANS

Filed Nov. 18, 1960 6 Sheets-Sheet 1

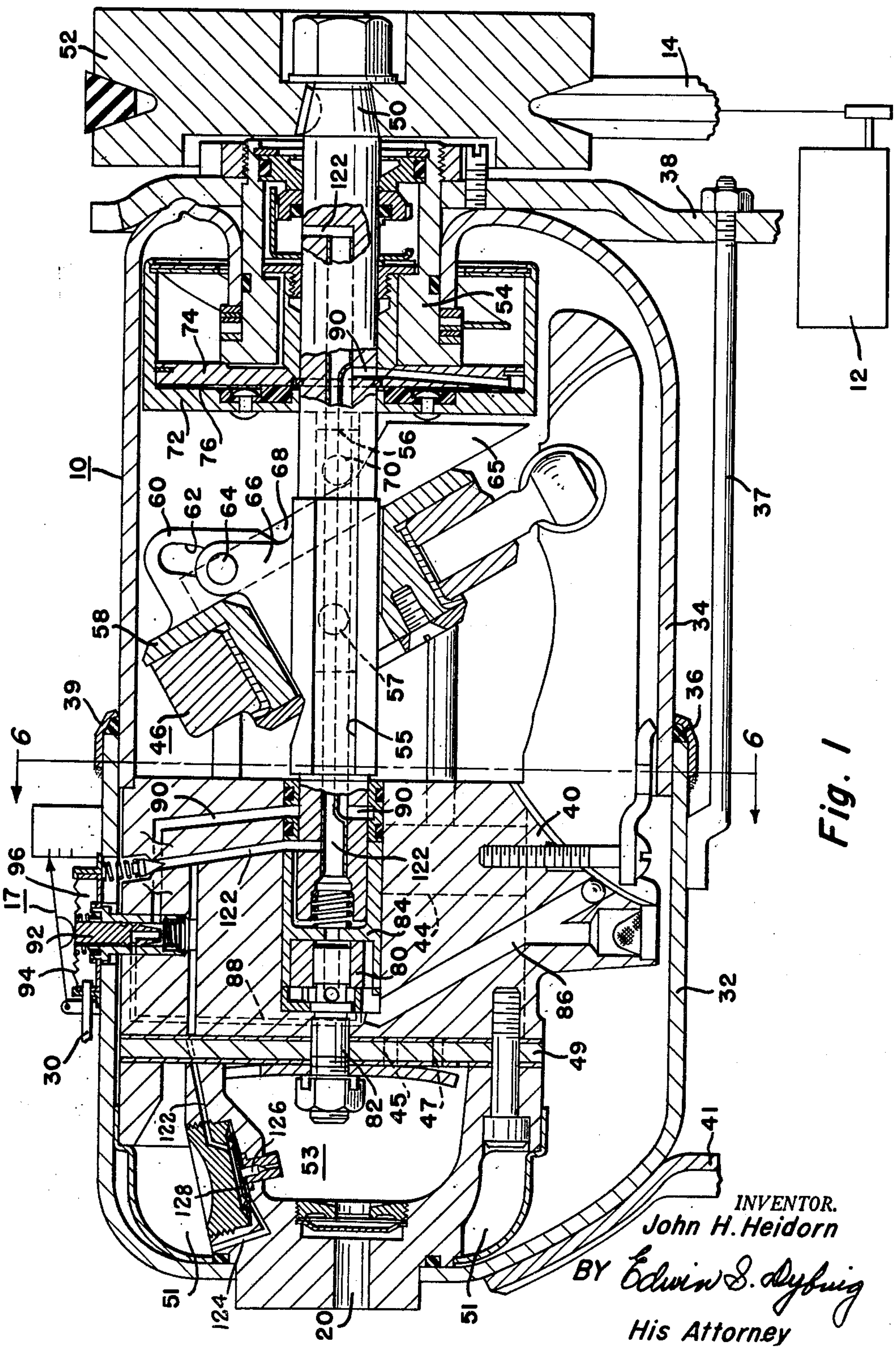

Fig. 1

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6 Sheets-Sheet 2

