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REFRIGERATION SYSTEM WITH VARIABLE SPEED COMPRESSOR

Filed April 14, 1959

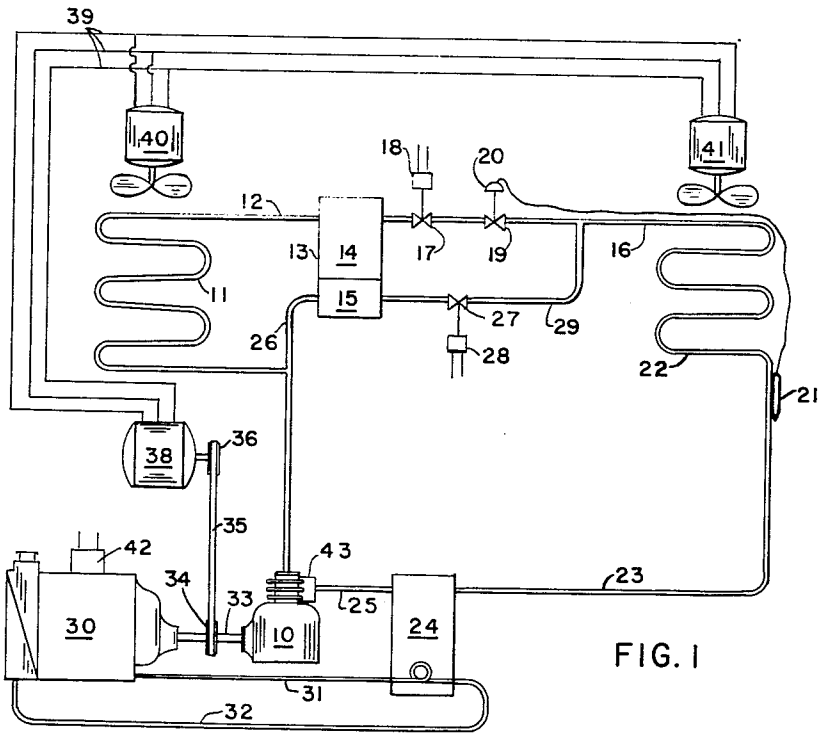


FIG. 1

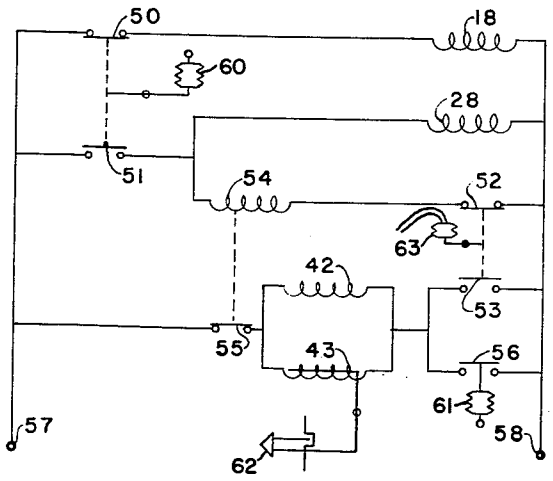


FIG. 2

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REFRIGERATION SYSTEM WITH VARIABLE SPEED COMPRESSOR

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This invention relates to controlling the temperature of an enclosed space and more particularly to a system adapted to condition the air in a cargo space of a mobile truck or railway freight car.

It is well known in the art that a refrigeration system which is capable of providing both heating and cooling to a refrigerator car is not required to operate at full capacity at all times and that some means for reducing the capacity of the system is desirable. If, for example, the refrigeration system includes a compressor driven by an internal combustion engine a significant decrease in wear of the compressor and engine parts may be achieved by operating the engine at low speed when full refrigeration capacity is not demanded of the system. In addition, by operating a refrigeration system in this manner a substantial saving in fuel consumption may be effected and substantially lower sound levels achieved as well as a reduction in the noxious exhaust fumes produced by the engine which are desirable or necessary features when such a system is operated within a city or depot. Since the use of an evaporator fan is generally necessary to the efficient operation of an air conditioning system such as might be employed in a railroad refrigeration car, it is desirable to operate the fan at a low speed when the cooling demand of the cargo space is substantially satisfied in order to reduce the power consumed and to produce the least amount of dehydration of the cargo which may include fresh or frozen foods which are generally adversely affected by dehumidification. In order to prevent dehumidification of the cargo in a refrigerator car, it is further desirable that the temperature of the evaporator coil be maintained close to the desired air or operating temperature of the area to be conditioned. However, under extreme conditions of temperature and at times when it is necessary to pull down the temperature of the cargo from the ambient temperature to the operating temperature, a high cooling capacity and low evaporator temperature is desirable. At other times it may be desirable to operate the refrigeration system in a manner to supply heat from the coil serving the cargo space in order to maintain the cargo at a desired temperature.

