

[54] HEAT EXCHANGER FOR COMPRESSED AIR

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[22] Filed: Sept. 16, 1970

[21] Appl. No.: 72,716

Related U.S. Application Data

[62] Division of Ser. No. 784,597, Dec. 18, 1968.

[52] U.S. Cl. 165/154, 165/177, 165/181

[51] Int. Cl. F28d 7/10, F28f 1/20

[58] Field of Search.....165/154, 181, 177

[56] References Cited

UNITED STATES PATENTS

2,316,063 4/1943 Gunter 165/143 X

2,413,360 12/1946 Maguire et al.....165/143 X
2,858,677 11/1958 Stone.....165/143 X
3,151,672 10/1964 Edmund.....165/143
3,173,196 3/1965 Grimm 29/157.3

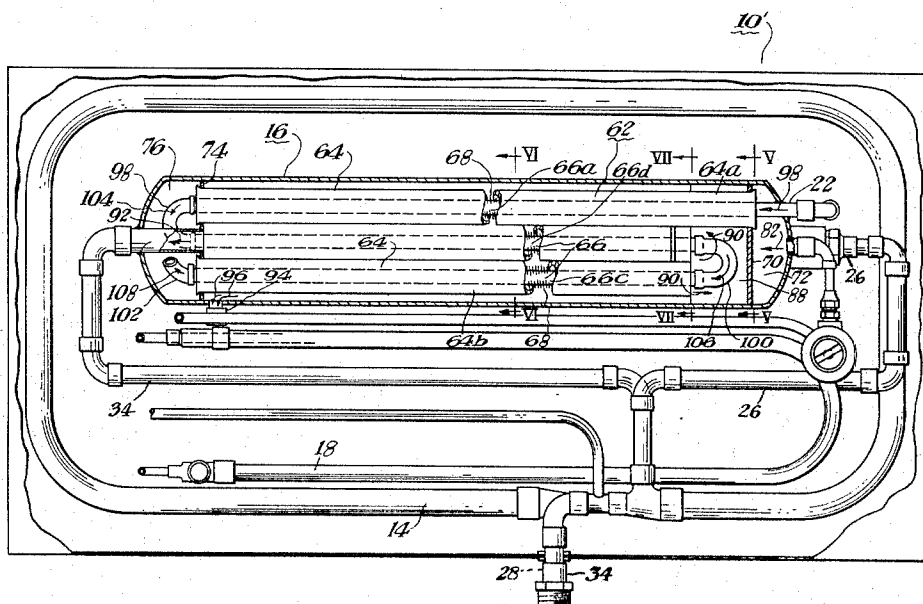
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[57] ABSTRACT

A heat exchanging structure for an evaporator and the like comprises a plurality of sheath tubes and a plurality of inner tubes inserted respectively and spacedly within the sheath tubes. A flow arrangement connects one group of the group of sheath tubes and the group of inner tubes in series and at least some of the other group of tubes in parallel.

In another such structure, inner and outer tubes are mounted in tube-in-tube relation, and at least one of the tubes include heat transfer spines.