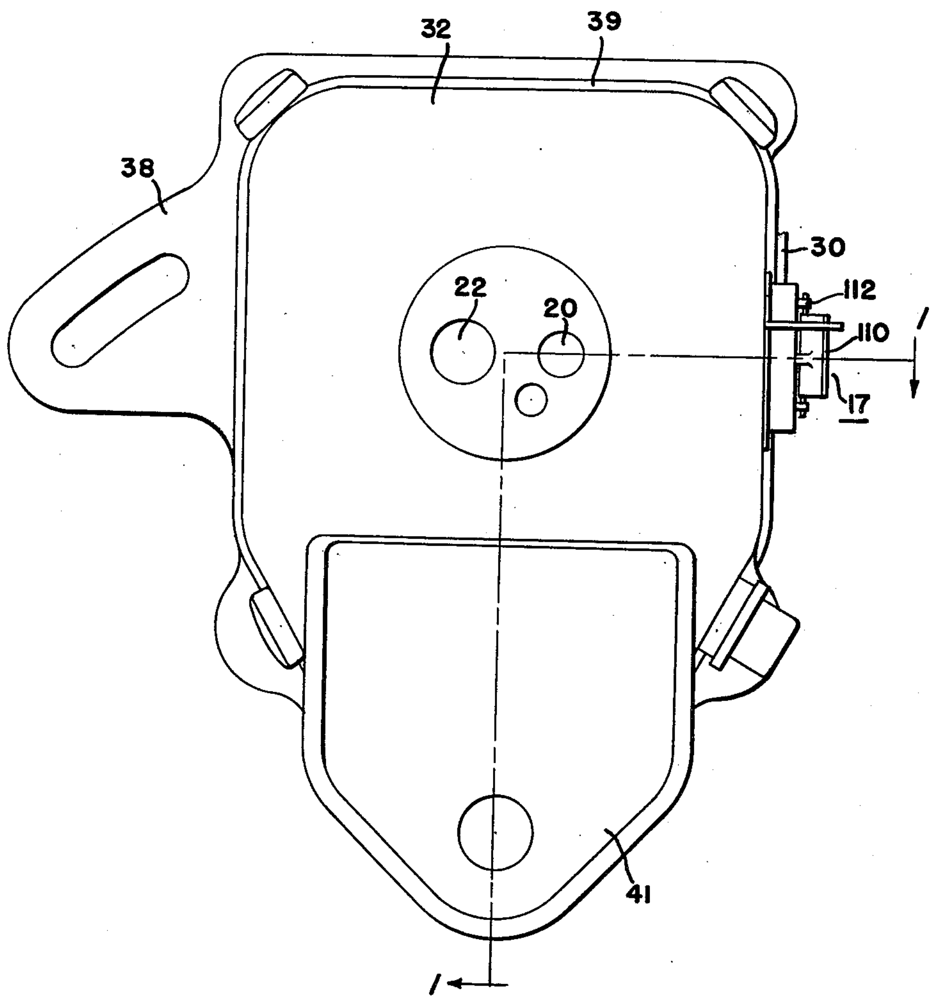

Fig. 2

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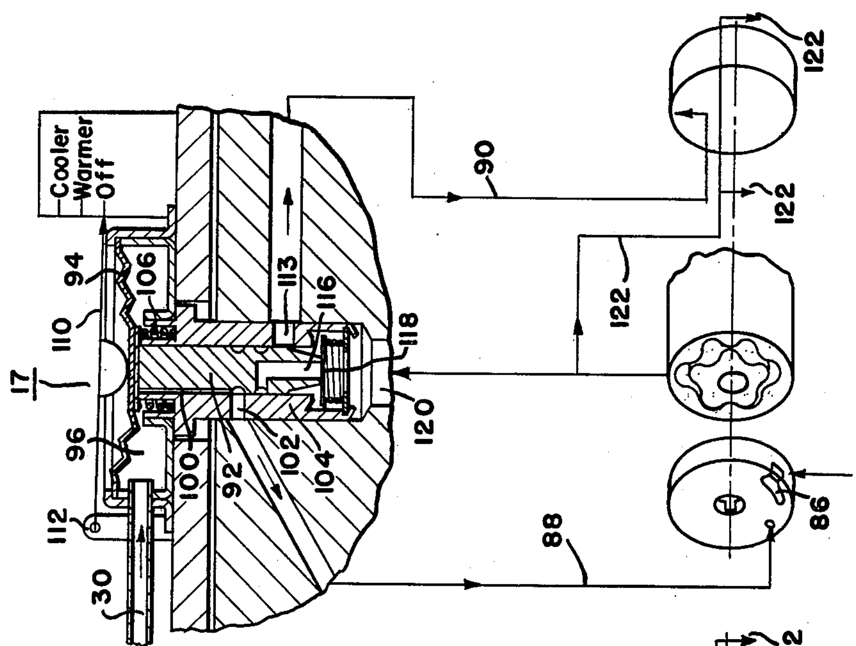

