United States Patent

Satchwell

[15] **3,635,283**

[45] **Jan. 18, 1972**

[54] MODULAR HEAT EXCHANGER

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[52] **U.S. Cl.** **165/37,** 165/76, 165/152

[51] **Int. Cl.** **G05d 23/00**

[58] **Field of Search** 165/34–38, 76, 165/152

[56] **References Cited**

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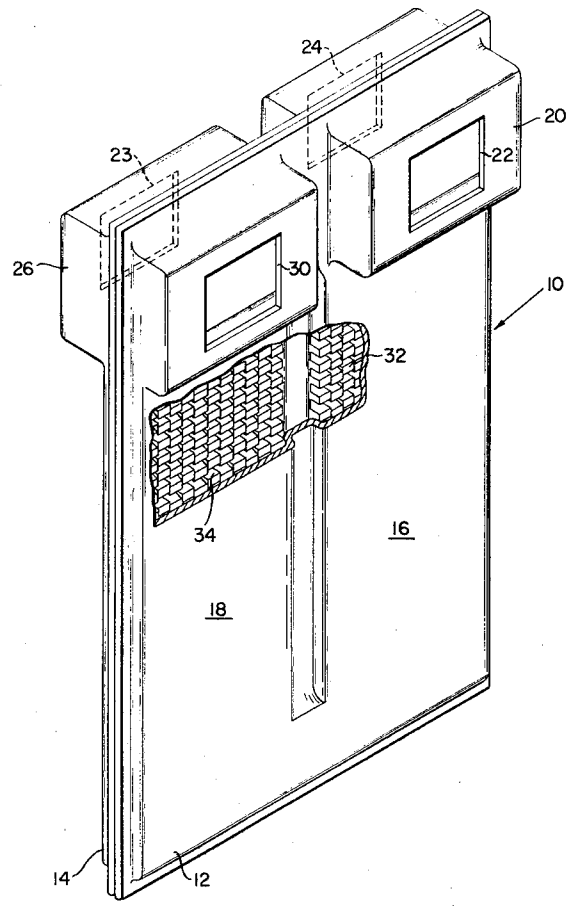
[57] **ABSTRACT**

A modular heat exchanger having a core of a plurality of individual core elements supported within a separate, removable heat exchanger case.

