April 19, 1966 A. A. MATTHIES 3,246,840

TEMPERATURE RESPONSIVE BIMETAL ACTUATED VALVE

Filed May 28, 1963

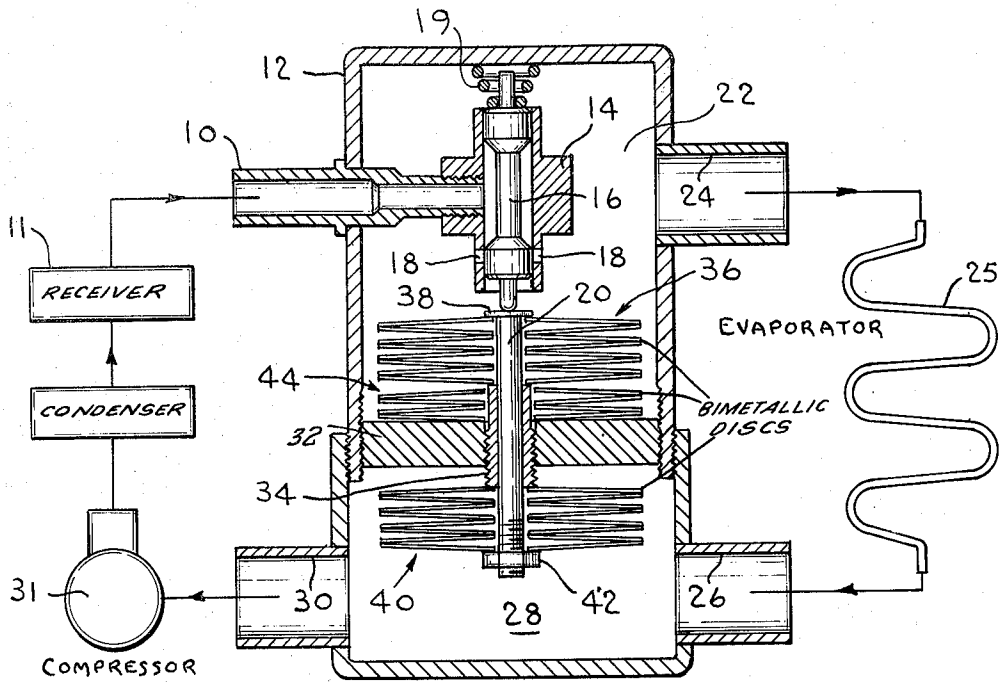


FIG. 1

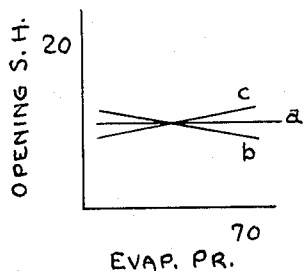


FIG. 2

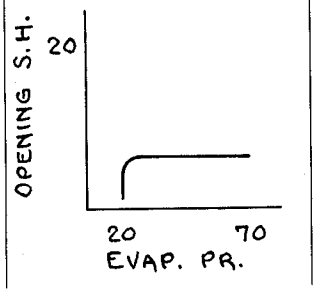


FIG. 3

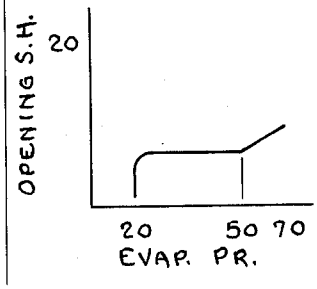


FIG. 4

INVENTOR.
ALAN A. MATTHIES
BY Bayard H. Michael
ATTORNEY

United States Patent Office 3,246,840
Patented Apr. 19, 1966

3,246,840

TEMPERATURE RESPONSIVE BIMETAL ACTUATED VALVE

Alan A. Matthies, Milwaukee, Wis., assignor to Controls Company of America, Melrose Park, Ill., a corporation of Delaware

Filed May 28, 1963, Ser. No. 283,877
9 Claims. (Cl. 236—91)

This invention relates to improved expansion valves for use in refrigeration systems.

An object of this invention is to provide an expansion valve having improved operating characteristics.

A further object of this invention is to eliminate pressure sensitive diaphragms, charged bulbs, and capillary tubing from expansion valves.

Another object is to provide an expansion valve which can operate at virtually any system pressure without adverse effect on its life.

A further object of the invention is to provide an expansion valve which does not lose control to external ambient conditions.

Other objects and advantages will be pointed out in, or be apparent from, the specification and claims, as will obvious modifications of the various embodiments shown in the drawings, in which:

FIG. 1 is a vertical section through the valve with the refrigeration system shown schematically; and

FIGS. 2, 3 and 4 are various exemplary superheat temperature-evaporator pressure curves which may be obtained with variations on the present construction.

