March 16, 1965 K. O. PARKER ETAL 3,173,480

HEAT EXCHANGER ASSEMBLY

Original Filed Oct. 13, 1958 2 Sheets-Sheet 1

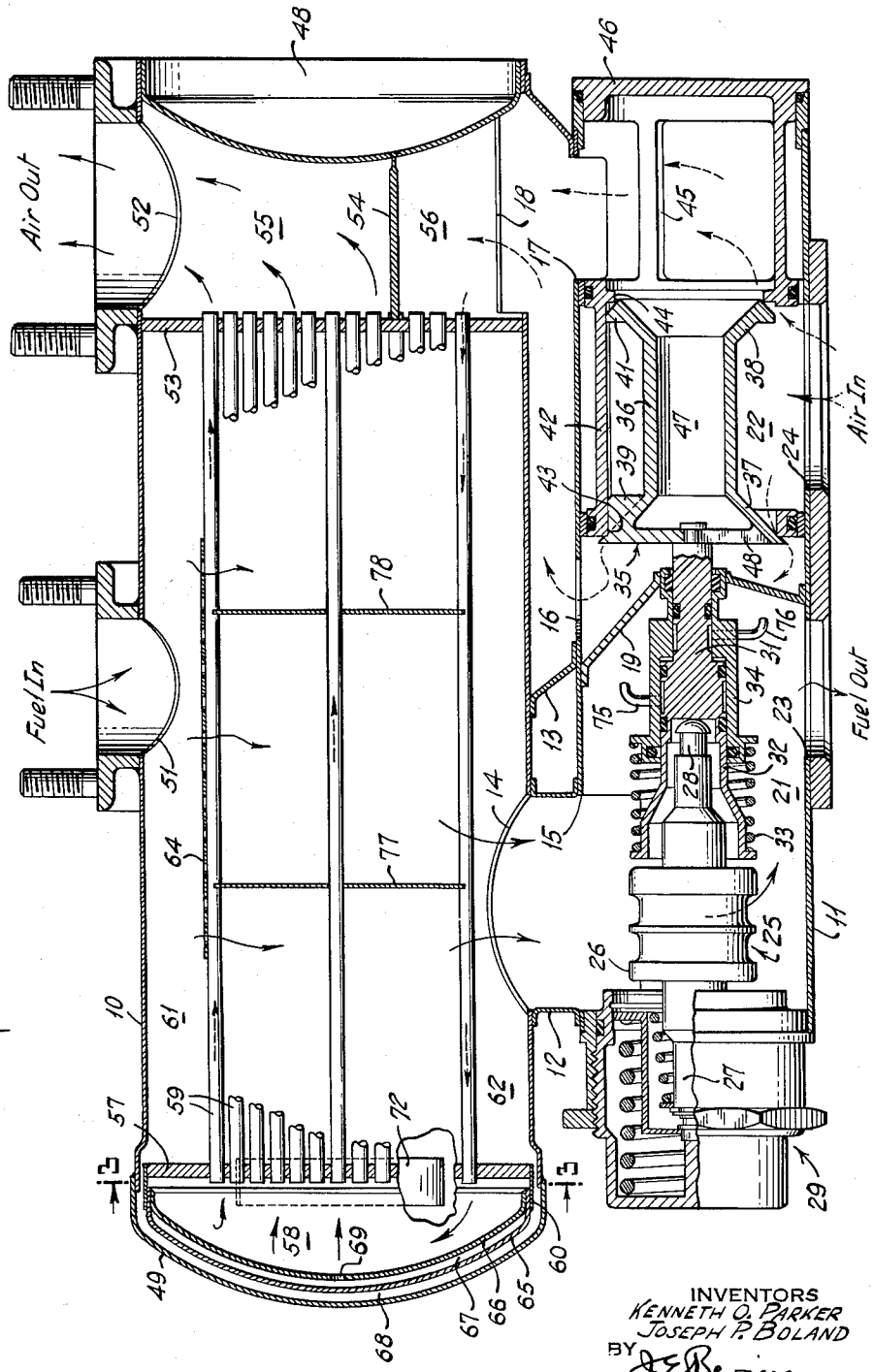


Fig. 1.

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Fig. 2.