12 Claims, 5 Drawing Figures



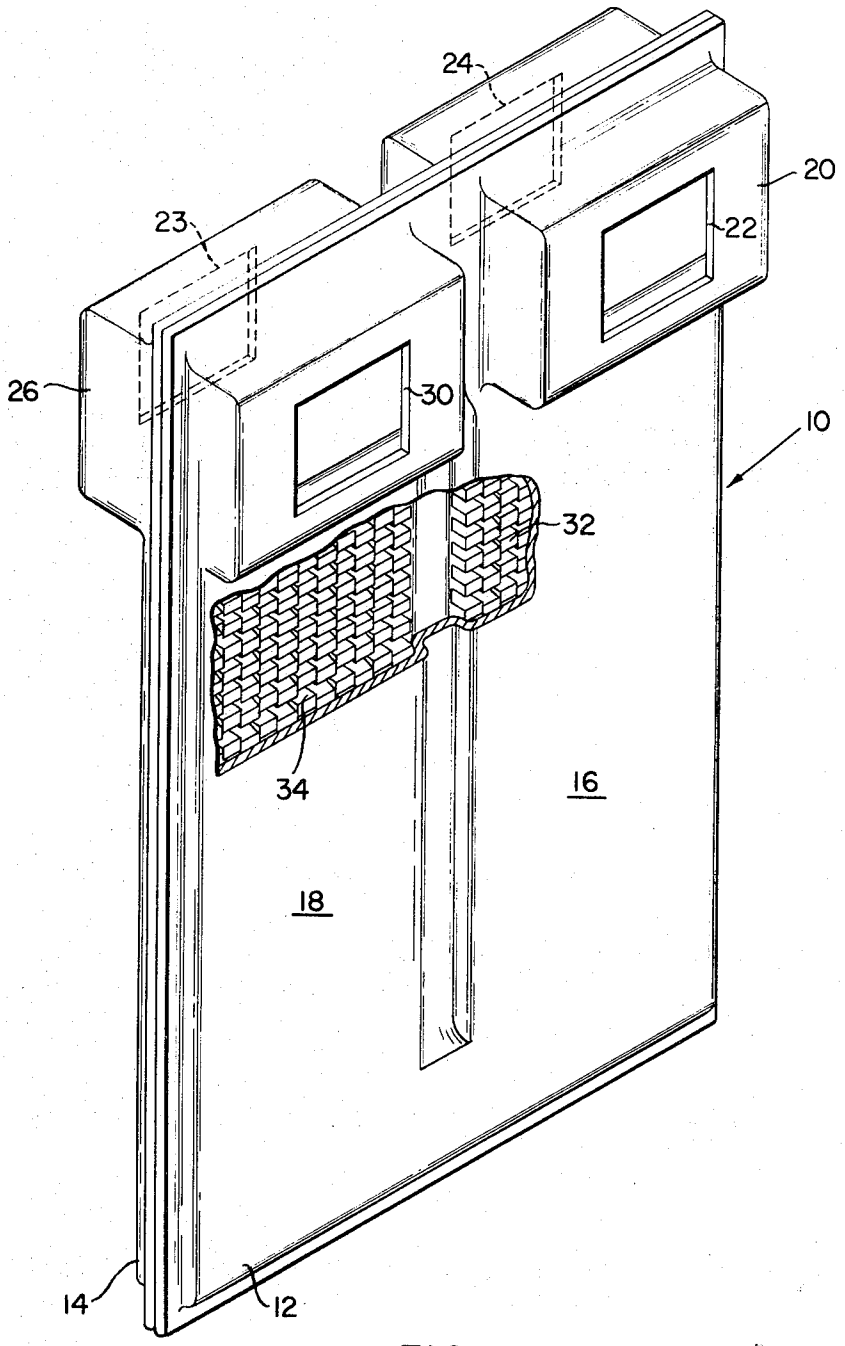


FIG. 1

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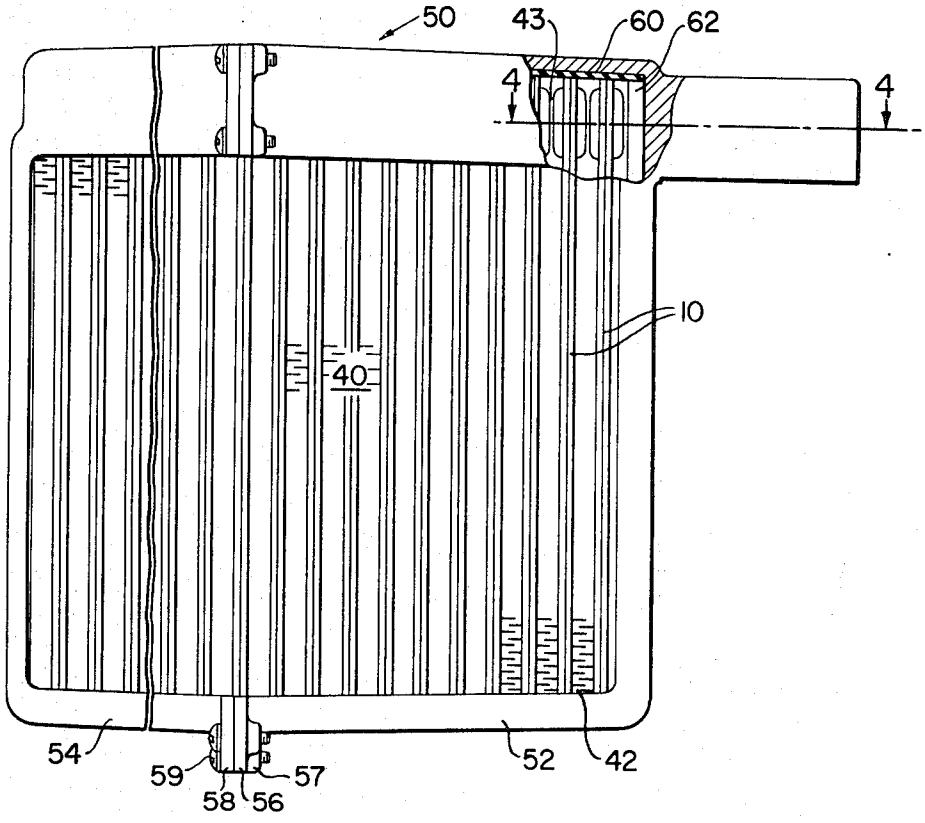

