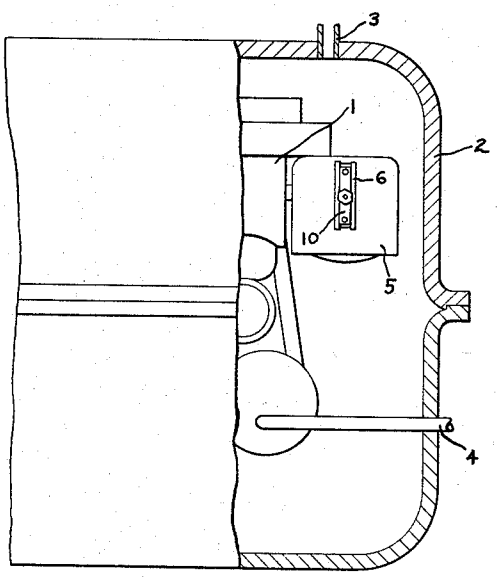
July 5, 1960 R. V. PRUCHA 2,943,638

FLOW RESTRICTING DEVICE

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FIG. 1



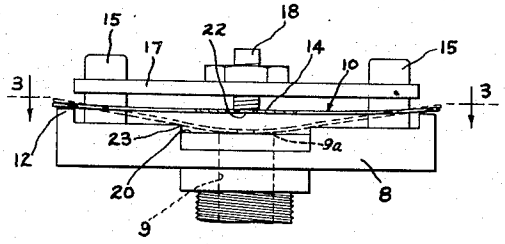


FIG. 2

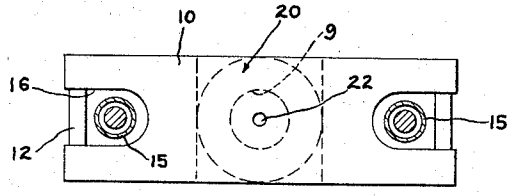


FIG. 3

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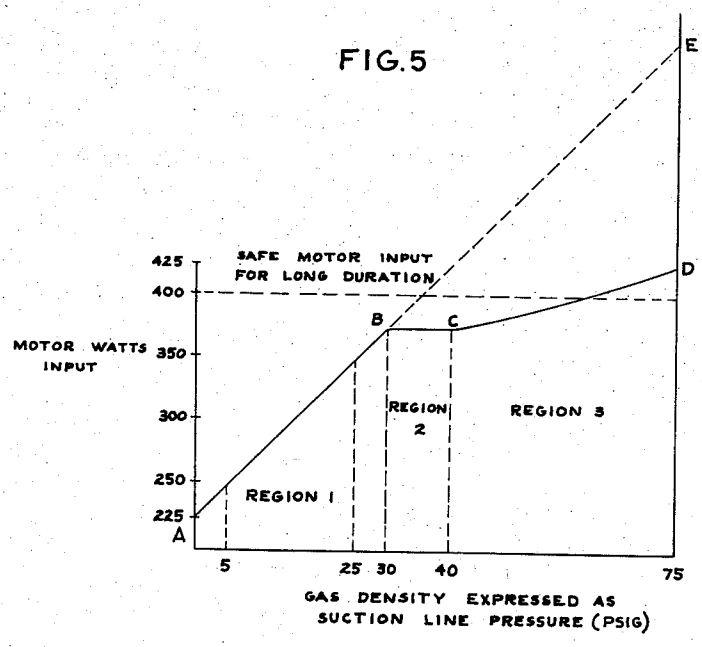
HIS ATTORNEY