Fig. 4

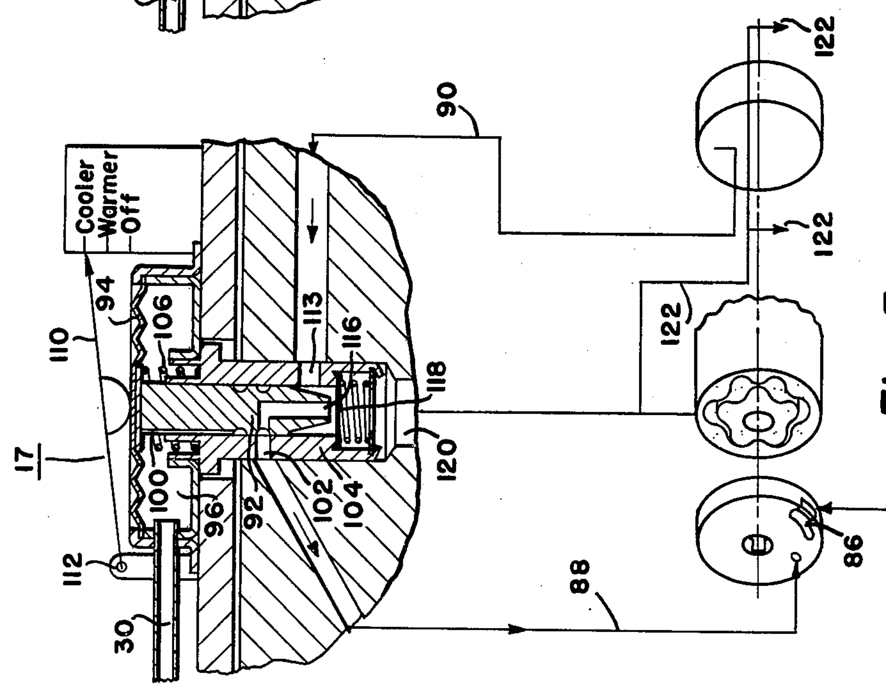

Fig. 3

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REFRIGERATING APPARATUS WITH COMPRESSOR OUTPUT MODULATING MEANS

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6 Sheets-Sheet 4

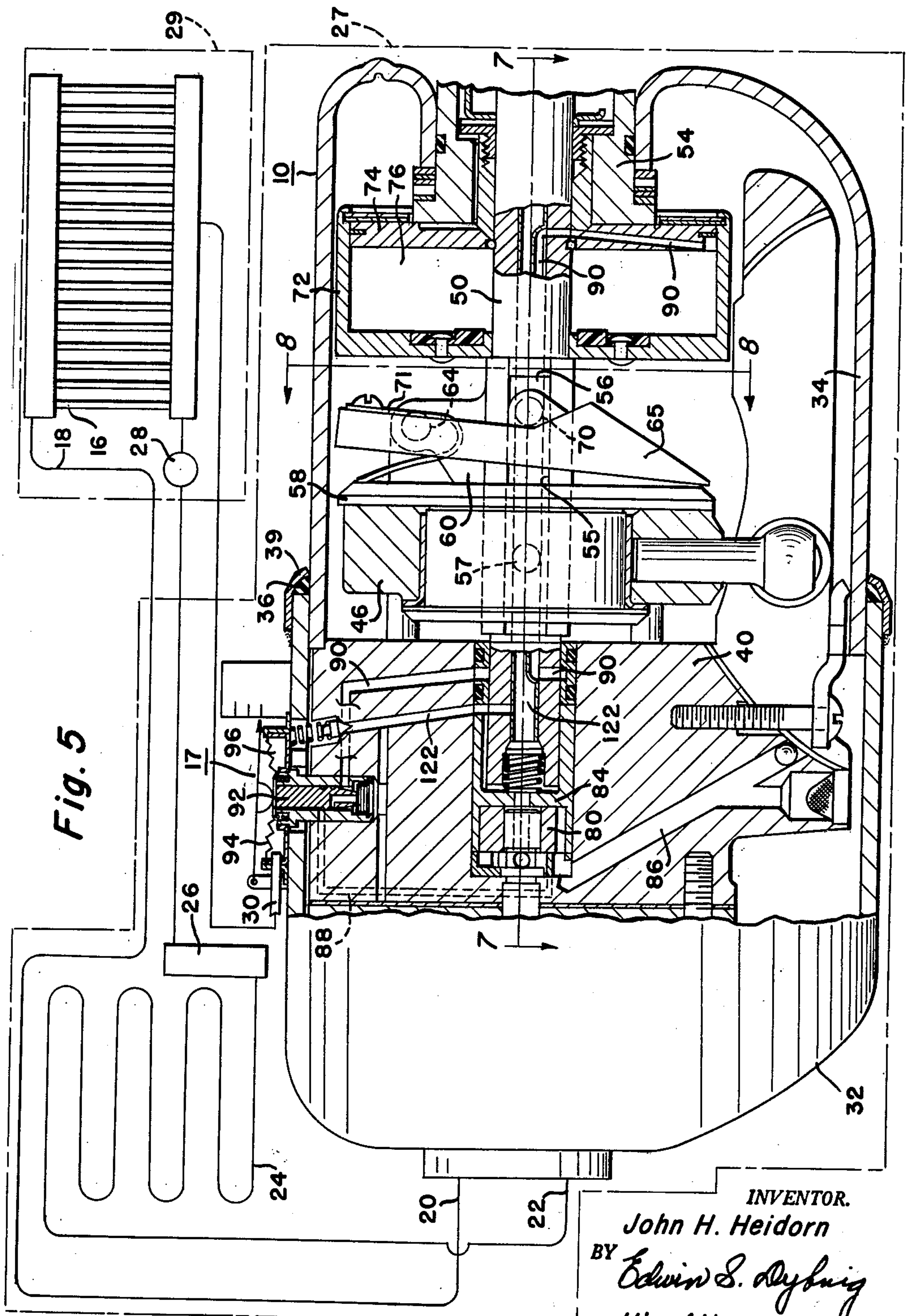

Fig. 5

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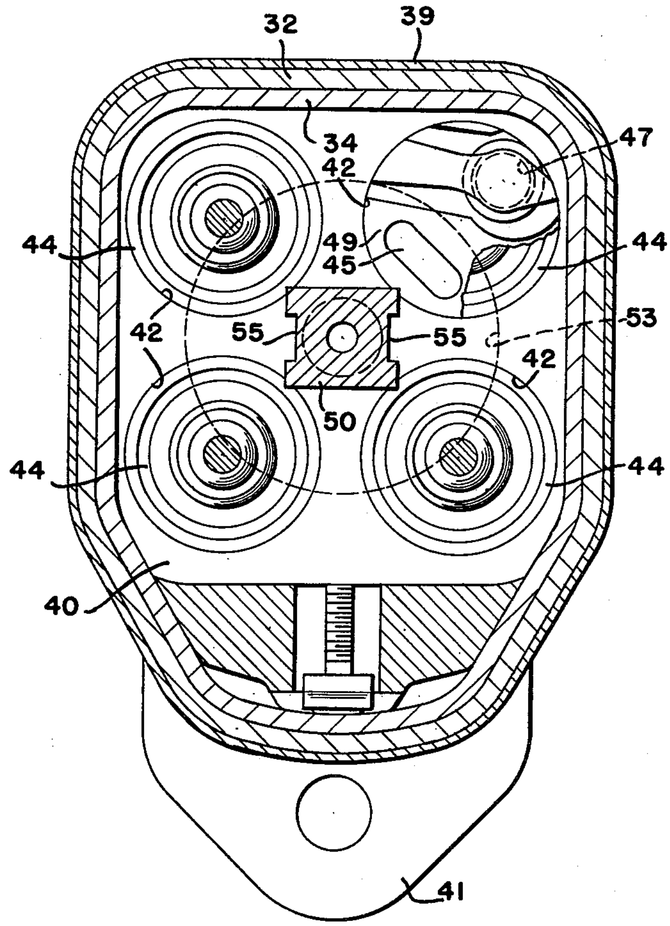