FIG. 2

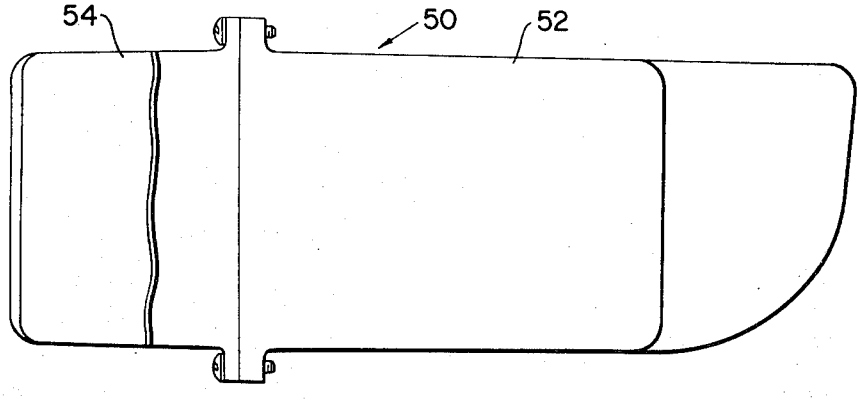

FIG. 3

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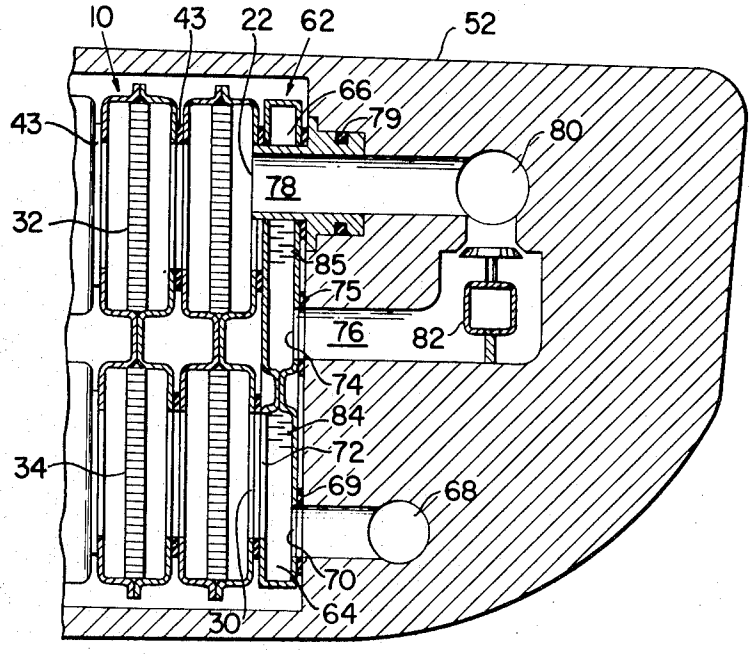