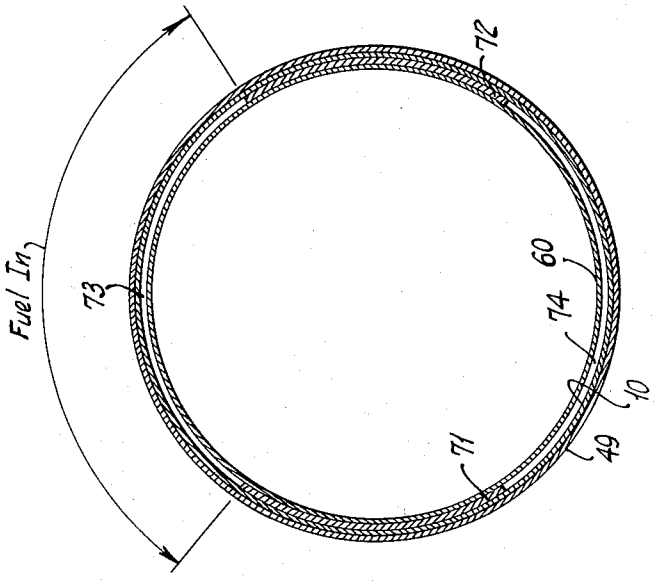
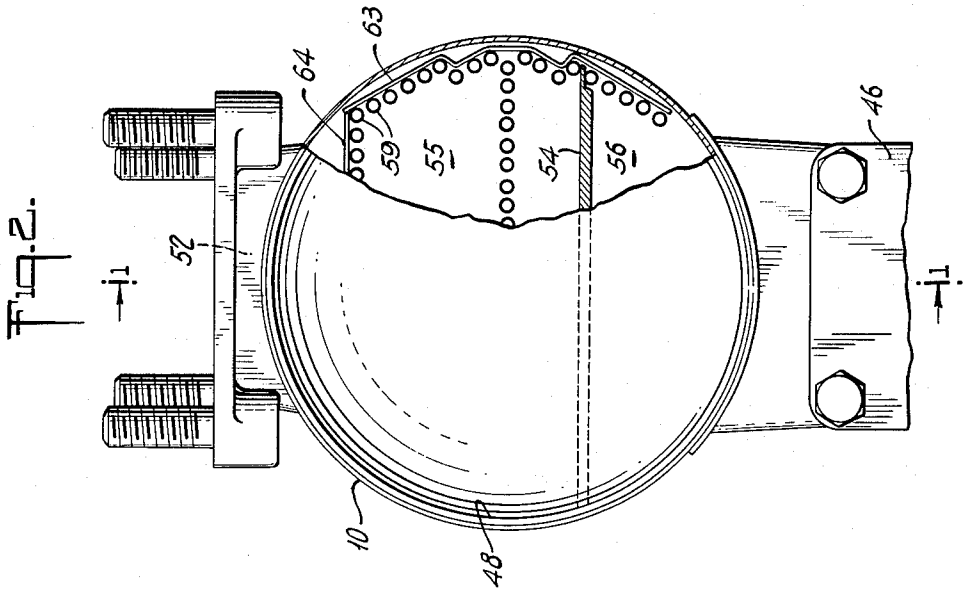


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HEAT EXCHANGER ASSEMBLY

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Original application Oct. 13, 1953, Ser. No. 766,813, now Patent No. 3,145,928, dated Aug. 25, 1964. Divided and this application Dec. 26, 1962, Ser. No. 328,442
3 Claims. (Cl. 165—158)

This invention relates to valve and heat exchanger assemblies, having especial reference to small and light weight integrated devices of the kind described for use in aerial craft.

An object of the invention is to adapt assemblies as described to the use of high pressure, high temperature air as a source of heat to warm fuel and for like purposes.

Another object of the invention is to construct a valve providing for accurate control over a flowing, high pressure, high temperature air through thermally responsive means in which fluid pressure effects upon the valve are substantially balanced out.

Another object of the invention is to provide a generally new valve unit in an assembly as described, characterized by a spool type poppet valve constructed and arranged substantially to be balanced against the effects of the fluid controlled thereby.

Still another object of the invention is to present a generally new heat exchange unit in an assembly as described providing for efficient, trouble free operation in the handling of high temperature, high pressure, fluids damaging effects of such high temperatures and high pressures being specifically inhibited.

Still another object of the invention is to provide for a generally new relationship between the valve and heat exchange units.