13 Claims, 7 Drawing Figures



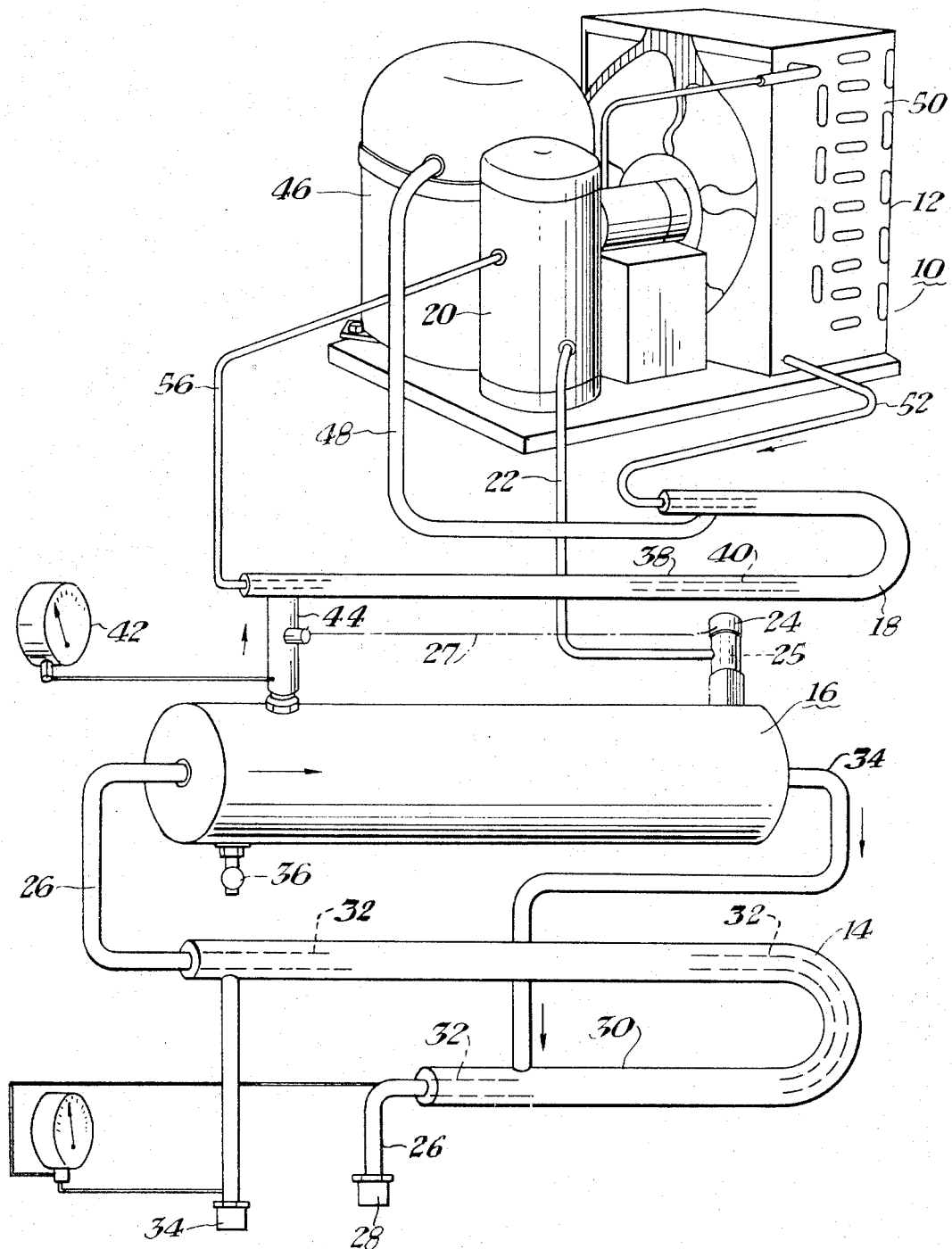


Fig. 1.

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Fig. 2.

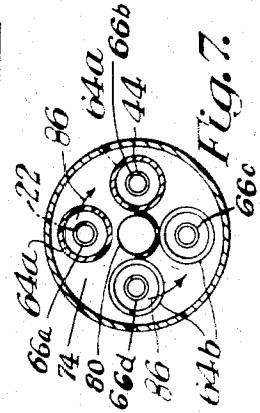
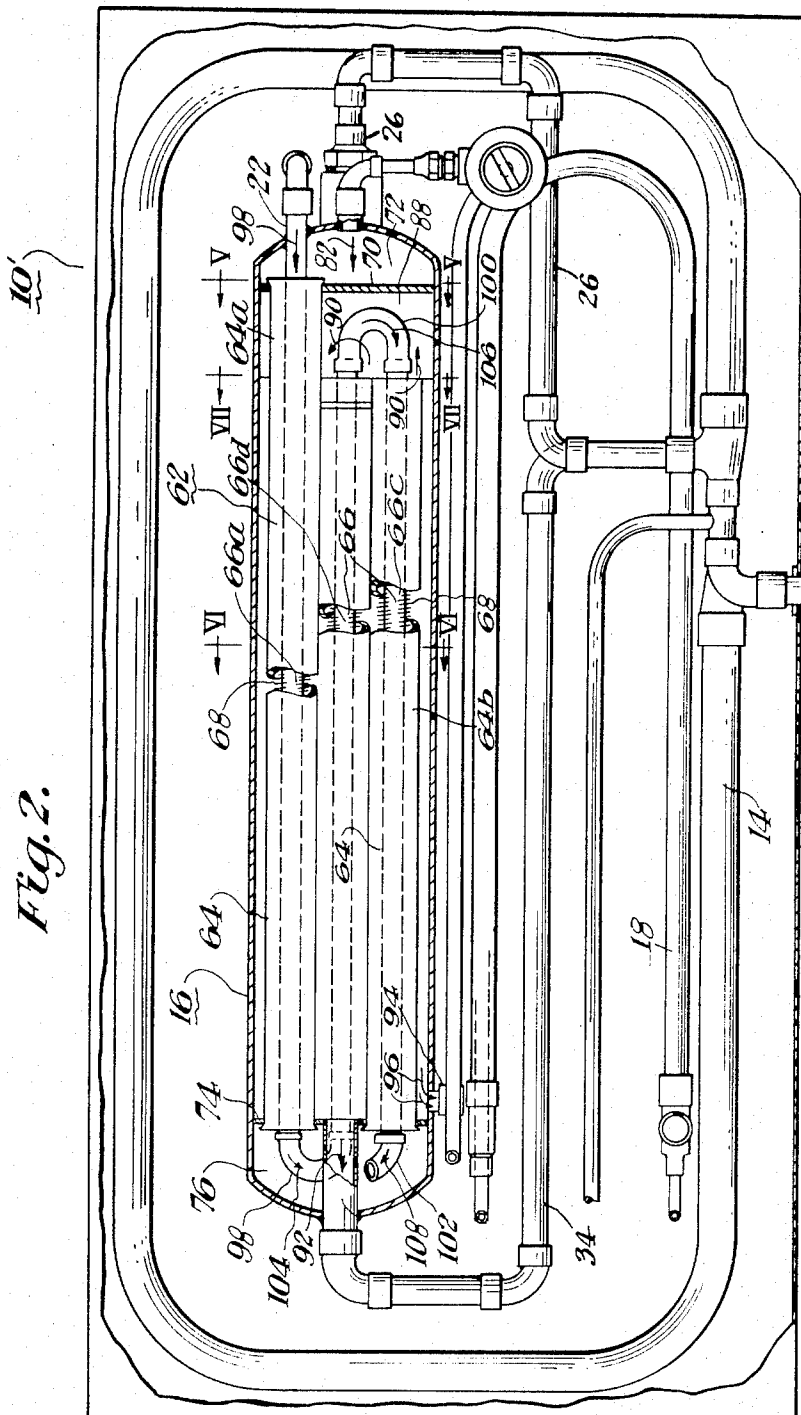


Fig. 7.