Fig. 6

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REFRIGERATING APPARATUS WITH COMPRESSOR OUTPUT MODULATING MEANS
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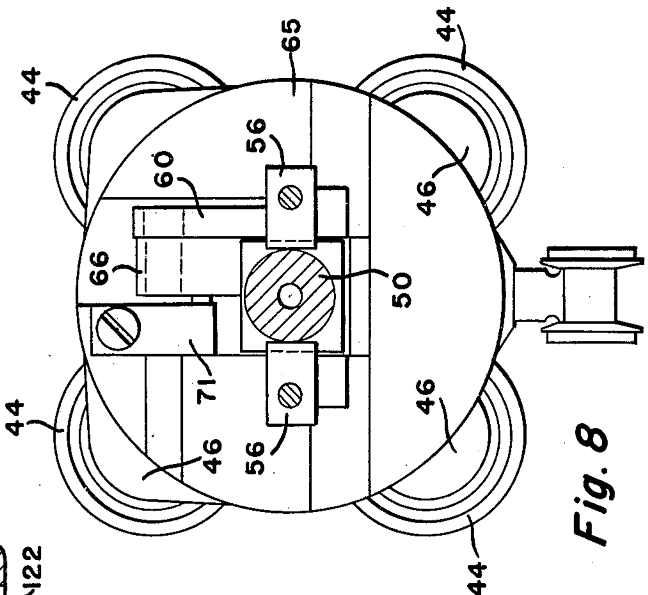

Fig. 8

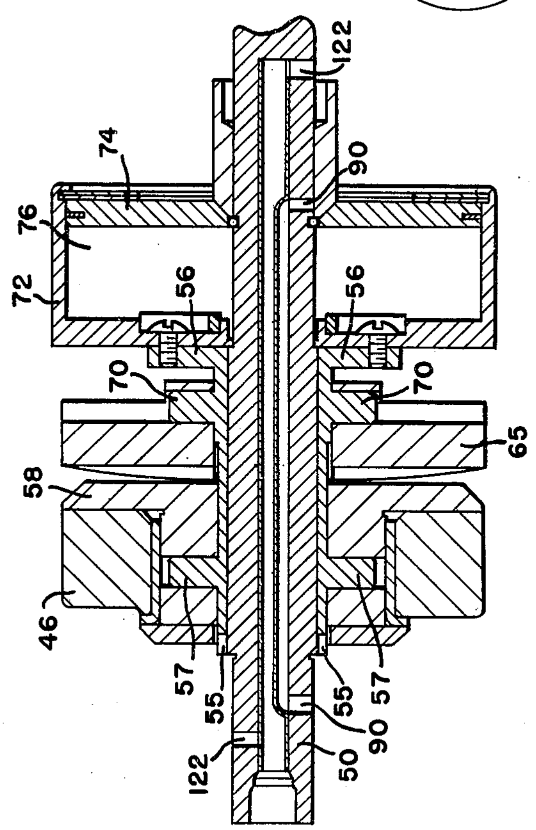

Fig. 7

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United States Patent Office

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REFRIGERATING APPARATUS WITH COMPRESSOR OUTPUT MODULATING MEANS
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Filed Nov. 18, 1960, Ser. No. 70,255
13 Claims. (Cl. 62—196)

This invention relates to refrigerating apparatus and more particularly to an automobile air conditioning system.

It is an object of this invention to provide an automobile air conditioning system in which the compressor is adapted to be directly driven by the car engine at all times and in which the output of the compressor is modulated in response to refrigeration requirements.

It is an object of this invention to provide a system having an improved compressor oiling arrangement whereby the compressor is properly lubricated even though no refrigeration is called for, such as during winter driving.

Still another object of this invention is to provide an improved arrangement for modulating the output of a compressor so as to compensate for wide variations in compressor speeds and wide variations in refrigeration requirements.

Further objects and advantages of the present invention will be apparent from the following description, reference being had to the accompanying drawings wherein a preferred embodiment of the present invention is clearly shown.

In the drawings:

FIGURE 1 is a sectional view of the compressor taken substantially on line 1—1 of FIGURE 2.

FIGURE 2 is an end elevational view of the compressor.

FIGURE 3 is a fragmentary sectional view schematically showing the oiling system.

FIGURE 4 is a view similar to FIGURE 3 showing the oil flow when the compressor is completely unloaded.

FIGURE 5 is an elevational view with parts broken away showing the arrangement of parts when the compressor operates at a reduced capacity and showing the refrigerant circuit.