It is also desirable to design a refrigeration system so that it employs standard components of relatively small size and low initial cost and to employ an internal combustion engine operating the refrigeration system which is as small as possible and still provides sufficient power during pull down. However, when using a relatively small engine for this purpose, it is desirable to provide some type of protection both to prevent high head pressures in the compressor from damaging the components of the system and to prevent high operating loads from stalling the engine.

Accordingly, it is an object of this invention to provide an improved refrigeration system of the type employing an internal combustion engine wherein the speed of the engine, fans and compressor may be decreased in response to decreases in cooling demand of the area to be conditioned.

It is a further object of this invention to provide a refrigeration system which will tend to maintain a relatively uniform temperature and a high level of humidity in the area to be conditioned.

It is a further object of this invention to provide a refrigeration system having means to reduce the speed of operation of components of the system under conditions of abnormally high loads or pressures and which may unload the compressor to prevent the engine from stalling.

It is a further object of this invention to provide a refrigeration system employing an internal combustion engine of minimal size for the refrigeration capacity required of the system.

It is a further object of this invention to provide a head pressure control in a refrigeration system which is capable of unloading the compressor and reducing the speed of operation of the engine employed in the system in response to a predetermined condition of high head pressure.

It is a further object of this invention to provide an improved control arrangement for a refrigeration system which will operate the system at varying speeds depending upon the demand made on the system and provide either heating or cooling when necessary.

These and other objects of my invention which will become apparent by reference to the following description and attached drawings are achieved in the preferred embodiment by providing a dual speed internal combustion engine directly driving the compressor of a refrigeration system. The refrigeration system is provided with a hot gas circuit to supply hot gas to the evaporator coil for heating and so as to remove accumulated ice if such should exist when the system is not required to produce refrigeration. A control circuit is provided for the refrigeration system saving a thermostat which controls the throttle of the dual speed engine so that as the temperature of the space to be conditioned approaches the desired operating temperature, the dual speed engine is operated at its lower speed and in addition the compressor may be partially unloaded under these conditions. The evaporator and condenser fans employed in the refrigeration system derive their power from an alternator which is driven by the dual speed engine and the fan speed is reduced in proportion to the reduction of engine speed by reason of the lower frequency voltage output of the alternator when the system is operated at partial capacity. A high head pressure safety control reduces the operating speed and unloads the compressor under conditions of high heads experienced by the compressor.

In the drawings:

FIGURE 1 is a schematic diagram of a refrigeration system embodying the present invention; and

FIGURE 2 is a schematic diagram of the electrical control circuit of the present invention.

Referring to the drawings and more particularly to FIGURE 1, in the preferred embodiment of my invention I provide a refrigeration system for conditioning the cargo space of a railway refrigeration car or truck which comprises a reciprocating three cylinder compressor **10** discharging into a condenser **11**. The condenser **11** discharges liquid refrigerant through line **12** into receiver **13** having a first compartment **14** and a second compartment **15** for the purpose of which will be more fully explained. From receiver **13** liquid refrigerant is conducted to evaporator **22** through liquid line **16** which is interrupted by liquid line solenoid valve **17** actuated by solenoid **18**. Liquid line **16** has an expansion device **19** therein which may be a conventional expansion valve actuated by a diaphragm **20** and a sensing element **21** placed at an appropriate point in the refrigeration circuit as shown in the drawing. Suction line **23** conducts refrigerant from evaporator **22** through a reevaporator **24** from which suction line **25** conducts the refrigerant back into compressor **10** and the cycle repeated as will be understood by those skilled in the art.

A dual speed internal combustion diesel engine having

first and second predetermined operating speeds and a solenoid actuated throttle for selecting the operating speed directly drives compressor **10**. Engine **30** has a cooling system and fluid line **31** conducts the warmed cooling fluid from the engine through reevaporator **24** where it is placed in heat exchange relation with refrigerant in the reevaporator and subsequently returned to the engine cooling system through line **32**. Unvaporized liquid refrigerant from suction line **23** is placed in heat exchange relation with the cooling system of the engine to assure that all of the refrigerant reaching the compressor through suction line **25** is vaporized regardless of the mode of operation of the system.