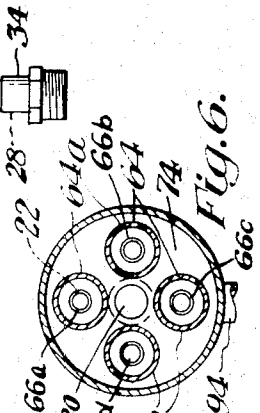


Fig. 6.

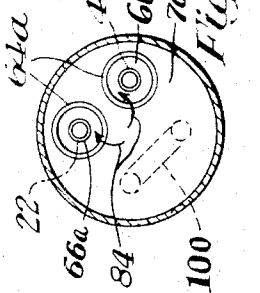


Fig. 5.

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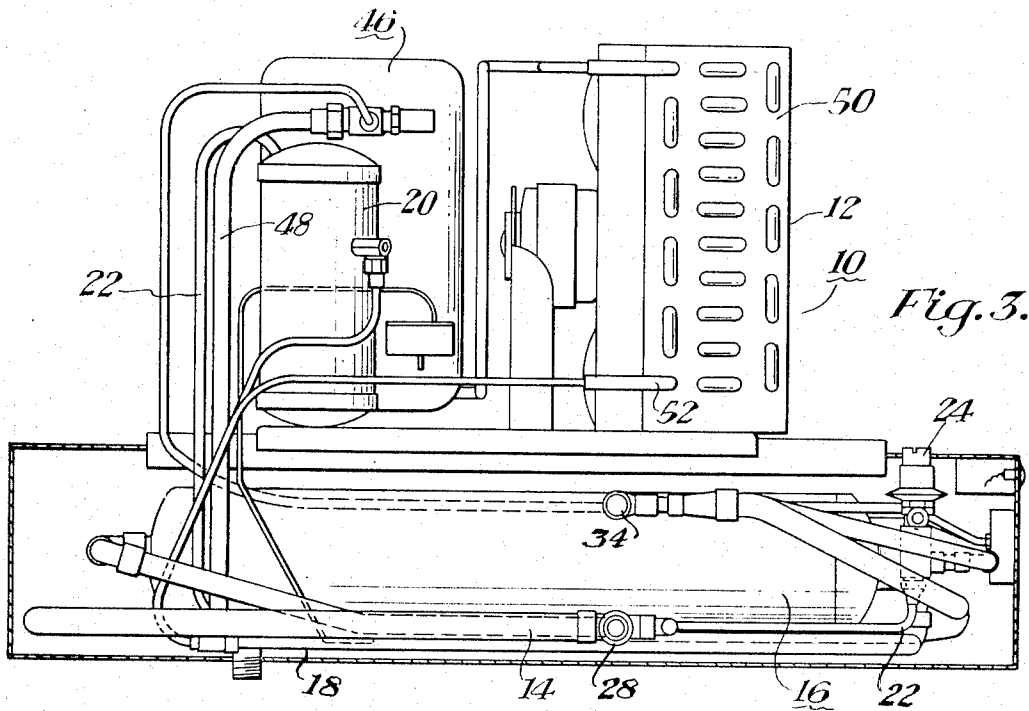


Fig. 3.

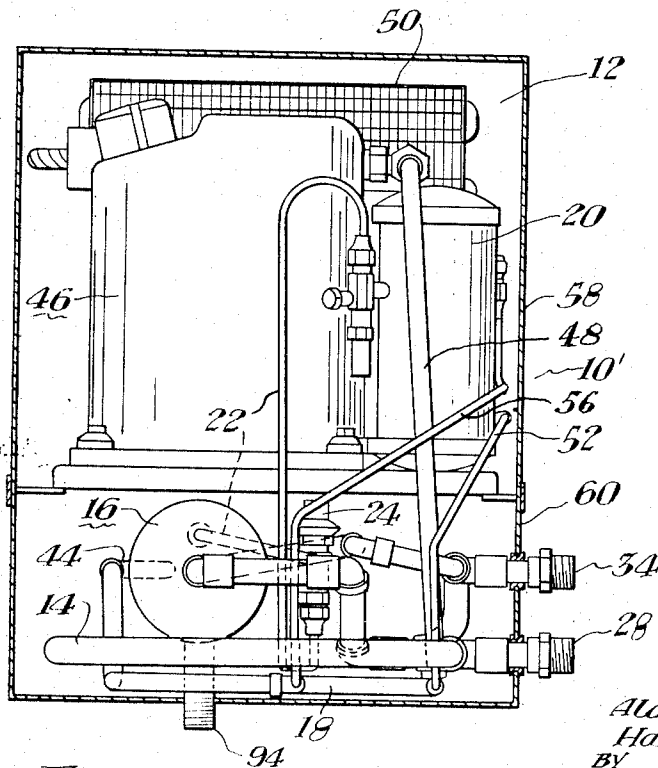


Fig. 4.