July 5, 1960 R. V. PRUCHA 2,943,638

FLOW RESTRICTING DEVICE

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FIG. 5



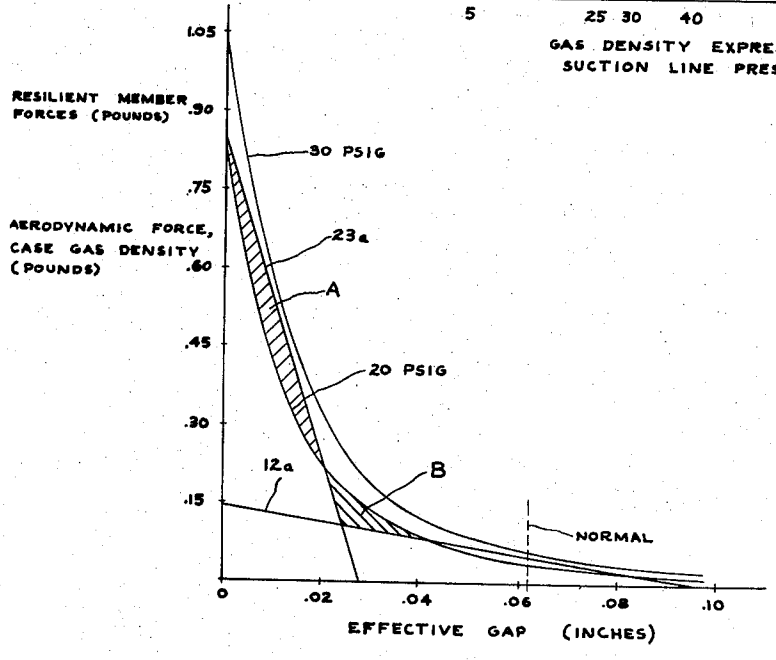


FIG. 4

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United States Patent Office 2,943,638 Patented July 5, 1960

2,943,638

FLOW RESTRICTING DEVICE

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Filed May 20, 1957, Ser. No. 660,184

2 Claims. (Cl. 137—498)

The present invention relates to a flow restricting device for restricting gas flow and is more particularly concerned with a device for use in connection with refrigerating apparatus for automatically limiting the load on the compressor drive motor.

During pull-down operation, a much larger load is imposed on the driving motor for a constant volume refrigerant compressor than is present during the normal operation of the system due to the fact that the refrigerant pressure on the suction or normally low pressure side of the system rises considerably when the compressor is not operating. Since the load on the compressor motor is proportional to the suction gas density or pressure, the motor capacity required for satisfactory pull-down is much higher than that required for normal operation of the refrigeration system at normal suction pressures. It is therefore desirable to provide some arrangement for limiting the load on the motor during pull-down conditions so that there can be employed a small or less expensive motor having a capacity just sufficient to drive the compressor under normal operating conditions. Also, in order to restore the system as quickly as possible to normal operating conditions following an idle period, it is desirable that the means for limiting the pull-down load positively restores the compressor to normal operation as quickly as possible.

Accordingly, it is an object of the present invention to provide a flow restricting device, the restricting and non-restricting operations of which are initiated by different densities of the gas, the flow of which is being controlled.

A further object of the invention is to provide a flow restricting device for controlling gas flow designed to provide a quick and positive flow restriction under abnormally high gas pressure conditions and also limit the restrictive period of operation to a minimum.

Further objects and advantages of the invention will become apparent as the following description proceeds and the features of novelty which characterize the invention will be pointed out with particularity in the claims annexed to and forming a part of this specification.

For a better understanding of the invention, reference may be had to the accompanying drawings in which:

Fig. 1 is a view, partially broken away, of a refrigerant compressor including the flow restricting device of the present invention;

Fig. 2 is an elevation view of the flow restricting device of the present invention;

Fig. 3 is a sectional view of the device of Fig. 2 along line 3—3 of Fig. 2;

Fig. 4 is a graph illustrating the operating forces characteristic of the flow restricting device of Fig. 2; and

Fig. 5 is a graph illustrating action of the restrictor in controlling motor load offered by the compressor.

Briefly described the flow restricting device of the present invention comprises a gas inlet port adapted to be connected to form part of the suction line of a refrigerant compressor or the like and means for limiting

the flow of gas through that port in the form of an elongated resilient member normally disposed ahead of the gas inlet port with the central portion thereof overlying the port in the path of the gas flowing to the port. Means are provided for supporting the end portions of the flexible member in this normal position whereby the unsupported portions of the flexible member are in the path of the gas flowing to the port, the spaces between the flexible member and the port opening forming a substantially unrestricted passage for gas flow to the port. The material characteristics and unsupported length of the resilient member are such that under normal gas pressure conditions, the flexible member remains in spaced relationship with the port but under a predetermined abnormally high pressure condition, the member, as a result of aerodynamic forces of the gas flowing to the port, flexes into a port restricting position in which the effective gas passage to the port limits the flow of gas and thereby provides overload protection for the compressor. In order positively to restore the flexible member to its normal operating position as soon as the overload condition is alleviated, means are provided for engaging the flexible member intermediate its end portions and its central portion when the member is in the port restricting position whereby the effective resilient forces of the flexible member are increased to a value overcoming the aerodynamic forces of the gas flowing through the restricted passage at gas densities that do not overload the compressor.