The refrigeration circuit of the instant invention is provided with means to defrost accumulated ice which may be formed on the evaporator coil **22** under normal operating conditions and to provide heat to the area to be conditioned when the temperature drops below a predetermined desired operating temperature. The heating defrost system illustrated in the drawing comprises a hot gas line **26** leading directly from the discharge of the compressor cylinders into the second compartment **15** of receiver **13** then through a hot gas defrost and heating solenoid valve **27** actuated by solenoid **28** and from there into evaporator **22** bypassing expansion device **19**. When it is desired to defrost evaporator **22** the solenoid **18** actuates liquid line valve **17** and interrupts the refrigeration cycle by preventing flow of refrigerant into evaporator **22**. At the same time solenoid **28** opens hot gas valve **27** which permits hot gaseous refrigerant discharged by compressor **10** to flow through hot gas line **29** directly into the evaporator coil **22**. Refrigerant in compartment **14** of receiver **13** is vaporized and floods condenser **11** as explained in Patent No. 2,762,206, issued September 11, 1956 to C. M. Ashley. Initially, the hot gas may be partially condensed in the evaporator and absorbs heat from the evaporator coil melting ice which may have formed on its surface. The partially condensed refrigerant is then conducted through suction line **23** into reevaporator **24** where it is placed in heat exchange relation with the warm cooling fluid of the disel engine and is reevaporated so that it enters compressor **10** through suction line **25** in the vapor state as also explained in the patent referred to above.

Internal combustion enganie **30** directly drives compressor **10** through shaft **33**. Pulley **34** mounted on shaft **33** drives pulley **36** mounted on shaft **37** of alternator **38** by means of belt **35**. Alternator **38** produces an alternating three phase output current or voltage which serves the dual function of supplying power for the operation of condenser A.C. fan motor **40** and evaporator A.C. fan motor **41** and of supplying power to operate the control circuits of the refrigeration system. Fans **40** and **41** are of the alternating current type generally designed for 60 cycle operation.

Engine **30** is of the internal combustion type and in the embodiment described operates at two predetermined speeds. Throttle solenoid **42** adjusts the fuel supply of the engine and determines at which of the two predetermined speeds the engine will operate. Pulleys **34** and **36** are so constructed as to drive alternator **38** at a speed to produce a 60 cycle A.C. output voltage when engine **30** is operating at the higher of the two predetermined speeds. When engine **30** is operated at the lower of its two predetermined speeds alternator **38** will be driven at a lesser speed and consequently the frequency of its output voltage will be reduced in proportion to the change in engine speed. When the speed of engine **30** is reduced, it has been found that the speed of fans **40** and **41** will correspondingly decrease due to the decreased frequency of the voltage or current supplied to them by alternator **38** without adversely affecting the controls.

The control circuit employed with the refrigeration system of the instant invention is shown schematically in FIGURE 2. Electrical conductors **57** and **58** are connected to two of the three electrical output conductors **39** of alternator **38** which supplies power for the control mechanism. Connected between conductors **57** and **58** are three series legs of the control circuit. The first leg may comprise a first thermostatic switch having a pair of contacts **50** in series with liquid line solenoid **18** previously described. Contacts **50** are shown in FIGURE 2 as being normally closed when the first thermostat calls for full cooling of the area to be conditioned. The thermostat may be located at any convenient place preferably within the compartment or area to be conditioned. Solenoid **18** cooperates with liquid line valve **17**, which it controls, to maintain the valve open when solenoid **18** is energized and to close valve **17** when solenoid **18** is deenergized. It will be appreciated that alternatively contacts **50** may be normally open if desired when calling for full refrigeration in which event the solenoid **18** would maintain liquid line valve **17** open when the solenoid was deenergized and closed when the solenoid was energized.

The second leg of the control circuit comprises a second set of contacts **51** which may be associated with the first thermostatic switch and in a normally open position for full cooling as can be observed from the diagram. Contacts **50** and **51** actually form a single pole double throw switch under such circumstances since one contact of each pair is at all times connected to conductor **57**. The other contact of set **51** is connected to a parallel circuit comprising in one leg heating solenoid **28** which, as has been previously described, controls hot gas valve **27** and, in the arrangement shown, maintains valve **27** closed when solenoid **28** is deenergized. The other leg of the parallel circuit referred to may comprise relay solenoid **54** in series with a first set of contacts **52** of a high pressure switch which will presently be described.