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HEAT EXCHANGER FOR COMPRESSED AIR

The present application is a division of our copending application entitled **GAS HANDLING APPARATUS AND METHOD**, Ser. No. 784,597, filed Dec. 18, 1968.

DESCRIPTION OF THE INVENTION

The present invention relates to means and methods of handling compressed gases and more particularly to dryers of the refrigeration type, including heat-exchanging structures, for compressed air and other gases.

Although our invention is described herein primarily with reference to evaporators used in compressed air handling equipment, it will be obvious as this description proceeds that the heat exchanging structure of our invention can be used with other fluids or combinations of fluids and in other fluid-handling systems.

A variety of equipment for cleaning and/or drying compressed air and other gases is known. Widely ranging operating conditions have made such equipment difficult to control with the desired stability. For example, in known refrigeration drying systems, stable control is difficult where the drying function is variable, i.e., when the compressed air or other gas is supplied in differing degrees of wetness. Simple pressure and temperature control means usually are not adequate for the requisite degree of control. The separated moisture may freeze in parts of the system and render it inoperative.

The operational difficulties of conventional equipment for handling compressed air and other gases are further aggravated where the compressed gas must be supplied at widely varying conditions of pressure and temperature. Conventional equipment has been unable to supply without complex controls and other complicated components, a consistent dewpoint dryness under these varying conditions, which are further complicated by variations in ambient air temperatures. For example, in industrial applications, compressed air handling equipment may be used for hot wet incoming air varying from 10 psig to 1000 psig at an inlet temperature of 130°F. or higher. Ambient temperatures may vary between 40°F. and 110°F. Under these conditions rather complicated conventional equipment is required to provide cooled, compressed gas with an acceptable and consistent dew-point dryness. Insofar as we are aware there is no available equipment which is capable of continuous operation and wherein the compressed air drying function can be varied at will between zero load and full load while maintaining a consistent dew-point dryness. Conventional equipment fails to provide an efficient evaporator or other heat-exchanger for this or analogous fluid systems.

In the past, a number of air handling systems have been proposed, typified by the U.S. Pats. to Coblenz, No. 2,632,315; Ritter, No. 2,513,679; Meckler, No. 3,102,399; Shipman, No. 2,257,983; Cook et al., No. 2,119,201; Schweller, No. 2,692,481; Newton, No. 2,367,305; Carrier, No. 2,154,263; Kohut, No. 2,835,476; and Lund, No. 2,451,682, all of which suffer from the aforementioned defects. Most of these prior systems utilize various arrangements of evaporators and regenerative heat exchangers for the incoming air or other gas which is being cooled, cleaned and/or dehumidified. However, none of these systems disclose the unique heat-exchanging structure of our invention,

and the particular flow paths, by which heat exchanging of the evaporator is accomplished with a high degree of efficiency. None of these references employs the heat-transfer enhancing means, contemplated by our invention, in the evaporator or other heat exchanger, together with other novel features of our invention, which is described below.

We overcome these deficiencies of the prior art by providing a unique heat-exchanging structure capable of wide application in the efficient handling of fluids. Our heat exchanger is particularly useful as an evaporator structure in a refrigeration drying system such as that disclosed and claimed in our aforementioned copending application. Our invention engenders high heat-exchanging efficiency through the use of a unique arrangement of heat-exchanging flow paths and heat transfer means. These characteristics are further enhanced by use of our heat-exchanging structure in conjunction with our aforesaid evaporative and refrigerational system. Although we describe our novel fluid handling equipment primarily in terms of removing or controlling the moisture content of compressed air, the compressed air or other gas can be further cleaned by removal of oil and other entrained foreign matter along with condensed moisture. Compressed gas or other fluids can be dried or otherwise cleaned by removal of other condensibles or entrained matter with our novel equipment, during certain heat-transfer applications of our invention.

We accomplish these desirable results by providing a heat exchanging structure for an evaporator and the like, said structure comprising a plurality of sheath tubes, a plurality of inner tubes inserted respectively and spacedly within said sheath tubes, and flow means for connecting one group of the group of sheath tubes and the group of inner tubes in series and for connecting at least some of the other group of tubes in parallel. In certain applications we prefer to dispose the inner tubes co-axially of the sheath tubes respectively, or otherwise in tube-in-tube relation.

We also desirably provide a heat exchanging structure for an evaporator and the like, said structure including inner and outer tubes mounted in tube-in-tube relationship, and conduit means coupled thereto for establishing a pair of heat exchanging paths respectively therethrough, at least one of said tubes having a plurality of heat transfer spines extending transversely toward an associated tube.

During the foregoing discussion, various objects, features and advantages of the invention have been set forth. These and other objects, features and advantages of the invention together with structural details thereof will be elaborated upon during the forthcoming description of presently preferred embodiments of the invention and presently preferred methods of practicing the same.

In the accompanying drawings we have shown certain presently preferred embodiments of the invention and have illustrated presently preferred methods of practicing the same, wherein:

FIG. 1 is a schematic fluid circuit of one arrangement of our compressed gas handling equipment;

FIG. 2 is a top plan view, with parts broken away and other parts removed, of a packaged equipment assembly arranged in accordance with FIG. 1;

FIG. 3 is a front elevational view of the apparatus as shown in FIG. 2;

FIG. 4 is a left side elevational view of the apparatus as shown in FIG. 3;

FIG. 5 is a cross sectional view of the primary evaporator shown in FIG. 2 and taken along reference line V—V thereof;

FIG. 6 is another cross sectional view of the evaporator of FIG. 2 and taken along reference line VI—VI thereof; and

FIG. 7 is still another cross sectional view of the evaporator of FIG. 2 taken along reference line VII—VII thereof.