Referring now to Fig. 1 of the drawing, there is shown a compressor 1 within a hermetically sealed case 2, the compressor being driven by a suitable motor (not shown). The compressor forms part of a refrigerating system (not shown) from which vaporized refrigerant is supplied to the interior of the case 2 through a suction line 3. Compressed refrigerant is supplied from the compressor to the system through an exhaust line 4. A muffler 5 is provided at the compressor intake so that during operation of the compressor the suction gas from the interior of the case 2 is first drawn through the muffler 5 and then flows from the muffler 5 to the compressor 1.

The compressor of this type is designed to operate intermittently in response to the load requirements on the refrigerating system. During a prolonged idle period, the refrigerant pressures within the system tend to equalize so that the low side pressure within the hermetic casing 2 may rise for example from a normal operating suction pressure of about 25 p.s.i.g. to a pressure of 75 p.s.i.g., the latter value depending upon a number of factors including the ambient temperature conditions. Since a refrigerant compressor of this type is normally a constant volume compressor, a motor capable of driving the compressor at the normal suction pressure or density conditions is considerably overloaded at the higher suction gas pressures.

In order to limit the load on the compressor motor, an overload limiting device or flow restricting device 6 is provided at the inlet to the muffler 5. The flow restricting device of the present invention, as shown more clearly in Figs. 2 and 3, comprises a body member 8 including a cylindrical gas passage 9 terminating in an inlet port 9a which is connected directly to the muffler 5. For the purpose of limiting or restricting the flow of gas to the compressor 1 during overload conditions, or in other words under conditions in which the pressure of the suction gas in the case 2 is substantially higher than normal, there is provided a resilient member 10 supported by means of the body 8 ahead of and in line with the gas flow to the passage 9. For this purpose, the body 8 comprises a first pair of shoulders 12 which are adapted to engage the end portions of the resilient member 10 and to support this member with the center por-

tion 14 thereof in overlying relationship with the passage 9 and in the path of the gas flowing to that port. The flexible member 10 is retained in the position overlying the passage 9 by the studs 15 loosely engaged by the slotted sections 16 of the end portions of the resilient member 10 and a plate 17 fixedly secured to the studs and extending therebetween. An adjusting screw 18 carried by the plate 17 is designed to contact the central portion of the resilient member 10 in its normal position and to exert thereon a force sufficient to hold this member in contact with the shoulders 12 and prevent flutter thereof during pulsating operation of the compressor 1.

In its normal full-line position as shown in Fig. 2, the resilient member 10 forms with the face portion 20 of the inlet port 9*a* substantially unrestricted passage or passages for the gas flowing from the case 2 to the muffler 5. Also in this position in the path of gas flowing through the passage 9, the flexible member 10 is subjected to the aerodynamic forces of the flowing gas and these forces tend to move or flex the resilient member 10 downwardly towards the inlet port. The resilient member 10, preferably composed of spring steel or the like, is so designed that it has, in its normal position, an effective resilient force which overcomes or resists the aerodynamic forces of the gas at gas pressures corresponding to or in the neighborhood of those existing under normal operating conditions of the refrigerating system. The resilient member 10 is also so designed that, at a predetermined abnormally high gas pressure corresponding to that which would overload the compressor drive motor, the resultant increased aerodynamic forces of the gas flowing to the passage 9 will cause the resilient member 10 to flex downwardly into contact with the face 20 of the inlet port 9*a* and thereby substantially restrict the flow of gas to the port. In this restricting position the flexible member 10 may completely close the passage 9 or only partially close that passage. In order to provide for a minimum flow of gas under these overload conditions there is preferably provided an orifice 22 in the resilient member 10 which communicates with the passage 9 and forms the minimum restricted passageway for gas when the resilient member 10 is in its flow restricting position.