The third leg of the control circuit may comprise relay contacts **55**, actuated by relay solenoid **54**, in series with a parallel circuit comprising throttle control solenoid **42** and suction valve unloading solenoid **43**. The parallel circuit formed by solenoids **42** and **43** is in series with a second parallel circuit formed by a second set of contacts **53** of the high pressure switch referred to above comprising one leg of the circuit and a set of contacts **56** of a second thermostatic switch comprising the other leg. It will be appreciated that the first and second thermostatic switches may be actuated by separate thermostats such as bellows **60** and **61** respectively, or may be actuated by a single thermostatic element having a plurality of sets of switch contacts adapted to be actuated at different temperatures.

Unloading solenoid **43** serves to actuate the suction valves **62** of two of the three cylinders of compressor **10** and to maintain the two suction valves of these cylinders in open position when it is energized thereby disabling two of the three cylinders of the compressor and unloading it by reducing the amount of work done by the compressor when the suction valves are open. Throttle solenoid **42** in circuit shown will cause engine **30** to operate at the higher of its two speeds when the solenoid is deenergized and will cause the engine to operate at the lower of its two speeds when it is energized.

The second thermostatic switch, referred to above, having contacts **56** is set to operate, in the circuit shown in the drawing, at a temperature a few degrees above the desired operating temperature of the area to be conditioned. If separate thermostats are employed, the thermostatic element of the second thermostatic switch may desirably be located near the thermostatic element of the first thermostatic switch to sense the temperature of the area being conditioned. The first thermostatic switch having contacts **50** and **51** is set to operate at the desired operating temperature for the area to be conditioned.

A high pressure switch having contacts **52** and **53**, which as shown in FIGURE 2 actually comprises a single pole double throw switch, is positioned in the refrigeration circuit so actuator **63** senses a predetermined ab-

normally high head pressure in the cylinders of compressor **10**. The high head pressure switch will generally be set to operate at a pressure just below that head pressure which will indicate a load on compressor **10** which may cause malfunctioning of the compressor or require so much power from engine **30** as to put it in danger of stalling.

In the circuit diagram shown in FIGURE 2 all contacts are in the position they will assume when the temperature of the area to be conditioned is sufficiently higher than the desired operating point set by the first thermostat such that the refrigeration system is operating at full capacity but without abnormally high head pressure in the compressor. It will be understood that in FIGURE 2 contacts **51**, **53** and **56** are shown as being in a normally open position and contacts **50**, **52** and **55** are shown in a normally closed position under those conditions. The particular configuration of open and closed contacts shown in FIGURE 2 is selected merely for convenience of illustration and that other arrangements of open or closed contacts may be employed to produce the same results by merely selecting valves in the refrigeration circuit which are normally open and closed depending on whether their associated solenoids are energized or deenergized as has been previously explained with reference to contacts **50** and valve **17** actuated by solenoid **18**.

In operation engine **30** is started and assuming that the first thermostat calls for full cooling, throttle **42** will be set in a position such that the engine runs at the higher of its two speeds. Liquid line valve **17** will be open and hot gas valve **27** will be closed under which circumstances refrigerant will be pumped from compressor **10** through condenser **11** into receiver **13** and from the receiver through expansion valve **19**, evaporator **22**, reevaporator **24** and back into compressor **10** causing cooling of the location in which the evaporator is placed. Both evaporator **22** and evaporator fan **41** will normally be placed in the cargo compartment of a refrigeration car or other vehicle and cause the same to be pulled down to the desired temperature. When engine **30** is running at full speed, evaporator fan **41** and condenser fan **40** will operate at full speed deriving their power from alternator **38** driven by the engine.

When the temperature of the area to be conditioned drops below the desired operating temperature, the control circuit will cause liquid line valve **17** to be closed and hot gas valve **27** to be opened. Refrigerant is then pumped from compressor **10** through compartment **15** of receiver **13** and directly into evaporator **22** through hot gas line **29**. If considerable frost has accumulated on evaporator **22** some of the hot gas from compressor **10** upon heating the cold evaporator may be condensed and flow through suction line **23** into reevaporator **24** where it will be reevaporated and passed through suction line **25** back to the compressor. Reference is made to Patent No. 2,762,206, issued September 11, 1956, to C. M. Ashley for a more complete description of similar defrosting systems and their application in a refrigeration system such as that of the instant invention.