Referring now more particularly to the drawings, an exemplary fluid handling equipment 10 of our invention comprises a refrigeration and condensing unit 12 of known construction, regenerative heat exchanger 14, primary evaporator 16 and auxiliary evaporator 18. The receiver 20 of the refrigeration and condensing unit 12 is connected through conduit 22 to expansion valve 24 and thence to the main evaporator 16 where the refrigerant fluid is vaporized. In this example, the expansion valve 24 is controlled automatically by pressure which is the function of degree of vaporization of the refrigerant fluid within the main evaporator 16.

The refrigerant is further vaporized within the evaporator 16 by heat transfer from hot wet compressed air supplied to the main evaporator 16 through conduit 26. Between the end of the conduit 26 connected to the evaporator 16 and the inlet end 28 of the conduit 26, the regenerative heat exchanger 14 is coupled. In this example, conduit 26 is effectively extended through the heat exchanger 14, which is formed in this example from a pair of co-axial tubes 30, 32. The outer heat exchanger tube 30 is coupled to conduit 34 forming the outlet of the main evaporator 16. Before reaching the main evaporator 16, the pressurized and dried outgoing air or other gas is therefore warmed regeneratively by heat exchanging association with the hot wet compressed air passing through inner co-axial tube 32.

Within the main evaporator 16, water, lubricating oil, dirt and other foreign matter are condensed or leached out of the pressurized gas passing through the evaporator 16 by heat exchanging association with the expanding refrigerant. Water or other foreign material is periodically drained from the evaporator 16 through drain valve 36.

The refrigerant, which is partially or completely vaporized in the evaporator 16 flows thence to the auxiliary evaporator 18, in this example, consisting of outer and inner co-axial tubes 38, 40. Suitable instrumentation 42 can be coupled to outlet refrigerant conduit 44, by which the primary evaporator 16 is connected to the outer co-axial tube 38 of the auxiliary evaporator 18. In passing through the auxiliary evaporator 18, the output refrigerant from the primary evaporator 16 is expanded further and returns to compressor 46 through conduit 48. The expansion of refrigerant in the auxiliary evaporator 18 in turn removes heat from refrigerant flowing from condenser 50 through conduit 52 which is coupled to the inner tube 40 of the auxiliary evaporator 18 from which it flows to receiver 20 through connecting conduit 56. The refrigerant is then recycled from the receiver 20 to expansion valve 24 and primary evaporator 16 through conduit 22.

In effect, then, both the incoming hot wet compressed air and the refrigerant supplied to the main evaporator 16 are cooled regeneratively before entering the primary evaporator 16. This arrangement per-

mits the gas handling equipment 10 to be controlled in the stable fashion under a wide range of operation and ambient conditions. In particular, refrigerant is supplied to the condensing unit 50 (conduit 52) and to the primary evaporator 16 (conduit 22) at correspondingly lower temperatures, whereby a marked increase in efficiency is obtained.

The valve 24 itself is of conventional construction but is provided with an internal pressure transmitting aperture 25 to render the valve 24 sensitive to fluctuations in line pressure. Alternatively as denoted by conduit outline 27 the valve 24 can be sensitized through conduit 27 to pressures elsewhere in the apparatus, for example the evaporator outlet conduit 44. A suitable valve is available from Alco Controls Corp., St. Louis, Missouri, for example catalog No. ACP-2 (internal pressure transmitting), ACPE-5 (external pressure transmitting) or CP-300. Other sizes are available depending on particular equipment capacities. Additionally, the valve 24 is provided with a stop member 29 to avoid complete closure of the valve 24.

In conventional gas handling apparatus of this type, it is expected that a pressure sensitive valve, such as the valve 24, will not closely follow load changes in the system, i.e., both the stability and the control in the system will be poor. However, we attain an unexpectedly stable system having an excellent control characteristic by employing the pressure sensitive valve 24 in conjunction with a continuously operated compressor 46. The compressor 46 is not operated intermittently or cyclicly as in conventional systems. This eliminates one source of the phenomenon known as hunting in the system.

The use of a continuously operated compressor, such as the compressor 46 in conjunction with the pressure sensitive valve 24 lays a basis for the vastly improved control characteristic exhibited by our novel apparatus. As the valve 24 is prevented from complete closure, the compressor 46 is sized so that it is capable of forcing the valve 24 more nearly closed when required for load changes in the increasing direction. The valve 24 moves toward its open position upon decreasing load, which increases load on the auxiliary evaporator 18. While the main evaporator 16 loads, the auxiliary evaporator 18 unloads. The compressor 46 also is selected on the basis of known criteria, for constant speed operation regardless of the load upon the system, within system capability. The use of a pressure sensitive valve, and a continuously operated constant speed compressor, coupled with the ability of the compressor to adjust the expansion valve opening endows the apparatus with considerable stability and with a control characteristic which is capable of compensating wide variations in incoming gas, pressure, temperature, and moisture content, as well as widely varying changes in ambient conditions. Our apparatus, therefore, is capable of supplying cool and dry compressed air or other gas at a consistent dew point dryness. At the same time, the cooperative aspects of the pressure sensitive valve 24 and the continuously operated compressor 46 positively prevents freezing of condensed moisture in any part of the equipment.