Other objects and structural details of the invention will appear from the following description when read in connection with the accompanying drawings, wherein:

FIG. 1 is a view in longitudinal section and partly diagrammatic, of a light-weight, integrated valve and heat exchange assembly in accordance with the illustrated embodiment of the invention;

FIG. 2 is a fragmentary end view, partly broken away of the assembly of FIG. 1; and

FIG. 3 is a detail view in cross-section taken substantially along the line 3—3 of FIG. 1.

Referring to the drawings, in accordance with the illustrated embodiment of the invention, a valve and heat exchanger assembly comprises a cylindrical open-ended heat exchanger casing or shell 10 and a similar valve casing 11. The casings 10 and 11 are in parallel adjacent relation to one another and physically interconnected through sheet metal connectors 12 and 13. The device 12 is essentially ring-shaped and is aligned with an opening 14 in the lower part of the casing 10 and an opening 15 in the upper part of the casing 11 to place the interiors of the casings 10 and 11 in communication with one another through these openings. The connector device 13 is in encompassing relation to spaced apart openings 16 and 17 in the valve casing 11 as well as to an opening 18 in the casing 10. An interior partition 19 in the valve casing 11, intermediate the ends thereof, divides the interior of the casing into separated compartments 21 and 22. The former is connected through device 12 and openings 14 and 15 with the interior of heat exchanger casing 10, and further is connected externally of the valve and heat exchanger assembly through an opening 23 in the lower part of the casing 11. The compartment 22 communicates with longitudinally spaced apart ports or openings 16 and 17 in the casing 11 and through connector device 13 and opening 18 with the interior of the heat exchanger casing 10. Compartment 22 communicates

also to the exterior of the assembly through an opening 24 in the lower part of the valve casing 11, the opening 24 being located between the ports 16 and 17 which are in the upper part of the valve casing.

The space 21 may be considered a thermostat chamber or compartment since it contains a thermostat assembly 25 of a known kind capable of generating relatively powerful forces of thrust in the presence of rising temperatures. Briefly, it includes a case 26 housing a material having the property of expansion under heat, reactant means 27 extending from one end of the case and a plunger 28 extending from the opposite end thereof. A housing unit 29 is integrated with the described parts of the assembly and is received in one end of the valve casing 11 in a manner to close such end. The case 26 extends axially from the housing unit 29 toward the partition 19 in a generally central position within the compartment 21 in such manner that fluid flowing through the compartment between the openings 15 and 23 may move freely over and around the case 26 which is thus exposed to and tends to take on the temperature of the surrounding fluid.

The plunger 28 of the thermostat assembly abuts one end of a rod 31 which has integrally formed therewith an extension sleeve 32 which is in surrounding relation to the plunger 28 and projects toward the case 26. A compression spring 33 is interposed between a terminal shoulder on the sleeve extension 32 and a similar shoulder on one end of a bushing 34, the other end of which is received in and anchored to the partition 19. The rod 31 extends axially through the bushing 34 and through the partition 19, the opposite or projecting end thereof extending into the compartment 22 where it is connected for unison motion with a valve element 35. Under rising fluid temperatures in the compartment 21, the material in case 26 expands. Reacting against means 27 and the housing unit 29, this motion is utilized in a relative extension of plunger 28. This motion results in and effects a similar extending, axial movement of the rod 31 and of the valve element 35 attached thereto. Extension of the rod 31 causes a compression of spring 33 whereby a force is provided for return of the parts in an opposite or retracting direction as the fluid temperature in chamber 21 lowers or is reduced.

In the chamber or compartment 22 the opening 24 is an inlet for fluid under pressure, the flow to outlet openings 16 and 17 being regulated by the valve element 35. The latter is spool-like in configuration, having a cylindrical body 36 on the ends of which are approximately frusto-conical heads 37 and 38. Bearing formations 39 and 41 on the respective heads are slidable in a bushing 42 stationarily installed in the casing. On opposite sides of the inlet opening 24, and intermediate the outlet openings 16 and 17, the bushing 42 provides longitudinally spaced apart valve seats 43 and 44 respectively engageable, on corresponding sides thereof, by frusto-conical seating surfaces on the heads 37 and 38.