The heating and defrosting operation may be continued until the head pressure in the compressor reaches a point where the high head pressure control switch is actuated. Alternatively, a temperature-responsive switch may be attached to the evaporator housing to sense a rise in temperature above the melting point of ice which would indicate that the evaporator has been defrosted. In the preferred embodiment, the first thermostat having contacts **50**, **51** will sense a rise in temperature of the conditioned area and put the system back on refrigeration at the proper time.

The operation of the control circuit shown in FIGURE 2 will now be described. The switches of the control circuit are shown in FIGURE 2 in the position that they would assume when the compartment to be conditioned is at a temperature sufficiently above the desired operating temperature to call for full cooling. Under these conditions the contacts **50** of the first thermostat are closed. Liquid line solenoid **18** is energized and therefore liquid line valve **17** is open permitting flow of refrigerant through the evaporator through evaporator **22** in a normal refrigeration cycle. Contacts **51** which as has been previously explained may be associated with first thermostat so as to form a single pole double throw switch are open under conditions calling for full cooling. Heating solenoid **28** is therefore deenergized and keeps hot gas valve **27** closed thereby blocking the entrance of hot refrigerant into evaporator **22**. Contacts **52** actuated by the high pressure switch are closed under circumstances where the compressor head pressures are not excessive. Since contacts **51** are open when the first thermostat calls for cooling, relay **54** is deenergized and contacts **55** associated therewith are closed. Where head pressures in the compressor are not excessive the contacts **53** in the third leg of the control circuit are open and where temperatures are above the desired operating point of the refrigeration system and the operating point of the second thermostat contacts **56** of the second thermostat are likewise open. Under these circumstances both throttle solenoid **42** and unloading solenoid **43** are deenergized so the engine is running at full speed and the compressor is fully loaded.

The second thermostat as previously described is set to operate at a temperature a few degrees above the desired operating temperature of the compartment to be conditioned. For example, if it is desired to maintain the cargo space of a refrigerator railway car at a temperature of 35° the second thermostat may be set to operate at 37°. When the cargo space reaches 37° on pull down contacts **56** of the second thermostat close. Closing contacts **56** actuates both throttle solenoid **42** and unloading solenoid **43** in parallel therewith. Energizing of throttle solenoid **42** actuates the throttle of engine **30** and causes it to reduce its speed to the lower of the two predetermined operating speeds. Energizing of unloading solenoid **43** causes the suction valves of two of the three cylinders in compressor **10** to remain open during their normal operation. This substantially reduces the amount of work which the compressor is called upon to perform and effectively reduces the load on engine **30** when the engine is operated at low speed and therefore consequently reduces the danger that the engine may stall at low speed.

Furthermore, as engine **30** operates at a lower speed the frequency of the output current or voltage of alternator **38** is correspondingly proportionally reduced. The reduction in output voltage frequency of alternator **38** correspondingly reduces the operating speeds of fan motors **40** and **41**. The power consumption of an A.C. fan motor is proportional to the cube of its speed and a significant reduction in power requirements by the fans is thereby achieved. For example, it has been found that engine **30** may be operated at 1800 r.p.m. on high speed and 1200 r.p.m. at low speed. If alternator **38** is driven so as to produce a 60 cycle output voltage at the 1800 r.p.m. speed of engine **30**, by dropping the engine speed to 1200 r.p.m. the output frequency of alternator **38** is reduced to 40 cycles and the fan speeds reduced proportionally without affecting the operation of the controls adversely.

The refrigeration system continues to operate at low speed cooling until the temperature of the area to be conditioned is brought down to the desired operating temperature set by the first thermostat. While the refrigeration system is operating at low speed the temperature of evaporator coil **22** is very close to the desired operating temperature and consequently a means of maintaining a high humidity in the refrigerated compartment may be achieved. As is well known in the art, it is generally highly desirable that the cargo space of a refrigerator

car be maintained at a relatively high humidity in order to properly preserve foods contained therein. Since evaporator **22** and evaporator fan **41** are generally positioned within the refrigeration compartment and the fan operated to cause circulation of the air within the compartment, the reduction of fan speed circulates a minimum of air in contact with food in the cargo space and consequently does not cause as much dehumidification of the food as would be experienced if a higher fan speed were employed. At low speed the amount of fuel consumed by the engine is substantially reduced and the wear on the parts of the engine and compressor is correspondingly reduced. Likewise the sound level of the equipment in operation is materially reduced over that of the high speed operating condition and the exhaust fumes produced by the engine are materially reduced.