As better shown in FIGS. 2-4 the package equipment unit 10' is arranged such that the refrigeration and condensing unit 12 is mounted within an appropriately shaped individual casing 58, while the primary evaporator 16, auxiliary evaporator 18 and the regenerative heat exchanger 14 are supported within a separate cas-

ing 60. Inlet and outlet conduits 28, 34 respectively, are supported upon a wall portion of the casing 60.

FIG. 2 of the drawings further illustrates a unique form of our primary evaporator 16 which is useful in the operation of our novel fluid handling apparatus 10 or 10'. The evaporator 16 or other heat-exchanging structure is arranged for obtaining an unusually high co-efficient of heat transfer between a fluid such as air or other pressurized gas entering and leaving the evaporator 16 via conduits 22 and 44 respectively (FIG. 4).

In this arrangement of the invention, the evaporator 16 is provided with a heat exchanging structure denoted generally by reference character 62. The heat exchanger 62 in this example includes a plurality of sheath tubes 64 each of which contains a spined inner tube 66, which can be supported substantially coaxially, or otherwise in tube-in-tube relationship, within the respective sheath tubes 64. The convecting spines 68 of each tube 66 can be made by lancing and erecting narrow strips of the wall material of the tubes 66, and the outer ends of the spines 68 are closely fitted within the associated sheath or tube 64. The spines 68 are substantially less in thickness than that of the tube walls to avoid any possibility of leakage. Because the bases of the spines are rooted integrally in the tube walls, the heat transfer characteristics are excellent.

In the illustrated arrangement the heat exchanger 62 includes four such sheath tubes 64 and a like number of associated or inner spined tubes 66, although a different number of sheaths and tubes obviously can be utilized as required. The inner tubes 66 desirably, but not necessarily, are disposed in co-axial relation to the sheath tubes 64, respectively.

Two of the sheath tubes 64, for example 64a, and the associated coaxial tubes as better shown in FIG. 5 are extended beyond the ends of the remaining sheath tubes 64b at the right end of the evaporator 16 as viewed in FIG. 2 and are secured to a baffle plate 70 where they communicate with plenum chamber 72 which in turn communicates with air inlet conduit 26.

The other ends of the sheath tubes 64a are secured to baffle plate 74 adjacent the other end of the evaporator 16 and thus communicate with opposite end plenum chamber 76. Desirably, the remaining sheath tubes, such as the tubes 64b, likewise are secured to the right-hand baffle plate 74 for communication with the adjacent plenum chamber 76 and with the first group of sheath tubes 64a. The tubes 64b however terminate short of the right-hand baffle plate 70 at the opposite end of the evaporator 16 and are supported relative to one of the longer sheath tubes 64a by semi-circular ring or bracket 78 (FIG. 7) which desirably is welded or otherwise secured to each of the shorter sheath tubes 64b and to one of the longer sheath tubes 64a. Use of the bracket 78 does not interfere with the flow of fluid between and around the outer surfaces of the sheath tubes 64a, 64b the purpose of which flow is described below. The flow baffle 74 at the opposite end of the evaporator 16 is provided with a central opening 80 as better shown in FIGS. 6 and 7 whereat the gas exit conduit 34 is joined and sealed (as by welding or the like — FIG. 2) for communication with fluid flowing between and around the sheath tubes 64.

With the arrangement just described, it will be seen that a fluid such as compressed air, or a liquid depending on the application of the invention, is caused to flow in parallel-series first through the longer sheath

tubes 64b. In addition, the compressed air or other fluid is induced to flow transversely of the spines 68 to enhance heat transfer between the respective fluids within tubes 64, 66. More specifically, the first-mentioned fluid enters the right-hand plenum chamber 72, as fiewed in FIG. 2, from inlet conduit 26 as denoted by flow arrow 82. From the chamber 72 such fluid flows into both of the longer sheath tubes 64a as denoted by flow arrows 84 in FIG. 5. After following parallel annular paths through the sheath tubes 64a the fluid enters plenum chamber 76 at the opposite end of the evaporator 16. In the plenum chamber 76 the compressed gas or other fluid flows from the adjacent ends of the sheath tubes 64a to the ends of the sheath tubes 64b as denoted by flow arrow 86 in FIG. 2. Thence, the fluid again follows parallel paths through the spines 68 of the shorter sheath tubes 64b. The sheath tubes are thus connected in a parallel-series relation.

At the opposite ends of the shorter sheath tubes 64b, the compressed gas or other fluid enters a third or intermediate plenum chamber 88 which is segregated from the adjacent end plenum chamber 76 by baffle 70. From the plenum chamber 88, as denoted by flow arrows 90, the fluid flows between and around the outer surfaces of the sheath tubes 64 to the central opening 80 of the baffle 74 and outlet conduit 34 at the opposite end of the evaporator 16. From the baffle opening 80, the compressed gas or other fluid exits from the evaporator 16 through conduit 34 as denoted by flow arrow 92. Alternatively, the exit conduit 34 can be closed or the conduit 34 and the baffle opening 80 can be omitted, and the fluid can be withdrawn via drain conduit 94 which communicates with the plenum 88 through the spaces between and around the sheath tubes 64 as denoted by flow arrows 96.