Since the aerodynamice forces acting upon the resilient member are a function not only of the gas pressure within the case 2 but also the size of the passage for the gas flowing to the passage 9, the aerodynamic forces acting upon the resilient member 10 when in its flow restricting position are much greater than those acting upon the member when in its normal position for the same gas pressure. Means are therefore provided in accordance with the present invention to return the resilient member 10 to its normal operating position at a gas pressure value which will not overload the compressor drive motor but which would otherwise maintain the resilient member 10 in its flow restricting position. For this purpose there is provided a pair of shoulders 23 on opposite sides of the inlet port 9*a*. These shoulders positively engage the flexible member 10 at points intermediate its end portions when the member 10 is in its flow restricting position thereby decreasing the unsupported length of the resilient member 10 and correspondingly increasing the effective resilient forces opposing the aerodynamic forces of the flowing gas. The shoulders 23 engage the resilient member 10 before the member contacts the inlet port 9*a* as the member moves from its normal position to its flow restricting position. As a result the resilient forces of the member 10 are able to overcome the aerodynamic forces of the gas flowing through the passage formed by the member 10 in its flow restricting position so that the member 10 returns to its non-restricting position at gas pressure conditions substantially higher than those which would continue to hold the resilient member 10 in its flow restricting position if it were supported at all times only by the outer shoulders 12.

This operation of the flow restricting device will better be understood by reference to Fig. 4 of the drawing.

In Fig. 4 of the drawing the curves indicated as 20 p.s.i.g. and 30 p.s.i.g. are plots of the aerodynamic gas forces on the resilient member 10 as a function of the size of the gap or passage between the resilient member and the face of the inert port at these two case pressures, it being understood that the 0 effective gap value represents the condition where a minimum flow of gas is obtained through the orifice 22. From a consideration of these two curves it can be seen that for a given case pressure, the aerodynamic forces rise sharply as the resilient member moves toward the face of the inlet port and restricts the gap or passage for gas to the inlet port. The straight lines on the graph represent the resilient or spring characteristics of the resilient member 10, the steeper line 23*a* representing the spring characteristics of the resilient member 10 when supported by the shoulders 23 or in other words when the resilient member is in its restricting position and the line 12*a* representing the spring characteristics of the member 10 when supported on the shoulders 12.

The flow restricting device having the properties plotted in Fig. 4 was designed to provide a normal passage for gas to the passage 9 equal to 0.0625 inch. As will be seen from Fig. 4 with the resilient member 10 in its normal position corresponding to an effective gap of 0.0625 inch, the gas density or pressure within the case 2 had to be at least 30 p.s.i.g. for the aerodynamic forces of the gas to equal or overcome the effective spring force. Therefore, at this pressure and at all higher case pressures, the gas force is great enough to cause the resilient member 10 to move to a restricting position relative to the inlet port 9. Thus during pull-down, case pressures in excess of 30 p.s.i.g. cause the resilient member 10 to seat relative to the inlet port within the first few strokes of compressor operation.

From a further consideration of the line 12*a* in Fig. 4 it will be seen that the resilient forces of the member 10 as supported only by the shoulders 12 would increase only slightly in its flexed or flow restricting (zero air gap) position. Therefore in the absence of some means for quickly returning the resilient member to its normal position, the case pressures would have to be considerably lower than the normal operating case pressure of 25 p.s.i.g.

By providing the second set of shoulders 23 for engaging the resilient member 10 in its closed position there is obtained an increased spring force characteristic represented by the line 23*a*. With this increased effective spring characteristic, it will be noted that the case pressure need be lowered only to approximately 20 p.s.i.g. under the zero gap condition in order that the resilient forces of the member 10 resting on shoulders 23 become larger than the aerodynamic forces of the flowing gas. The member 10 then snaps back to its normal operating position in which the effective gap or passage for gas is that indicated by the normal line 12*a* of Fig. 4. In this position the spring characteristics of the member 10 are sufficient to maintain the member 10 in its normal position. In this connection it may be noted that the cross sectioned area A between the 20 p.s.i.g. curve and the line 23*a* represents the energy for returning the resilient member 10 to its normal position while the cross sectioned area B between the curve 20 p.s.i.g. and the lines 12*a* and 23*a* represents the aerodynamic forces of the gas at this range of effective air gap conditions which must be overcome in order to complete the travel of the member 10 back to its normal position. Once the member has passed the point of intersection of line 12*a* and curve 20 p.s.i.g. at about 0.04 inch effective gap, the resilient member forces are always higher than the gas aerodynamic forces. This characteristic makes it possible to obtain positive removal of the restricting blade 10 from its restricting position by a sim-

ple and inexpensive means for shaping the spring force characteristic.