When the temperature of the area to be conditioned reaches the desired operating point, the first thermostat which is set to operate at that point opens contacts **50** and closes contacts **51**. Opening of contacts **50** deenergizes liquid line solenoid **18** which interrupts the refrigeration circuit by closing liquid line valve **17**. At the same time closing contacts **51** energizes heating solenoid **28** which in turn opens hot gas valve **27** admitting hot gas from compressor **10** into evaporator **22** to defrost the evaporator if such is required and to supply heat to the conditioned area until the temperature of the area exceeds the desired operating temperature.

Closing contacts **51** also energizes relay **54** thereby opening contacts **55**. When contacts **55** are opened both unloading solenoid **43** and throttle solenoid **42** are deenergized. This reloads the compressor by permitting closure of the suction valves of all cylinders of compressor **10** and causes the engine **30** to go into high speed operation. It will be seen therefore that the defrosting operation is normally done at high speed with a fully loaded compressor and is generally accomplished in a short time interval.

If during the heating or cooling cycle of the refrigeration system excessively high head pressures are experienced by compressor **10**, the high pressure will actuate the high head pressure switch thereby opening contacts **52** and closing contacts **53**. Opening contacts **52** deenergizes relay **54** which closes contacts **55**. Closing contacts **55** energizes throttle solenoid **42** and unloading solenoid **43** thereby unloading compressor **10** and reducing the speed of engine **30** regardless of the position of contacts **56**, i.e. the second thermostat. It will be appreciated that if high head pressures occur while the refrigeration system of the instant invention is operating, either on the heating or the cooling cycle, above the predetermined maximum safe operating head pressure set by the head pressure control switch, the system will instantly go into low speed, unloaded operation providing reduced capacity heating or cooling. This in turn will prevent engine **30** from stalling and will prevent damage to the components of the refrigeration system. After the excessively high head pressure is reduced below the predetermined pressure, the head pressure switch will again close contacts **52** and open contacts **53** putting the system back into high speed operation assuming that the thermostats do not call for low speed operation.

When the temperature of the area to be conditioned rises on account of the hot gas flowing through evaporator **22** to a point above the desired operating temperature of the area to be conditioned, contacts **50** of the first thermostat will close while contacts **51** will open. This places the refrigeration system on low speed cooling again until such time as either the temperature in the area to be conditioned rises causing contacts **56** of the second thermostat to open, which puts the refrigeration system into high speed cooling, or until the temperature of the area to be conditioned drops causing contacts **50** to open and contacts **51** to close, putting the system on high speed heating.

It will be noted that in the system described engine **30** is always operating as is compressor **10** and that the system is always either heating or cooling the conditioned area. If, however, it is desired to provide a dead band between heating and cooling the same may be achieved by disassociating contacts **51** from the first thermostat and associating them with a third thermostat or a third set of switch contacts which are actuated at a temperature slightly below the desired operating temperature.

By means of the system described I am enabled to provide a refrigeration system suitable for use in a railway refrigeration car or other transportation cooling system which employs standard alternating current components throughout and which is simple in operation and effective for the purposes desired. By providing a dual speed diesel engine in the system and a compressor which is unloaded and operated at low speed under high loads, I am enabled to employ an engine which may be sized for the anticipated normal cooling load imposed on the system. This results in cost economies because the engine need not be large enough to supply all of the power that would be required if the compressor were fully loaded and operating at high speed during severe operating conditions as might be experienced upon initial pull down of the cargo space. Further, low speed operation of the engine enables quiet and economical operation of the refrigeration system when maximum cooling capacity is not required. The overall power consumption of the refrigeration system on low speed operation is further reduced by operating the fans at low speed due to the change in alternator voltage frequency while at the same time I have found that the alternator voltage and frequency is sufficient to operate standard electric and thermostatic controls. If, for any reason, the first thermostatic switch should fail to operate, the engine and compressor are protected by the high head pressure switch from damage. In addition, low speed operation is desirable both from the standpoint of control of noxious exhaust fumes and reduction of noise should the refrigeration car be required to stand in a building or at a depot. Likewise, it has previously been noted that by operating the evaporator fans at reduced speed and the evaporator coil at a temperature close to the desired operating temperature of the cargo space a relatively high humidity is maintained which is desirable in the preservation of many foods.