In the position of the parts illustrated, the valve element 35 is fully closed, the heads 37 and 38 thereof contacting the seats 43 and 44 in a manner to preclude communication of the inlet opening 24 with the outlet openings 16 and 17. In the event of a lowering of temperature in the thermostat chamber 21, the valve element is withdrawn or retracted from the valve seats, through action of the spring 33 as before described, with the result that flow is permitted from opening 24 through the compartment 22 and past both valve seats 43 and 44 to respective openings 16 and 17, the fluid reaching the latter opening through openings 45 in the bushing 42. The latter is formed beyond the openings 45 with a closed end wall 46 effectively received in and closing that end of the valve casing opposite the housing unit 29. The valve element 35 accordingly adjusts in response to changing fluid tempera-

ture in the thermostat chamber 21 and has a modulating effect upon fluid flow from the inlet opening 24 to the outlet openings 16 and 17. Moreover, since the valve element has a spool-like configuration as shown, with the inlet 24 intermediate the ends thereof, it will be understood that the valve element is substantially balanced against the effects of pressure of the incoming fluid, the heads 37 and 38 of the valve presenting approximately equal areas to such fluid. The pressures beyond the valve seats 43 and 44, at opposite ends of the valve element, tend to equalize since these areas are interconnected through the openings 16 and 17 and the interior of device 13. Also, these areas at the opposite ends of the valve element are interconnected through the valve itself, the element being hollow or formed with an interior passage 47. A spider configuration 48 at the left-hand end of the valve element provides freedom of communication therethrough while permitting a secure attachment of the rod 31 to the valve.

The heat exchanger casing 10 is closed at its one end by an inverted cap or dome 48. A dome 49 closes the opposite end thereof. Intermediate the ends of the casing, in the upper part thereof are longitudinally spaced apart openings 51 and 52. A tube sheet 53 is received in the casing 10 to lie, with the closure element 48, on opposite sides of the opening 52. The space between the elements 48 and 53 is divided by an intermediate horizontal partition 54 into an upper chamber 55 communicating with the opening 52 and a lower chamber 56 communicating with the opening 18. Another tube sheet 57 is received in an expanded portion of the casing 10 at that end thereof closed by cap 49. It defines with such cap a chamber 58. Mounted within and extending through the respective tube sheets 53 and 57 are heat exchange tubes 59, open-ended to communicate freely with the chambered spaces beyond the tube sheets. The tubes 59 are closely spaced together to define a tube bundle extending substantially from wall to wall of the casing in a transverse intermediate portion thereof while leaving above and below the bundle upper and lower header chambers 61 and 62. As shown in FIG. 2, insert strips 63 may be mounted on the periphery of the tube bundle to fill the space between the bundle and the shell casing in a manner to inhibit peripheral flow around the bundle. In overlying relation to the tube bundle and preferably fastened thereto for better heat conduction, is a transverse spreader plate 64 perforated for a distributed introduction of fluid into the tube bundle.

Whereas the tube sheet 53 is anchored to the casing 10, the sheet 57 is floating therein in such manner that differential expansion as between the shell casing and the tube bundle will not destroy fluid-tight connections in the assembly. Mounted on the tube sheet 57 is a supplemental cap assembly including a ring 60 and dome portions 65 and 66, the latter being approximately concentric with the closure cap 49 and defining therebetween a chamber 67. The outer element 75, moreover, defines with the cap 49 a further chamber 68. Chamber 67 communicates with the chamber 58 through a small diameter opening 69. Arcuate inserts 71 and 72 (FIG. 3) are interposed at diametrically opposed points between the casing 10 and the ring 60 in such manner as in effect to define upper and lower flow passes 73 and 74 from the header chamber 61 to the chamber 68 and from the chamber 68 to the lower header chamber 62.

The assembly is in the illustrated instance adapted for use as a fuel heater, flowing liquid fuel being warmed by high temperature air drawn from a suitable source. According to the construction and arrangement of parts, the fuel enters the assembly by way of opening 51 in the upper part of the heat exchanger casing 10. Descending into the header chamber 61, the fuel is spread out upon the underlying plate 64 and so reaches all parts of the tube bundle, including those immediately underlying the spreader plate since the plate is perforated as indicated.