Inlet **10** leading from the receiver **11** passes through the housing wall **12** to terminate in the central portion of sleeve **14** in which the balanced valve **16** is slidably mounted. Thus, the inlet pressure acts against the upper and lower ends of the balanced valve so as to have no effect on its operation. The valve is shown in the position it occupies when it has just cut off flow through the orifices or slots **18** in the lower portion of the sleeve. Spring **19** is compressed between the housing wall and the upper end of the valve to bias the valve to follow the motion of the valve operator **20**. When the valve **16** moves downwardly from its illustrated position, refrigerant will flow through the orifices **18** into chamber **22** and through outlet **24** to the system evaporator **25**. Flow from the evaporator comes back through fitting **26** into the lower chamber **28** and out through fitting **30** which leads to the inlet of compressor **31**.

Chambers **22** and **28** are separated by the partition wall **32** threadably mounted inside the housing **12**. Gland nut **34** is mounted in the central portion of partition **32** with its upper end projecting above the upper surface of the partition as illustrated. A bimetal stack **36** is mounted between the upper end of the gland nut and the underside of flange **38** on the top of valve operator **20** which passes through the gland nut.

The bimetal stack **36** consists of a plurality of predished bimetallic discs with their low expansion sides adjacent and their high expansion sides adjacent so that the stack tends to increase in thickness (or produce an increasing force) with an increase in temperature. Another bimetal stack **40** is mounted between the bottom of the gland **34** and nut **42** threaded on the lower end of the valve operator **20**. A third stack **44** rests on the top wall of the partition **32** and is designed, when operative, to increase in dimensional thickness to the point where it will act directly against the bimetal stack **36** and add its force to that of stack **36**.

It will now be appreciated that stacks **36** and **44** in chamber **22** are subjected to the temperature and pressure of the refrigerant entering the evaporator while stack **40** in chamber **28** is subjected to the temperature and pressure

of the refrigerant leaving the evaporator. For reference purposes, stack **36** will hereafter be referred to as the inlet stack while stack **40** can be referred to as the outlet stack. Since the construction just described permits of so many variations in operating characteristics, it is best to understand the various principles involved by considering some of the possibilities separately before the total structure and its possible variations are considered. Therefore, this discussion will first be directed towards operation of this type of valve as a thermostatic expansion valve and for this discussion, we might assume that the bimetal stack **44** is removed, leaving only stacks **36** and **40**. Let us further assume that these two stacks are identical in all respects and each will tend to increase its thickness as the temperature surrounding it increases. Under such circumstances, it will be apparent that the outlet stack **40** will have to be warmer than the inlet stack **36** for it to move the valve operator **20** in the valve opening direction. Since the refrigerant is always at its saturation temperature at the coil inlet and remains at that temperature throughout the coil until the last drop is boiled off, any increase in temperature at the evaporator outlet represents a refrigerant superheat condition (neglecting coil pressure drop). Any increase in evaporator load will increase the superheat or, put another way, the temperature at stack **40** which will result in an opening movement of the valve to pass more refrigerant to meet these increases in load and re-establish system balance.

As mentioned above, the valve is shown in the just closed position. Any desired superheat condition can be obtained by turning the valve partition wall in or out (up or down). In the illustrated position, there would be an approximate zero degrees opening-superheat setting. If the wall is turned in, the relative temperature rise of the outlet stack **40** with respect to inlet stack **36** necessary to open the valve will increase and, therefore, the superheat setting will be elevated. Whatever the setting, the superheat setting will remain constant without regard for operating pressure of the evaporator, as shown by the line A in the temperature-pressure curve of FIG. 2. It should be appreciated that changing the relative strength of the two stacks can be used to adjust the superheat curve of FIG. 2. Thus, if the outlet stack **40** is made more active (thicker or more powerful) than the inlet stack **36**, the curve can be made to slope downwardly, as illustrated by curve B in FIG. 2. The converse of this is true also, that is, if the inlet stack is more powerful than the outlet stack an upward slope such as curve C may be obtained.