FIG. 4

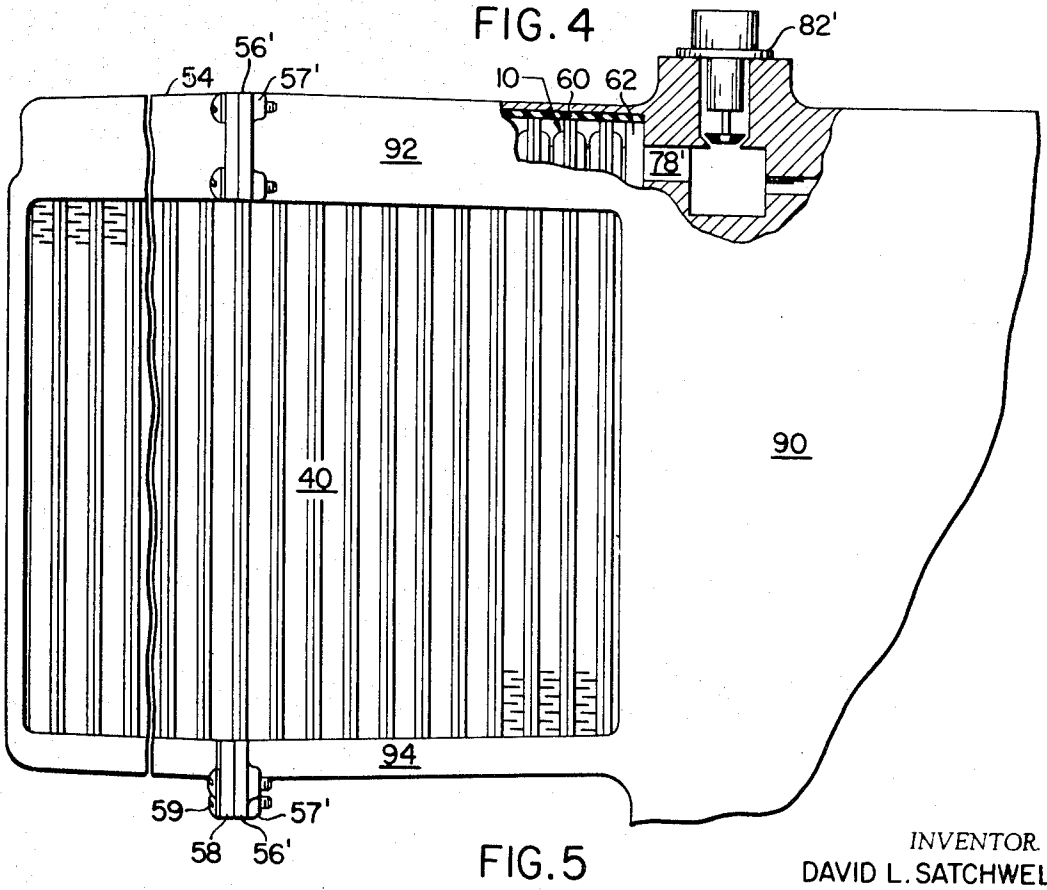

FIG. 5

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MODULAR HEAT EXCHANGER

BACKGROUND OF THE INVENTION

This invention relates generally to heat exchangers and more particularly to a modular heat exchanger made up of individual core elements supported by a removable case having two sections removably jointed together.

In prior heat exchangers, particularly those adapted for the cooling of congealable fluids such as lubricating oils, the development of a leak or other defect in the heat exchanger core required disposal of the entire heat exchanger including the case. The integral case and core also imposed severe vibration problems in many instances and did not permit flexibility with respect to the size of the core to meet varying heat transfer requirements. Also, location of the integral case and core relative to the source of fluid to be cooled could not be optimized. In addition, despite many exotic solutions, start up of the heat exchanger at low temperatures still presented problems.

BRIEF SUMMARY OF THE INVENTION

This invention provides a modular heat exchanger core element which can be stacked with like elements to form a modular heat exchanger core. The individual core elements each include an integral header to achieve parallel flow paths through core elements.

The heat exchanger core, made up of any number of stacked core elements, is supported by a two-section heat exchanger case can be removed to permit maintenance and separate replacement of individual core elements or of the entire core. Resilient pads can be provided at the points of support to isolate the core from vibration. A warm up tube in parallel with the core elements and with its flow controlled by heat responsive valve means can be utilized when required for start up. Further, one section of the heat exchanger case can be integral with the source of fluid to be cooled.

It is, therefore, an object of this invention to provide an individual heat exchanger core element which may be stacked with like elements to form a modular heat exchanger core.

Another object of this invention is to provide an individual heat exchanger core element having an integral header and adapted to be stacked into a modular heat exchanger core with the individual elements having parallel flow paths.

Yet another object of this invention is to provide a modular heat exchanger in which the core can be removed from its case and separately maintained.

Still another object of this invention is to provide a modular heat exchanger in which the heat exchanger core is isolated from case vibrations.