While I have shown and described the preferred form of my invention it will be appreciated that the same may be otherwise embodied within the scope of the following claims.

I claim:

1. In a refrigeration system having a compressor, a variable speed internal combustion engine adapted to drive the compressor, an evaporator located in heat exchange relation with air being conditioned, a condenser and an expansion device connected to form a refrigeration system, said engine having two predetermined speeds of operation, speed control means associated with said engine to control its speed of operation, a thermostatically actuated control circuit for sensing the temperature of an area to be conditioned, said speed control means being regulated by said thermostatically actuated control circuit, an alternator adapted to be driven by said engine at a speed proportional to the speed of the engine and thereby adapted to provide an alternating electrical current output of a frequency proportional to the speed of operation of the engine, a fan having an A.C. motor associated with said refrigeration system, said fan motor being electrically connected to and deriving its power from said alternator thereby having an operating speed proportional to the frequency of the electrical output of said alternator, so that the speed of said fan and the capacity of said refrigeration system are changed in response to changes in the temperature of the area to be regulated.

2. A control circuit for a refrigeration system having a compressor driven by a dual speed internal combustion engine, an evaporator, an expansion device and a con-

denser connected to form a refrigeration system, comprising a first thermostatic switch having a pair of contacts, the thermostatic element of which is adapted to sense the temperature in an area to be conditioned and to actuate said first thermostatic switch at the desired operating temperature of said area, the contacts of said first thermostatic switch being in series with a relay solenoid, a high pressure switch adapted to sense abnormally high head pressures in the compressor of said refrigeration system and to be actuated thereby at a predetermined pressure, said high pressure switch having a pair of contacts in series with said first thermostatic switch and said relay solenoid to form a leg of said control circuit, said control circuit further comprising another leg connected in parallel with said first described leg and comprising a series connected circuit comprising a pair of contacts associated with said relay solenoid and connected in series with solenoid means for reducing the power demand on said internal combustion engine connected in series with a pair of sets of parallel connected switch contacts, one of said sets of contacts being actuated by said high pressure switch and the other being actuated by the thermostatic element of a second thermostatic switch adapted to sense the temperature of said area to be conditioned and to be actuated at a temperature a predetermined few degrees above the desired operating temperature of said area, and means to supply electrical current to the junctions of the two legs of said control circuit connected in parallel.

3. A control circuit for a refrigeration system having a compressor, an evaporator, a condenser, an expansion device and a dual speed internal combustion engine to drive the compressor wherein said engine has a predetermined high speed and a predetermined low speed operating condition, a throttle solenoid and a throttle adapted to be actuated by said throttle solenoid to control the speed of operation of said engine, said control circuit comprising a thermostatic switch in series with said throttle solenoid, the thermostatic element of said switch being adapted to sense the temperature of an area to be conditioned, said thermostatic switch and said solenoid throttle being adapted to co-act to change the speed of said engine in response to the cooling demand of the area to be conditioned, another thermostatic switch the thermostatic element of which is adapted to sense the temperature of the area to be conditioned, a solenoid valve in said refrigeration system adapted to interrupt the refrigeration cycle, the solenoid of said valve being in series with said other thermostatic switch and cooperating therewith to interrupt the refrigeration cycle when said other thermostatic switch is satisfied, the first named switch being adapted to be actuated at a predetermined temperature above the desired operating temperature and said other thermostatic switch being adapted to be actuated at said operating temperature, and an unloading solenoid also in series with said first named thermostatic switch adapted to unload a cylinder of said compressor when the temperature of the area to be controlled is lower than said predetermined temperature above the operating temperature.

4. A control circuit for a refrigeration system having a compressor, an evaporator, a condenser, an expansion device and a dual speed internal combustion engine to drive the compressor wherein said engine has a predetermined high speed and a predetermined low speed operating condition, a throttle solenoid and a throttle adapted to be actuated by said throttle solenoid to control the speed of operation of said engine, said control circuit comprising a thermostatic switch in series with said throttle solenoid, the thermostatic element of said switch being adapted to sense the temperature of an area to be conditioned, said thermostatic switch and said solenoid throttle being adapted to co-act to change the speed of said engine in response to the cooling demand of the area to be conditioned, another thermostatic switch the thermostatic element of which is adapted to sense the temperature of the area to be conditioned, a solenoid valve in said refrigeration system adapted to interrupt the refrigeration cycle, the solenoid of said valve being in series with said other thermostatic switch and cooperating therewith to interrupt the refrigeration cycle when said other thermostatic switch is satisfied, the first named switch being adapted to be actuated at a predetermined temperature above the desired operating temperature and said other thermostatic switch being adapted to be actuated at said operating temperature, and means to reduce the speed of said engine to the lower of the two predetermined speeds when the engine is operating at the higher of said predetermined speeds, comprising a compressor head pressure responsive switch associated with said compressor and adapted to actuate said throttle solenoid at a predetermined maximum head pressure in said compressor to reduce the compressor speed and thereby prevent stalling of said engine.