FIGURE 6 is a sectional view taken substantially on line 6—6 of FIGURE 1 and showing parts broken away.

FIGURE 7 is a fragmentary sectional view taken on line 7—7 of FIGURE 5.

FIGURE 8 is a sectional view taken on line 8—8 of FIGURE 5.

Referring now to the drawings wherein a preferred embodiment of the invention has been disclosed, reference numeral 10 designates an axial compressor which is adapted to be driven by the main car engine 12 through suitable belt means 14. In the arrangement shown the compressor operates at widely varying speeds which are determined by the car speed rather than by refrigeration requirements and the compressor is also called upon to operate for long periods of time when no refrigeration is required.

The refrigerating system includes the usual refrigerant evaporator 16 having an outlet line 18 leading to the compressor inlet 20. The compressed refrigerant leaves the compressor 10 through an outlet 22 connected to a conventional condenser 24. The condensed refrigerant collects in a receiver 26 from whence the liquid refrigerant flows through a suitable pressure reducing means which for purposes of illustration has been shown as an expansion valve 28. The compressor 10 and the condenser 24 are preferably located in the engine compartment of the car which has been designated by the reference numeral 27 in the schematic showing in FIGURE 5 of the drawing.

The evaporator is arranged in a compartment 29 so as to cool air for the passenger compartment of the car in the usual manner.

The compressor includes a pair of cup-shaped sheet metal casing elements 32 and 34 which completely enclose the compressor mechanism and so as to form an oil sump for the compressor. Since the compressor operates continuously, special oil return means must be provided so as to provide a constant supply of oil for the compressor bearings. For this purpose an oil return line 30 is provided which leads from the bottom of the evaporator 16 to a compressor capacity control valve unit designated by the reference numeral 17 from whence the oil can be supplied to the inlet 88 of the oil pump for the compressor in a manner explained more fully hereinafter.

The open end of the casing element 34 telescopes within the open end of the casing element 32 and the joint between the two is sealed by means of an O-ring 36. Bolts 37 which have one end secured to the casing element 32 and have another end passing through the one mounting bracket 38 are provided as shown for holding the casing elements in assembled relationship. A malleable ring 39 secured to the casing element 32 holds the O-ring 36 in place. The brackets 38 and 41 are used for mounting the compressor in the engine compartment of an automobile.

The compressor is of the multiple cylinder axial type and includes a main cylinder block 40 having a plurality of cylinder bores 42 in which pistons 44 reciprocate. The usual inlet and outlet ports 45 and 47 are provided in the valve plate 49 and communicate with the inlet and discharge chambers 51 and 53 in accordance with conventional practice.

A wobble plate drive mechanism generally designated by the reference numeral 46 serves to reciprocate the pistons 44 in response to the rotation of the main drive shaft 50. A drive pulley 52 is keyed to the drive shaft 50 so as to impart rotation to the drive shaft in response to operation of the car engine. The drive shaft 50 is journaled in a bearing assembly 54 which is supported in fixed relationship to the mounting bracket 38 and the cup-shaped casing element 34 as shown. The inner end of the drive shaft projects into an end cavity formed in the oil pumping gear element 84 which is rotatably supported in the cylinder block 40. The compressor is of the general type shown in my copending application Serial No. 827,346, filed July 15, 1959, to which reference may be had for a more detailed description of various details of construction which are common to both compressors.

The shaft 50 includes a non-circular portion provided with guide slots 55 on opposite sides thereof in which slide elements 56 are mounted. The slide elements 56 are provided with pivot pins 57 which pivotally support the wobble plate element 58. The non-circular portion includes a projection 66 which supports a pivot pin 64.

Power is transmitted from the drive shaft 50 to the socket plate 46 of the wobble plate assembly through the wobble plate element 58 which rotates in unison with the shaft 50. The element 58 is provided with a projection 60 having a guide slot 62 formed therein for receiving the pin 64 which can never shift axially on the shaft 50. Axial movement of the slide elements 56 and associated pins 57 causes a change in the angular relationship between the wobble plate and the drive shaft so as to vary the stroke of the pistons. A pivotally mounted counterweight 65 is supported on the pin means 70 carried by the slide 56. This counterweight shifts as the wobble plate shifts so as to better balance the rotating parts. A blade spring 71 carried by the counterweight 65 biases the counterweight away from the wobble plate element 58 adjacent the upper edge of the counterweight 65 as viewed in FIGURE 5.

The slides 56 are secured to and are adapted to be reciprocated by means of a cup-shaped piston element 72 which is slidably mounted on the shaft 50. The cup-shaped piston element 72 cooperates with a stationary internal piston like member 74 so as to form an expansible chamber 76. The size of the expansible chamber is varied by supplying lubricant under pressure into the chamber 76. At high lubricant pressures, the cup-shaped piston element 72 will be shifted to the left, as viewed in FIGURE 1, so as to cause the slides 56 which carry the pins 57 to move to the left. Movement of the slide 56 to the left as viewed in FIGURE 1 serves to reduce the angle of the wobble plate element 58. The arrangement is such that in the extreme position of movement of the slide element 56, the wobble plate will be disposed in a plane perpendicular to the axis of rotation of the shaft so as to render the compressor ineffective to compressed refrigerant. FIGURE 1 shows the arrangement of the wobble plate for maximum compressor capacity whereas FIGURE 5 shows the arrangement for reduced capacity operation.