One point should be noted here with respect to the foregoing description where it was said that any increase in temperature at the coil outlet represents a refrigerant superheat condition (neglecting coil pressure drop). Actually, there is always some coil pressure drop and it is of interest to note that the present construction can compensate for this quite readily. Thus, it will be noted that the valve operator shaft **20** is subjected to a pressure drop which will be equivalent to the evaporator pressure drop. This tends to feed more refrigerant to the coil which, in turn, tends to compensate for the increase in superheat which would normally result from coil pressure drop. The diameter of the operator shaft **20** can be selected to create a desired differential force such that the resultant deflection and valve opening compensate exactly for the pressure drop of the coil. Therefore, evaporator pressure drop is easily compensated without additional parts or cost and becomes virtually an inherent characteristic of the present expansion valve. This, therefore, overcomes a particularly troublesome problem of the prior art in a most satisfactory way.

The foregoing description of this valve operating as a thermostatic expansion valve eliminated stack **44**. It is interesting to note that this same basic construction can be

made to operate as an automatic expansion valve (a constant pressure valve) by the further elimination of the outlet stack 40. This would necessitate, of course, sealing the lower end of the gland nut 34 to prevent leakage down past the operator stem 20 and, in effect, the partition 32 can be considered the outside of the valve body. Under these conditions, there is only stack 36 left in operation and with this stack calibrated to control at any desired temperature it is obvious that any increase in evaporator temperature will result in heating the stack to decrease the refrigerant flow to bring about a decrease in evaporator temperature. Therefore, the control will maintain a constant evaporator pressure by sensing and modulating in response to the corresponding saturation temperature of the evaporator. While not shown on FIG. 2, this can be considered a vertical line on the chart.

The just described automatic expansion valve operation can be combined with thermostatic valve characteristics by using the construction shown in FIG. 1 except that stack 44 will still be removed and the operating characteristic of the outlet stack 40 will be modified so that it becomes slack (the over-all stack dimension becomes less than the dimension between the bottom of gland nut 34 and the retaining nut 42) at some predetermined low temperature with the result that it becomes functionless, since it is no longer able to balance out the inlet stack 36. At this predetermined temperature, the valve is controlled exclusively by the inlet stack so that the action is identical to that just described with respect to the automatic expansion valve operation per se. This gives a very unique characteristic in that the thermostatic expansion valve can be provided with a low temperature limit at which conversion takes place from thermostatic to automatic expansion valve operation. The curve obtainable with such an arrangement is shown in FIG. 3.

At this point in the description we can consider the active function of stack 44 which has been eliminated from consideration in the previous operational characteristics. This stack is designed to be slack at temperatures below a predetermined high temperature limit or knock-off temperature as it is known in the trade. On reaching this predetermined high temperature, the stack will have increased in dimension to the point where it starts acting against the underside of stack 36 to add its force to that of stack 36 which greatly increases the amount of bimetallic material subject to evaporator inlet conditions. The temperature at which this transition will take place can be calibrated by adjusting the projecting length of gland nut 34. The longer the projection, the higher the knock-off temperature. When the knock-off point is reached, the valve closing action with increasing evaporator temperature is much faster than when only stack 36 was operative. This has the net effect of sharply increasing the evaporator superheat (by starving the coil) and, therefore, limits the maximum temperature the evaporator can reach, regardless of load. This high temperature limit characteristic is important since it prevents overloading the compressor by limiting the flow of refrigerant to a safe maximum. By way of illustrating the versatility of the present control, this could still be combined with the automatic expansion valve (AXV) characteristic to result in an operational curve such as shown in FIG. 4. If the AXV characteristic was not desired, the vertical portion of this curve could be eliminated so that the straight line horizontal constant superheat thermostatic valve operation would obtain throughout the pressure range. It is of interest to note that both ends of the FIG. 4 curve can be made to move in the opposite direction with some modification to the present construction. Thus, the modified curve would have the flow pressure (flow temperature) curve rise vertically rather than drop vertically while the high pressure slope would become downward instead of upward. This is all done by moving stack 44 to chamber 28 to be slack below a predetermined high temperature and go solid (and become operational) at the predetermined high temperature and having the inlet stack 36 go slack when the evaporator temperature decreased to some predetermined level. This is not particularly significant from the standpoint of common refrigeration control practice, but is interesting insofar as it illustrates the extreme versatility of this construction and concept.

In the foregoing description, stacks 36 and 40 operate directly between a solid abutment and the valve operating shaft 20. If desired, a spring can be interposed between each although this still results in a constant superheat, assuming the stacks are equal and the springs are equal. This does permit modifying the curve, however, by keeping constant stacks and merely changing the spring rates applied between each stack and the valve operating shaft. Still another approach would be to interpose a spring between one stack only and the shaft. With these variations, the curves can be made adjustable without changing the size of the stack. A further design variation would be to have a stack comparable to stack 44 but so designed as to contract, rather than expand, with increasing temperature and thereby permit removing such a stack from operational consideration as the temperature goes up. Here again, such a stack could be placed to affect operation of either stack 36 or stack 40. Under some conditions, it may be desirable to employ auxiliary stacks comparable to 44 on both sides of the partition and these could be either expanding or contracting with increasing temperature or could be a combination. Thus, all of these ways of approaching any design problem will permit adjusting the curve to meet the requirements far better than anything heretofore proposed in this industry. Indeed, it is possible to provide a series of auxiliary stacks on one side or the other so as to become progressively effective or to be progressively removed from operation.