In Fig. 5, the action of the restrictor is illustrated in terms of motor watt input vs. gas density for a particular hermetic system and restrictor. This figure shows three distinct regions. Without a restrictor, the motor load characteristic is represented by the line AE, point E representing the motor load or overload at the start of pull-down at a suction pressure of 75 p.s.i.g. Region 1, which is the normal operating region falls on this characteristic namely within the portion of the curve designated by AB which is below the safe operating motor input for long duration. With the restrictor, the characteristic follows the curve ABCD. Region 1 falls on the portion of the curve AB where the restrictor blade 10 is resting against the stop 18 and does not restrict the gas flow. After a prolonged idle period, the gas density will be high, corresponding to a case pressure of approximately 75 p.s.i.g. The initial period of operation starts at point D and proceeds along line DC, passing through region 3. During this period of operation, blade 10 is firmly seated in the restricting position and the slope of line CD is determined by the size of the orifice 22 in blade 10. Operation in region 3 takes place for a very short period of time so that the safe load limit can be exceeded for a matter of seconds without damage to the motor. Operation very quickly reaches region 2, starting at point C whereby flexing of the blade relative to face 20, opens more area to gas flow and effectively holds the watt load constant. At point B, the restriction is no longer needed and the blade is designed to return by snap action to its normal position at approximately this point. The compressor then proceeds to operate under unrestricted suction line conditions.

While there has been shown and described a specific embodiment of the present invention it is to be understood that the invention is not limited to the particular construction shown and it is intended by the appended claims to cover all modifications within the spirit and scope of the invention.

What I claim as new and desire to secure by Letters Patent of the United States is:

1. A flow restricting device for limiting the flow of gas therethrough comprising a body having a gas passage extending therethrough and terminating in a port located on a surface of said body, an elongated resiliently flexible member for limiting the flow of gas through said port, first support means on said body engaging the end portions of said member for supporting said member in a normal position in a plane spaced from the surface plane of said body, said member having a central portion located in the path of gas flowing to said port, retaining means for loosely positioning said member on said first support means, said central portion having a flow restricting orifice therein, said member being capable of flexing movement in accordance with variations in the pressure of gas flowing to said port between said normal position in spaced relation with said port at normal gas pressures and a port restricting position in which said central portion contacts said port and restricts the flow of gas through said port at abnormally high gas pressures, the resiliency of the unsupported length of said member between said supports in said normal position being such that at a predetermined abnormal pressure of the gas flowing to said port said member moves to said port restricting position, and second support means on said body disposed between said first support means and laterally spaced from and on opposite sides of said port in a plane intermediate the surface plane of said body and the plane of said first support means, the plane of said second support means being spaced above the plane of said body a sufficient distance whereby said second support means engage said member intermediate said end portions and said central portion before said central portion contacts said port as said member moves to said port restricting position so as to decrease the unsupported length of said member and thereby increase the effective resiliency of said member when in said port restricting position for returning said member to said normal position at a gas pressure between said normal and abnormal gas pressures.

2. A flow restricting device for limiting the flow of gas therethrough comprising a body having a gas passage extending therethrough and terminating in a port located on a surface of said body, an elongated resiliently flexible member for limiting the flow of gas through said port, first support means engaging the end portions of said member for supporting said member in a normal position in a plane spaced from the surface plane of said body, said member having a central portion located in the path of gas flowing to said port, retaining means for loosely positioning said member on said first support means, said central portion having a flow restricting orifice therein, said member being capable of flexing movement in accordance with variations in the pressure of gas flowing to said port between said normal position in spaced relation with said port at normal gas pressures and a port restricting position in which said central portion contacts said port and restricts the flow of gas through said port at abnormally high gas pressures, the resiliency of the unsupported length of said member between said supports in said normal position being such that at a predetermined abnormal pressure of the gas flowing to said port said member moves to said port restricting position, and second support means disposed between said first support means and laterally spaced from and on opposite sides of said port in a plane intermediate the surface plane of said body and the plane of said first support means, the plane of said second support means being spaced above the plane of said body a sufficient distance whereby said second support means engage said member intermediate said end portions and said central portion before said central portion contacts said port as said member moves to said port restricting position so as to decrease the unsupported length of said member and thereby increase the effective resiliency of said member when in said port restricting position for returning said member to said normal position at a gas pressure between said normal and abnormal gas pressures.

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