A still further object of this invention is to provide a modular heat exchanger in which a section of the heat exchanger case is integral with the source of fluid to be cooled.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a perspective view, partially cut away, of a modular heat exchanger core element,

FIG. 2 is a side elevation view, partially cut away, of the modular heat exchanger,

FIG. 3 is a top plan view of the modular heat exchanger of FIG. 2,

FIG. 4 is a cross-sectional view taken along line 4—4 of FIG. 2,

FIG. 5 is a side elevation view, partially cut away, of the modular heat exchanger where one section of the heat exchanger case is integral with an engine crankcase.

DETAILED DESCRIPTION OF INVENTION

The individual heat exchanger core element **10** which can be stacked to form a modular heat exchanger core is illustrated in FIG. 1. Basically this element shown in a counterflow configuration for purposes of illustration only, is made up of two formed tube plates **12** and **14** which are joined at their

periphery to form an enclosed structure. The enclosed structure is divided into an inlet section **18** and an outlet section **16**, by either the shape of the formed tube plates **12** and **14** or by a restriction (not shown) placed between the two plates **12** and **14** when they are joined together. In the counterflow configuration shown, the inlet section **18** and outlet section **16** will communicate with each other at the bottom of the core element **10**.

An inlet header **26** is provided at the top of the inlet section **18** and includes an inlet **30**, and outlet **23** on opposite sides thereof. An inlet header **20** also having an inlet **24** and outlet **22** is provided at the top of the outlet section **16**.

Both the inlet section **18** and outlet section **16** are provided with heat transfer surfaces such as fin sheets **34** and **32** respectively. These sheets may be of the rectangular offset type as illustrated.

The individual core elements **10** can be constructed of a lightweight structural material having good heat transfer characteristics such as aluminum and may be individually brazed, for example, in a salt bath dip to form the structure involved.

The individual core elements **10** can be stacked together to form a modular heat exchanger core **40**, as shown in FIG. **2**. The number and size of the individual core elements **10** would be determined by the heat transfer requirements for the heat exchanger. The elements **10** would be joined at their respective headers to permit flow from one inlet header to an adjacent inlet header and likewise from one outlet header to an adjacent outlet header. Fin sheets **42** can be provided between individual core elements **10** to increase heat dissipation from the fluid within the core elements.

The individual core elements **10** including the fin sheets **42** may be brazed together to form an integral unit if desired. Also, the brazing of the individual core elements can be deferred and the entire core assembly brazed at the same time. If however, the individual core elements are not to be brazed together, gaskets **43** can be provided between the outlet and inlet of adjacent headers.

As shown in FIGS. **2** and **3**, the heat exchanger case **50** is made up of two separate sections **52** and **54** which are joined together to support the modular core **40**. The first section **52** and second section **54** of the case **50** may be provided with lugs **56** and **58** respectively by which bolts **59** can be used to secure the attachment of the first section **52** to the second section **54**. Integral nuts **57** in the lugs **56** of the first section provide for a secure attachment. Resident pads **60** of a material such as felt can be used between the case **50** and modular core **40** at points of support to provide vibration isolation for the core. The second section **54** of the heat exchanger case **50** can be provided in varying lengths to accommodate different heat exchanger core sizes.

A warm up tube **62** can be provided in the modular heat exchanger core **40**, particularly when the heat exchanger is to be used to cool a congealable fluid. This warm up tube **62**, like the individual core elements **10**, is divided into an inlet section **64** and an outlet section **66**. As shown in FIG. **4**, an inlet **68** provided in the first section **52** of the case **50** communicates with an inlet **70** in the inlet section **64** of the warm up tube **62**. An outlet **72** in the inlet section **64** of the warm up tube **62** communicates with the inlet **30** of the inlet header **26** of the adjacent core element **10**.

An outlet **74** in the outlet section **66** of the warm up tube **62** communicates with a first outlet **76** in the first case section **52**. A conduit **78** through the outlet section **66** of the warm up tube **62** permits a direct flow from the outlet **22** of the outlet header **20** of the adjacent core element **10** to the second outlet **80** of the first case section **52**. Gaskets **69** and **75** may be provided to prevent leakage between inlets **68** and **70** and between outlets **74** and **76** respectively, while an O-ring **79** prevents leakage between conduit **78** and outlet **80**.