A gear type oil pump is provided which includes an external gear 80 pivotally supported on a stationary pin 82 and an internal gear element 84 drivingly connected to the inner end of the drive shaft 50 so as to be driven thereby. As best shown in FIGURES 3 and 4, the oil pump has a first inlet 86 which serves to withdraw lubricant from the main oil sump formed in the lower part of the compressor housing and a secondary inlet 88 which may be selectively connected by the valve 92 to either to the oil return line 30 leading from the bottom of the evaporator or to the line 90 leading to the compressor modulation control cylinder 76.

As best shown in FIGURES 3 and 4 of the drawings, the valve element 92 is controlled in response to movement of a diaphragm element 94. The diaphragm element 94 forms one wall of a pressure chamber designated by the reference numeral 96 which is connected to the oil return line 30 whereby the pressure within the chamber 96 corresponds to the pressure within the evaporator 16. When the evaporator pressure falls below a predetermined value such as when little or no refrigeration is required, the diaphragm 94 will move the valve element 92 into the position in which it is shown in FIGURE 4. When the valve element 92 occupies the position in which it is shown in FIGURE 4, the secondary inlet 88 of the oil pump is directly connected to the oil return line 30 through the passage 100 formed in the valve element 92 and the passage 102 formed in the outer valve housing 104. By virtue of this arrangement, it is obvious that lubricant can be returned to the compressor even though the control calls for little or no refrigeration. The arrangement is such that if for any reason the main supply of lubricant has migrated to the condenser 24 and the receiver 26 so as to leave the evaporator 16 and the oil sump in the compressor devoid of the necessary amount of lubricant for satisfying the needs of the oil pump, the outlet pressure of the oil pump will drop to the point where the lowered pressure in the compressor modulating chamber 76 will cause the compressor to be operated at increased capacity so as to flush the oil from the condenser and the receiver into the evaporator from whence it will be returned to the inlet of the oil pump. When the necessary oil has been made available for use by the oil pump, the compressor will be unloaded again if no refrigeration is needed.

The diaphragm 94 is biased into its uppermost position by means of a coil spring 106 which is arranged as shown. A manually controlled temperature control lever 110 is provided as shown. One end of this lever 110 is pivotally secured to a fixed pivot 112 and the other end may be manually set in any desired position. When the lever 110 is in the off position, the valve element 92 is held in the position in which it is shown in FIGURE 4 irrespective of variations in evaporator pressure. In this position the oil pump inlet line 88 is directly connected to the oil return line 30 by the valve element 92.

As best shown in FIGURES 3 and 4, the secondary inlet to the oil pump is connected to the compressor modulation cylinder through the line 90 and the passages 113 and 116. Thus, when the temperature control lever 110 is set in the position designated as cooler and when the evaporator pressure is relatively high, the valve element 92 will occupy the position in which it is shown in FIGURE 3 with the result that no pressure build up can take place in the compressor modulation cylinder 76 with the result that the compressor will operate at maximum capacity. When the evaporator pressure decreases, the diaphragm 94 will be pulled downwardly and will carry with it the valve element 92 so as to begin to unload the compressor. This prevents reducing the evaporator pressure to the point where freeze up of the evaporator might otherwise occur. While FIGURE 3 shows the valve in the position in which the compressor would operate at full capacity and FIGURE 4 shows the control valve 92 in the position in which the compressor would operate at zero capacity, it is obvious that in intermediate positions of the control valve 92 the pressure within the modulation cylinder would be modulated so as to provide compressor capacities between maximum and minimum.

A check valve 118 is provided in the passage 120 which leads from the outlet of the oil pump to the bottom inlet of the control valve 92. When the control valve 92 is in its upper position, the check valve 118 prevents high pressure oil from flowing into the passage 90 which leads to the compressor unloading chamber 76. In this position of the valve 92 and the check valve 118 the oil pump inlet 88 is connected to the passage 90 so as to reduce build up of pressure in the chamber 76. When the control valve 92 moves downwardly, it moves the check valve 118 downwardly so as to connect the passages 90 and 120 and so as to close the lower end of the passage 116 whereby the oil pump can not withdraw lubricant from the passage 90.

As shown in FIGURES 3 and 4, the outlet of the oil pump is at all times connected to a series of oil feed passages 122 formed in the cylinder block 40 and the drive shaft 50 so as to feed lubricant to all parts of the compressor requiring lubrication. As shown in FIGURE 1 of the drawings, an unloader passage 124 connects the inlet chamber 51 and the discharge chamber 53. An oil pressure operated unloader valve 126 is disposed to control flow through the passage 124 whereby the compressor is unloaded when the oil pressure applied to the upper side of the diaphragm 128 is inadequate to hold the valve 126 closed such as when the compressor stops.

The lever 110 is preferably in the form of a blade spring which can flex a limited amount as the valve plunger 92 moves in response to changes in the balance of forces which tend to move the plunger 92. The one end of the blade spring is pivotally mounted at a fixed point as shown and the other end is manually set at the desired operating condition.

While the embodiment of the present invention as herein disclosed, constitutes a preferred form, it is to be understood that other forms might be adopted.