From the foregoing paragraph, it will be seen that pressure drops are reduced by causing the compressed gas or other fluid to flow through successive pairs of the sheath tubes 64 in parallel-series fashion. The pressure drop can be further minimized, if desired, by flowing the gas or other fluid through all of the sheath tubes in simple parallel fashion, by connecting the outlet 34 directly to the end plenum 76, and by extending the ends of the sheath tubes 64b to the adjacent end plenum 72. On the other hand, the refrigerant enters conduit 22 as denoted by arrow 98 and flows through refrigerant tube 66a. At the other end of the refrigerant tube 66a, the refrigerant is conducted to the refrigerant tube 66b through a reverse bend fitting or hose section 98 or other suitable conduit means. The refrigerant tube 66b at its opposite end is similarly coupled by a second hose section 100 to refrigerant tube 66c, which in turn is coupled to refrigerant tube 66d through a third hose fitting 102. The refrigerant tubes 66a and 66d are disposed in sheath tubes 64a while refrigerant tubes 66b and 66c are in the shorter sheath tubes 64b. The fourth refrigerant tube 66d communicates with exit refrigerant conduit 44 as shown in FIG. 5. For convenience, the reverse fittings 98, 102, are disposed in plenum 76 while the reverse fitting 100 is in the third or intermediate plenum 88, of the evaporator 16. The flow of refrigerant successively through the refrigerant tubes 66a, 66b, 66c, and 66d and the respectively associated fittings 98, 100, 102 is denoted respectively by flow arrows 104, 106, 108. The several plena 72, 88, 76 are spaced along the length of the heat-exchanger tank (FIG. 2).

It will be understood, of course, that other flow paths for the compressed gas and the refrigerant fluid respectively can be provided through our novel heat exchanger structure 62. We have found, however, that the aforescribed flow paths are very effective in the efficient transfer of heat between compressed gas and a refrigerant or other heat-exchanging fluids. It will be further understood that other heat-exchanging fluids or liquids can be utilized in place of those noted above.

From the foregoing it will be apparent that novel and efficient forms of heat exchanging structure for compressed air and the like have been disclosed herein. While we have shown and described certain presently preferred embodiments of the invention and have illustrated certain presently preferred methods of practicing the same, it is to be distinctly understood that the invention is not limited thereto but may be variously embodied and practiced within the spirit and scope of the invention.

We claim:

1. A heat exchanger comprising a plurality of sheath tubes, a plurality of inner tubes inserted respectively and spacedly within said sheath tubes, means for supporting said tubes within an elongated tank therefor, plenum chamber means adjacent each end of said tank and communicating with the ends of said sheath tubes, conduit means disposed within at least one of said plenum chamber means and coupled to adjacent ends of said inner tubes for connecting at least some of said inner tubes in series, first flow circulating means coupled to said plenum chamber means for circulating a first heat exchanging fluid through said sheath tubes exteriorly of said inner tubes, second flow circulating means extending through at least one of said plenum chamber means for sealed connection to the adjacent ends of said inner tubes for circulating a second heat exchanging fluid through said inner tubes, said plenum chamber means including a pair of baffles spacedly mounted adjacent the ends of said tank so as to form a plenum chamber at each end of said tank, some of said sheath tubes being joined adjacent their ends to said flow baffles respectively so as to communicate with said plenum chambers respectively, means for mounting said sheath tubes in generally parallel spaced relation within said tank, and the remainder of said sheath tubes being joined adjacent their ends to one of said baffles so as to communicate with the associated plenum chamber and with some of said sheath tubes, the opposite ends of said remainder sheath tubes terminating short of the other of said baffles so as to communicate with flow spaces extending between and around said sheath tubes and between said baffles.

2. A heat exchanger comprising a plurality of sheath tubes, a plurality of inner tubes inserted respectively and spacedly within said sheath tubes, means for supporting said tubes within an elongated tank therefor, plenum chamber means adjacent each end of said tank and communicating with the ends of said sheath tubes, conduit means disposed within at least one of said plenum chamber means and coupled to adjacent ends of said inner tubes for connecting at least some of said inner tubes in series, first flow circulating means coupled to said plenum chamber means for circulating a first heat exchanging fluid through said sheath tubes exteriorly of said inner tubes, second flow circulating means extending through at least one of said plenum chamber means for sealed connection to the adjacent

ends of said inner tubes for circulating a second heat exchanging fluid through said inner tubes, and an intermediate plenum chamber spaced along the length of said tank and separated from said end plenum chamber means by a pair of flow baffles spaced from the ends of said tank respectively, said sheath tubes being divided into groups of longer and shorter sheath tubes, said longer sheath tubes having their ends joined to said baffles respectively in communication with said end plenum chamber means respectively, said shorter sheath tubes having their one ends joined to one of said baffles in communication with the adjacent one of said end plenum chamber means and having their other ends terminating short of the other of said baffles in communication with said intermediate plenum chamber.

3. The combination according to claim 2 wherein bracket means are joined to said shorter tubes adjacent said other ends thereof and to an adjacent wall surface of at least one of said longer sheath tubes for supporting the said shorter sheath tubes.