Within the tube bundle, the fuel flows over and around the tubes 59 and collects in the lower header chamber 62 whence it may be discharged by way of outlet opening 14. From the latter the fuel passes through the connector device 12 into thermostat chamber 21 of the valve unit, and, flowing over and around the thermostat case 26, leaves the assembly by way of outlet port 23. The air circuit is into the assembly by way of inlet opening 24 in the valve casing 11, out of the valve casing under control of valve element 35, by way of ports 16 and 17, and then into the heat exchanger casing by way of inlet opening 18 therein. The incoming air is received in chamber 56 of the heat exchanger from which it flows through communicating tubes 59 through the tube bundle to the chamber 58 which acts as a turn-around space wherein the air has access to other tubes of the tube bundle and flows through these tubes backward through the bundle to the chamber 55 and thence out of the heat exchanger by way of outlet port 52. The flowing air and fuel accordingly are in heat transfer relation to one another through the walls of the several tubes 59 with the result that heat is taken from the air and absorbed into the fuel. The air flows through the tube bundle in two passes and the location of the partition 54 is such that the average air velocity through both passes is approximately equal.

The air and fuel circuits are effectively sealed from one another. The supplemental dome assembly 60, 65 and 66 effectively restricts the air to the interiors of the tubes and to the turn-around chamber 58. Outer closure cap or dome 49 effectively closes the end of casing 10 and retains the liquid fuel from escape. The chamber 67, defined by the spaced apart domes 65 and 66, provides an insulation chamber to avoid overheating of fuel present in the outer chamber 68. Small diameter opening 69 obviates a build-up of air pressure in the chamber 67. The insert devices 71 and 72 in effect apply across the chamber 68 the drop in pressure which necessarily exists as between the upper header chamber 61 and lower header chamber 62. As a result a limited flow of fuel is compelled to take place through the chamber 68 by way of communicating openings 73 and 74. A continuing movement of fuel accordingly takes place through the chamber 68, avoiding excessive vaporization therein and effecting also a cooling of the outer one of the dome elements 65, 66.

A separation of the air and fuel circuits in the valve casing is effected primarily by the partition 19. Ring-seals are mounted within the stationary bushing 34 in surrounding relation to the rod 31 and inhibit a flow of either of the fluids along the exterior of this rod. Any seepage that may occur is adapted to be bled off by drains 75 and 76, in the manner diagrammatically illustrated in FIG. 1.

It will be understood that the assembly has a regulating function in regard to the fuel out temperature, tending to hold this temperature at a predetermined value through adjustments in the position of the valve element 35 whereby to vary the amount of air passing through the heat exchanger.

Vertical partition-like members 77 and 78 disposed in the tube bundle are used for stiffening or strengthening the bundle and do not affect the flow pattern.

What is claimed is:

1. A tubulous heat exchanger, including a shell, spaced apart tube sheets in said shell, one anchored thereto and the other floating, tubes supported between said sheets, closure means secured to said floating tube sheet and defining therewith a chamber in communication with adjacent tube ends, and another closure means in superposed spaced relation to the first said closure means and secured to said shell to be in surrounding relation to the first said closure means, and means to restrict communication of said last named chamber with the shell interior around said floating tube sheet to diametrically opposed portions of the shell interior.

2. A tubulous heat exchanger, including a shell, spaced apart tube sheets in said shell, one anchored thereto and another floating therein, tube supported between said sheets, said tubes comprising a bundle defining with the shell diametrically opposed chambers on opposite sides of the tube bundle, dome means secured to said floating tube sheet and defining therewith a turn-around chamber for fluid flowing through said tubes, the inner surface of said dome means being in contact with said fluid, and means to flow another fluid over the exterior of said dome means for a temperature moderating effect, said other fluid being admitted to one of said diametrically opposed chambers in said shell and flowing across the tube bundle to the other one of said chambers and then out of the shell, said other fluid having a temperature different from the temperature of the fluid flowing through said tubes, said last named means comprising a second dome means secured to the shell and in superposed spaced relation to the first said dome means and defining therewith a chamber communicating around said floating tube sheet with the interior of said shell, and further comprising means limiting such communication to the diametrically opposed chambers within said shell whereby to provide a pressure difference for flow of the said second fluid through the chamber as defined by the last named dome means.

3. A tubulous heat exchanger, including a shell, spaced apart tube sheets in said shell, one anchored thereto and another in floating relation to the shell, tubes supported between said sheets, closure means secured to said floating tube sheet and defining therewith a chamber in communication with adjacent tube ends, another closure means in superposed spaced relation to the first said closure means and defining a chamber in communication with the interior of said shell between said sheets, and circumferentially spaced apart insert means installed between the one said closure means and said other closure means limiting communication of said chamber with the interior of said shell to spaced apart points on opposite sides of the tubes supported between said sheets.

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