What is claimed is as follows:

1. In an automobile air conditioning system, the combination, an evaporator for cooling air for the passenger compartment of an automobile, a compressor, a condenser, refrigerant flow connections between said compressor, condenser and evaporator, said compressor including a main housing, a drive shaft journaled in said housing and arranged to be driven by the car engine, said housing having an oil sump formed therein, an oil return line from said evaporator to said housing, an oil pump operated by said shaft, compressor output modulation

means, an expansible chamber type of actuator for said modulation means, means connecting the outlet of said oil pump to said expansible chamber, valve means selectively connecting the inlet of said pump to said expansible chamber or to said oil return line, and means responsive to the pressure in said evaporator for actuating said valve means.

2. In an automobile air conditioning system, the combination, an evaporator for cooling air for the passenger compartment of an automobile, a compressor, a condenser, refrigerant flow connections between said compressor, condenser and evaporator, said compressor including a main housing, a drive shaft journaled in said housing and arranged to be driven by the car engine, said housing having an oil sump formed therein, an oil return line from said evaporator to said housing, an oil pump operated by said shaft, compressor output modulation means, an expansible chamber type of actuator for said modulation means, means connecting the outlet of said oil pump to said expansible chamber, valve means selectively connecting the inlet of said pump to said expansible chamber or to said oil return line, and means responsive to the pressure in said evaporator for actuating said valve means, said valve means comprising a valve guide, a valve stem slidably mounted in said guide, means forming a fluid chamber adjacent one end of said valve stem having one wall in the form of a diaphragm abutting said valve stem, said oil return line communicating with said fluid chamber.

3. In an automobile air conditioning system, an evaporator for cooling air for the passenger compartment of said automobile, a compressor, a condenser, refrigerant flow connections between said compressor, condenser and evaporator, said compressor including a main housing, a drive shaft journaled in said housing and arranged to be driven by the car engine, a wobble plate carried by said drive shaft, a plurality of compressing units driven by said wobble plate, a compressor output modulation means for varying the angle of said wobble plate so as to vary the output of said units, an actuator for said modulation means including means forming an expansible chamber surrounding said drive shaft, an oil return line from said evaporator to said housing, an oil pump operated by said shaft, means connecting the outlet of said oil pump to said expansible chamber, valve means selectively connecting the inlet of said pump to said expansible chamber or to said oil return line, and means responsive to the pressure in said evaporator for actuating said valve means.

4. In an automobile air conditioning system, an evaporator for cooling air for the passenger compartment of an automobile, a compressor, a condenser, refrigerant flow connections between said compressor, condenser and evaporator, said compressor including a main housing, a cylindrical block disposed within said housing and having a plurality of compression chambers therein, a drive shaft journaled in said housing and arranged to be drivingly connected to the car engine, a wobble plate supported on said drive shaft, a plurality of piston means drivingly connected to said wobble plate and arranged to operate in said compression chambers, compressor output modulation means including means for varying the angle of said wobble plate, an expansible chamber type of actuator for said modulation means, an oil return line from said evaporator to said housing, an oil pump operated by said shaft, means connecting the outlet of said oil pump to said expansible chamber, valve means selectively connecting the inlet of said pump either to said expansible chamber or to said oil return line, and means responsive to the pressure in said evaporator for actuating said valve means so as to reduce the output of said compressor as the pressure in said evaporator is reduced.

5. In an automobile air conditioning system, an evaporator for cooling air for the passenger compartment of said automobile, a compressor, a condenser, refrigerant flow connections between said compressor, condenser and evaporator, said compressor including a main housing, a compressor drive shaft, an oil return line from said evaporator to said housing, an oil pump operated by said shaft, a wobble plate carried by said drive shaft, a plurality of compressing units driven by said wobble plate, a compressor output modulation means for varying the angle of said wobble plate so as to vary the output of said units, an actuator for said modulation means including an expansible chamber, means connecting the outlet of said oil pump to said expansible chamber, valve means selectively connecting the inlet of said pump to said expansible chamber or to said oil return line, and means responsive to the pressure in said evaporator for actuating said valve means.

6. In a refrigerating system; a compressor; a condenser; an evaporator; means connecting said compressor, condenser and evaporator in refrigerant flow relationship; said compressor comprising a housing, a cylinder block disposed within said housing, a drive shaft having its one end journaled in one wall of said housing and its other end journaled in said cylinder block, said cylinder block having a plurality of cylinder bores formed therein substantially parallel to the axis of said shaft, pistons arranged to reciprocate in said cylinder bores and a wobble plate drive mechanism operated in response to rotation of said shaft and drivingly connected to said pistons; compressor output modulation means for varying the angle of said wobble plate relative to said drive shaft; an expansible chamber type of actuator for said modulation means; an oil pump drivingly connected to said shaft; means connecting the outlet of said oil pump to said expansible chamber; valve means for selectively connecting the inlet of said pump to said expansible chamber or to the bottom portion of said evaporator; and means responsive to the pressure in said evaporator for actuating said valve means.

7. In a refrigerating system, the combination, a condenser, an evaporator, a compressor housing, a cylinder block disposed within said housing, a drive shaft, said cylinder block having a plurality of cylinder bores formed therein substantially parallel to the axis of said shaft, pistons arranged to reciprocate in said cylinder bores, a wobble plate drive mechanism disposed on said shaft and operated in response to rotation of said shaft, said drive mechanism being connected to said pistons so as to cause reciprocation of said pistons, compressor output modulation means for varying the angle of said wobble plate relative to said drive shaft, an expansible chamber type of actuator for said modulation means, an oil pump drivingly connected to said shaft, means connecting the outlet of said oil pump to said expansible chamber, valve means for selectively connecting the inlet of said pump to said expansible chamber or to the bottom portion of said evaporator, and means responsive to the pressure in said evaporator for actuating said valve means.