Although various embodiments of the present invention have been illustrated and described, it will be apparent to those skilled in the art that various changes and modifications may be made therein without departing from the spirit of the invention or from the scope of the appended claims.

I claim:

1. A valve comprising, a housing having a partition therein dividing the housing into first and second chambers, an inlet to and an outlet from each chamber, a balanced valve in the first chamber regulating flow therethrough unaffected by inlet or outlet pressures, a valve operator passing through the partition and connected to the valve while being subjected to the pressure differential between the chambers, a bimetal sensor in each chamber and connected to the operator to regulate the valve to maintain a desired temperature differential between the chambers, the size of the operator and the characteristics of the bimetal sensors being selected to influence valve motion to maintain desired temperature and pressure differentials between the chambers.

2. A valve comprising, a housing, a partition in the housing dividing the housing into first and second chambers, a valve operator passing through the partition, a bimetal stack in each chamber seated against the partition and connected to the operator, an inlet to and an outlet from each chamber, a valve in the first chamber for regulating flow from the inlet to the outlet, a third bimetal stack in one of the chambers engageable with the valve operator only in a portion of the operational temperature range of the valve to thereby modify the valve operation in said portion.

3. A valve comprising, a housing, a partition in the housing dividing the housing into first and second chambers, a valve operator passing through the partition, a bimetal stack in each chamber seated against the partition and connected to the operator, an inlet to and an outlet from each chamber, a valve in the first chamber for regulating flow from the inlet to the outlet, said partition being adjustably movable in the housing whereby the partition

and the bimetal stacks seated thereagainst may be moved as a unit to adjust the temperature differential between the chambers necessary to open the valve.

4. A valve according to claim 3 in which the operator is subjected to the pressure differential between the chambers and modifies the valve movement in accordance therewith.

5. A valve according to claim 4 in which the valve is of the balanced type unaffected by inlet pressure.

6. A valve comprising, a housing having first and second chambers, an inlet and an outlet for ecah chamber, a valve in the first chamber, a valve actuator, a bimetallic sensor in each chamber operatively engaging the actuator at all times whereby the movement of the actuator is determined by both sensors, and another sensor in one of the chambers having a lost motion connection to the operator whereby said another sensor affects movement of the actuator only in a portion of the temperature range.

7. A valve comprising, a housing, a partition dividing the housing into first and second chambers, an inlet and an outlet for each chamber, a boss threaded into the partition, a valve operator passing through the boss and partition, a stack of bimetals in each chamber, each stack seating on the boss and engaging the operator, a valve operated by the operator, and a third bimetal stack in one chamber having a lost motion connection with the other bimetal stack in that chamber and fitting between said other stack and the partition whereby the boss may be threadably adjusted relative to the partition to adjust the temperature at which the third stack becomes operative.

8. A valve according to claim 7 in which the partition

is threaded into the housing to permit adjustment of the bimetal stacks relative to the valve.

9. A valve comprising, a housing divided into two chambers each having an inlet and an outlet, valve means in one chamber for regulating flow therethrough, bimetal sensor means in each chamber, actuator means interconnecting the sensor means whereby the forces are opposed, said actuator means being connected to the valve means whereby the valve means is actuated in accordance with the net force and motion of the sensor means, and means for adjusting the actuator means and both sensor means as a unit relative to the valve means whereby the operating temperature differential of the valve may be adjusted.

References Cited by the Examiner

UNITED STATES PATENTS

990,772	4/1911	Pollard	62—212
1,219,515	3/1917	Whittelsey	236—93 X
2,159,819	5/1939	Snediker	236—12
2,651,467	9/1953	Troy	236—12
2,700,716	6/1955	Grooms	236—91
2,964,243	12/1960	Jorgensen	236—59
3,090,559	5/1963	Bayer	236—12
3,169,704	2/1965	Domm et al.	236—59

OTHER REFERENCES

Publication: "Principles of Industrial Process Control," by Eckman, pp. 88–91, published by John Wiley, New York, 1945.

ALDEN D. STEWART, *Primary Examiner.*

MEYER PERLIN, WILLIAM F. O'DEA, *Examiners.*