4. The combination according to claim 3 wherein said intermediate plenum chamber is further defined by the adjacent wall portions of said tank and by the outer wall surfaces of said longer and said shorter sheath tubes, and inlet and outlet means for said sheath tubes are coupled to said tank in communication with the other of said end plena and with said intermediate plenum chamber respectively.

5. The combination according to claim 2 wherein said first circulating means are extended into said tank to an opening in one of said baffles in communication with said intermediate plena and with said shorter sheath tube other end.

6. A heat exchanger comprising a plurality of sheath tubes, a plurality of inner tubes inserted respectively and spacedly within said sheath tubes, means for supporting said tubes within an elongated tank therefor, plenum chamber means adjacent each end of said tank and communicating with the ends of said sheath tubes, conduit means disposed entirely within at least one of said plenum chamber means and coupled to adjacent ends of said inner tubes for connecting some of said inner tubes in series with the remainder thereof, first flow circulating means coupled to said plenum chamber means for circulating a first heat exchanging fluid through said plenum chamber means and through said sheath tubes exteriorly of said inner tubes and of said conduit means along the entire length thereof, at least said one chamber means being shaped to provide a flow of said first fluid substantially transversely of said conduit means, and second flow circulating means extending through the other of said plenum chamber means for sealed connection to the adjacent ends of said inner tubes for circulating a second heat exchanging fluid through said inner tubes and said conduit means.

7. Heat exchanger structure including an elongated tank having first and second groups of heat exchanging tubes mounted therein, one of said groups of tubes being sheathed respectively within the other, said plenum chamber means including end plena and an intermediate plenum spaced along the length of said tank, said first tubes including a number of longer tubes disposed with their ends communicating respectively with said end plena and a number of shorter tubes disposed with their one ends in communication with one of said end plena and their other ends in communication with said intermediate plenum, first flow circulating means

coupled to said plenum chamber means for circulating a first heat exchanging fluid through said sheath tubes exteriorly of said inner tubes, and second flow circulating means extending through at least one of said plenum chamber means for sealed connection to the adjacent ends of said inner tubes for circulating a second heat exchanging fluid through said inner tubes.

8. A heat exchanger comprising a first group of heat exchanging tubes, a second group of heat exchanging tubes positioned respectively within said first tubes, a first plenum structure coupled to the adjacent ends of said first tubes in communication therewith, a second plenum structure coupled to the opposite ends of said first tubes in communication therewith, conduit means supported in at least one of said plenum structures and connected respectively to the adjacent ends of said second tubes in communication therewith for coupling at least some of said second tubes in series, first circulating means coupled to said plenum structures for circulating a first heat exchanging fluid therethrough and through said first tubes, and second circulating means coupled to said second tubes for circulating a second heat exchanging fluid therethrough, said heat exchanger including a tank having said tubes mounted therein, said conduit means and said plenum structures being mounted within said tank, and an intermediate plenum within said tank and disposed generally between said first and said second plenum structures, said sheath tubes including at least one longer tube disposed with its ends communicating respectively with said plenum structures and a shorter tube disposed with its one end in communication with one of said plenum structures and its other end in communication with said intermediate plenum.

9. The combination according to claim 8 wherein said end plena and said intermediate plenum are separated by baffle plates disposed adjacent the end portions of said tank, and conduit means are extended through one of said end portions to an opening in the adjacent baffle plate in communication with said intermediate plena and with said shorter sheath tube other end.

10. A heat exchanger comprising a first group of heat exchanging tubes, a second group of heat exchanging tubes positioned respectively within said first tubes, a first plenum structure coupled to the adjacent ends of said first tubes in communication therewith, a second plenum structure coupled to the opposite ends of said

first tubes in communication therewith, conduit means disposed entirely within at least one of said plenum structures and connected respectively to the adjacent ends of said second tubes in communication therewith for coupling some of said second tubes in series with the remainder thereof respectively, first circulating means coupled to said plenum structures for circulating a first heat exchanging fluid therethrough and through said first tubes but exteriorly of said second tubes and of said conduit means along the entire length thereof, said one plenum chamber structure being shaped to provide a flow of said first fluid substantially transversely of said conduit means, and second circulating means extending through the other of said plenum structures and coupled to said second tubes for circulating a second heat exchanging fluid therethrough and through said conduit means.

11. The combination according to claim 10 wherein said plenum structures and said conduit means are further disposed for the direction of concurrent flows through at least one of said sheath tubes and associated inner tube and for the direction of countercurrent flows through the remainder of said sheath tubes and associated inner tubes respectively.

12. The combination according to claim 10 wherein at least some of said tubes have a plurality of heat transfer spines secured thereto, said spines extending transversely toward respectively associated tubes.

13. A heat exchanger comprising a group of heat exchanging tubes, a pair of end plenum structures, at least one of said exchanging tubes having its ends coupled respectively to said end plenum structures in communication therewith, an intermediate plenum structure disposed generally between said end plenum structures, a remainder of said tubes having the ends thereof coupled respectively to one of said end plenum structures and to said intermediate plenum structure in communication therewith, first circulating means coupled to the other of said end plenum structures and to said intermediate plenum structure for circulating a first heat exchanging fluid therethrough and through said heat exchanging tubes, and second circulating means including conduit means disposed in heat transfer relationship with said heat exchanging tubes for circulating a second heat exchanging fluid through said conduit means.

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