8. In a refrigerating system, the combination, a condenser, an evaporator, a compressor housing, a cylinder block disposed within said housing, a drive shaft within said housing, said cylinder block having a plurality of cylinder bores formed therein substantially parallel to the axis of said shaft, pistons arranged to reciprocate in said cylinder bores, a wobble plate drive mechanism operated in response to rotation of said shaft and drivingly connected to said pistons, compressor output modulation means for varying the angle of said wobble plate relative to said drive shaft, an expansible chamber type of actuator for said modulation means, an oil pump drivingly connected to said shaft, means connecting the outlet of said oil pump to said expansible chamber, valve means for selectively connecting the inlet of said pump to said expansible chamber or to the bottom portion of said evaporator, and means responsive to the pressure in said evaporator for actuating said valve means.

9. In an automobile air conditioning system, an evaporator for cooling air for the passenger compartment of said automobile, a compressor, a condenser, refrigerant flow connections between said compressor, condenser and evaporator, said compressor including a main housing, a drive shaft journaled in said housing, an oil return line from said evaporator to said housing, an oil pump driven by said shaft, refrigerant compressing means driven by said shaft, output modulation means for varying the output of said compressing means, an actuator for said output modulation means including an expansible chamber power unit, means connecting the outlet of said oil pump to said expansible chamber power unit, valve means selectively connecting the inlet of said pump to said expansible chamber power unit or to said oil return line, and means responsive to the pressure in said evaporator for actuating said valve means.

10. In an automobile air conditioning system, the combination, an evaporator for cooling air for the passenger compartment of an automobile, a compressor, a condenser, refrigerant flow connections between said compressor, condenser and evaporator, said compressor including a main housing, a drive shaft journaled in said housing and arranged to be driven by the car engine, said housing having an oil sump therein, compressor output modulating means including an expansible chamber type of actuator, an oil pump operated by said shaft and having an inlet communicating with said oil sump, means including a modulating valve connecting the inlet of said pump to said chamber, means for connecting the outlet of said pump to said chamber, said valve comprising a valve guide, a valve stem slidably mounted in said guide, means forming a fluid chamber adjacent one end of said valve stem, one wall of said fluid chamber comprising a flexible diaphragm arranged to actuate said valve stem, means for returning oil from said evaporator to said fluid chamber whereby said diaphragm is responsive to changes in pressure within said evaporator.

11. In an automobile air conditioning system, the combination, an evaporator for cooling air for the passenger compartment of an automobile, a compressor, a condenser, refrigerant flow connections between said compressor, condenser and evaporator, said compressor including a main housing, a drive shaft journaled in said housing and arranged to be driven by the car engine, said housing having an oil sump therein, compressor output modulating means including an expansible chamber type of actuator, an oil pump operated by said shaft and having an inlet communicating with said oil sump, means including a modulating valve connecting the inlet of said pump to said chamber, means for connecting the outlet of said pump to said chamber, said valve comprising a valve guide, a valve stem slidably mounted in said guide, means forming a fluid chamber adjacent one end of said valve stem, one wall of said fluid chamber comprising a flexible diaphragm arranged to actuate said valve stem, means for returning oil from said evaporator to said fluid

chamber whereby said diaphragm is responsive to changes in pressure within said evaporator, said compressor having an inlet port communicating with the outlet of said evaporator and an outlet port communicating with the inlet of said condenser, a valve between said outlet port and said condenser preventing reverse flow of fluid from said condenser to said compressor, and means responsive to a given decrease in pressure at the outlet of said oil pump for connecting said inlet port and said outlet port so as to unload said compressor.

12. In an automobile air conditioning system, the combination, an evaporator for cooling air for the passenger compartment of an automobile, a compressor, a condenser, refrigerant flow connections between said compressor, condenser and evaporator, said compressor including a main housing, a drive shaft journaled in said housing and arranged to be driven by the car engine, said housing having an oil sump therein, compressor output modulating means including an expansible chamber type of actuator, an oil pump operated by said shaft, means including a valve for selectively connecting the inlet of said pump to said expansible chamber or to the bottom of said evaporator comprising a valve guide, a valve stem slidably mounted in said guide, means forming a fluid chamber adjacent one end of said valve stem, one wall of said fluid chamber comprising a flexible diaphragm arranged to actuate said valve stem, means for returning oil from said evaporator to said fluid chamber whereby said diaphragm is responsive to changes in pressure within said evaporator.

13. In an automobile air conditioning system, the combination, an evaporator for cooling air for the passenger compartment of an automobile, a compressor, a condenser, refrigerant flow connections between said compressor, condenser and evaporator, said compressor including a main housing, a drive shaft journaled in said housing and arranged to be driven by the car engine, said housing having an oil sump therein, compressor output modulating means including an expansible chamber type of actuator, an oil pump operated by said shaft, means including a valve responsive to the pressure in said evaporator connecting the inlet of said pump to said expansible chamber, means for connecting the outlet of said pump to said chamber, said valve means comprising a valve guide, a valve stem slidably mounted in said guide, means forming a fluid chamber adjacent one end of said valve stem, one wall of said fluid chamber comprising a flexible diaphragm arranged to actuate said valve stem, and means for returning oil from said evaporator to said fluid chamber whereby said diaphragm is responsive to changes in pressure within said evaporator.

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