5. In combination: a refrigeration system comprising a compressor having a plurality of cylinders, a condenser, an expansion device, and an evaporator connected to form a refrigeration circuit; an engine operatively connected to drive said compressor, said engine having at least a first operating speed and a second operating speed, said first operating speed being greater than said second operating speed, and speed control means associated with said engine to reduce the speed thereof from said first operating speed to said second operating speed; refrigerant pressure sensing means to sense a refrigerant pressure condition of said refrigeration system which is indicative of a heavy load being imposed on said engine; compressor unloading means for unloading a cylinder of said compressor; and means to actuate said speed control means to reduce said engine speed from said first operating speed to said second operating speed and said compressor unloading means from a loaded condition to an unloaded condition of said compressor in response to said refrigerant pressure condition being sensed by said sensing means to thereby reduce the power demand on said engine when said sensing means senses a refrigerant pressure condition indicative of a heavy load being imposed on the engine.

6. In combination: a refrigeration system comprising a compressor having a plurality of cylinders, a condenser, an expansion device, and an evaporator connected to form a refrigeration circuit; an engine operatively connected to drive said compressor, said engine having at least a first operating speed and a second operating speed, said first operating speed being greater than said second operating speed, and speed control means associated with said engine to reduce the speed thereof from said first operating speed to said second operating speed; a fan associated with said refrigeration system, an alternating current fan motor connected to drive said fan, and an alternator driven by said engine at a speed proportional to the speed of said engine and electrically connected to said fan motor to supply current thereto of a frequency proportional to the speed of said engine so as to drive said fan at a speed proportional to the speed of said engine; refrigerant pressure sensing means to sense a refrigerant pressure condition of said refrigeration system which is indicative of a heavy load being imposed on said engine; compressor unloading means for unloading a cylinder of said compressor; and means to actuate said speed control means to reduce said engine speed from said first operating speed to said second operating speed and said compressor unloading means from a loaded condition to an unloaded condition of said compressor in response to said refrigerant pressure condition being sensed by said sensing means to thereby reduce the power demand on said engine when said sensing means senses a refrigerant pressure condition indicative of a heavy load being imposed on the engine, said reduction in engine speed also serving to reduce the speed of said fan and fan motor

thereby further reducing the power demand on said engine.

7. In a refrigeration system, a compressor, a dual speed internal combustion engine adapted to drive said compressor, said engine having first and second predetermined operating speeds, said first speed being higher than said second speed, pressure sensing means to sense a predetermined pressure condition in said refrigeration system, an evaporator, a condenser, and an expansion device connected with the compressor to form a refrigeration circuit, a fan having an A.C. motor associated with said refrigeration system said A.C. motor being adapted to drive said fan at a speed proportional to the frequency of the current supplied to it, an alternator adapted to be driven by said engine at a speed proportional to the speed of said engine, said alternator providing an alternating current electrical output having a frequency proportional to the driving speed thereof, said fan motor being electrically connected to and adapted to be driven by the electrical output of said alternator, said pressure sensing means

being operatively associated with said engine to reduce its speed from the predetermined first operating speed to the predetermined second operating speed to thereby reduce the speed of said compressor upon sensing said pressure condition, said system serving to reduce the load imposed on said engine by said alternator when the engine is operating at the reduced speed condition by reducing the speed of said fan motor proportionally to the reduction in speed of said engine.

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UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,010,289 November 28, 1961

Henry W. Kuklinski

It is hereby certified that error appears in the above numbered patent requiring correction and that the said Letters Patent should read as corrected below.

Column 2, line 30, for "saving" read -- having --; column 3, line 45, for "enganie" read -- engine --.

Signed and sealed this 17th day of April 1962.

(SEAL)
Attest:

ESTON G. JOHNSON
Attesting Officer

DAVID L. LADD
Commissioner of Patents