The flow of fluid through the first outlet **76** is controlled by a heat responsive valve **82**, such as a Vernatherm valve, Vernatherm being a trademark of American Standard. Both the

inlet and outlet sections 64 and 66 of the warm up tube 62 can be provided with a plurality of individual fins 84 and 85, respectively to increase the heat transfer surfaces within the warm up tube 62 with a minimum resistance to fluid flow.

While the above-described heat exchanger can be used for a variety of fluids, it is particularly useful for congealable fluids such as lubricating oils used to cool and lubricate an internal combustion engine and the operation of the heat exchanger will be described in this respect. In the start up of the heat exchanger, particularly at lower temperatures, the core 40 will be full of congealed oil. As the flow of oil from the crankcase of an internal combustion engine is initiated, it will take the path of least resistance namely through the inlet 70 of the warm up tube 62 into the inlet section 64 of the warm up tube, through the inlet section 64 and outlet section 66 of the warm up tube and out through the outlet 74 of the outlet section 66 of the warm up tube 62 to the first outlet 76 of the case 50. The valve 82 is designed to permit the flow of oil through the first outlet 76 at low temperatures and to shut off the flow at higher temperatures. This initial flow path at low temperature principally results from the fact that the resistance to flow through the inlet and outlet sections 16 and 18 of the individual core elements 10 is much greater than the resistance to flow through the warm up tube 62.

As the temperature of the flowing oil rises, the heat from the oil passing through the warm up tube 62 will start to decongeal the congealed oil in the core element 10 adjacent to he warm up tube 62. Also, as the oil increases in temperature, the heat responsive valve 82 will start to close thereby increasing the resistance flow through the warm up tube 62.

The interaction of the above two factors, will, as the temperature of the oil increases, initiate flow first through the core element adjacent to the warm up tube 62 and successively through the next adjacent individual core elements and extending eventually the entire length of the modular core 40. When a sufficient temperature has been reached, the valve 82 will completely shut off flow through the first outlet 76 of the case and in essence remove the warm up tube 62 from the flow through the core 40.

While the individual core elements have been shown as providing a series of parallel flows from the in-line headers, it should be recognized that many alternate flow and header configurations are possible. The number of core elements making up an individual core can be varied in response to heat transfer requirements. The separate nature of the core and case permits the maintenance and replacement of the core with relative ease. This separate arrangement also permits the first section of the case to made integral with the source of congealable fluid to be cooled as shown in FIG. 5. The crankcase 90 of an internal combustion engine can be provided with an upper projection 92 and a lower projection 94 which corresponds to the first section 52 of the heat exchanger case 50. These projections 92 and 94 include lugs 56' having integral nuts 57' to enable attachment to the lugs 58 of the second case section 54 by means of bolts 59. The second section 54 can be identical to that previously described in FIGS. 2 and 3. The inlet and outlets to the heat exchanger core 40 would be included in the crankcase 90 in a manner similar to that described in FIG. 4. The heat responsive valve 82' is mounted directly in the crankcase 90, as shown.

While specific embodiments of the present invention have been illustrated and described in considerably detail, it should be recognized that modifications can be made thereto without departing from the spirit and scope of the invention as defined in the appended claims.

What I claim is:

1. A modular heat exchanger comprising:
- a modular heat exchanger core having a plurality of substantially identical individual core elements; and
- a heat exchanger core case positioned around said core and having a first section and a second section, said second core case section detachably secured to said first core case section to removably support said core.

2. The modular heat exchanger of claim 1 wherein said individual core elements comprise:
- a first tube plate;
- a second tube plate substantially identical to said first tube plate, the outer periphery of said first tube plate joined to the outer periphery of said second tube plate to form an enclosure between said second tube plates;
- restricting means within said enclosure defining an inlet section and an outlet section within said enclosure;
- said inlet section of said enclosure having an inlet header at the one end thereof, said inlet header having an inlet on one side thereof and an outlet on he opposite side thereof;
- said outlet section of said enclosure having an outlet header at the one end thereof, said outlet header having an inlet on one side thereof and an outlet on the opposite side thereof;
- a first fin sheet positioned within said inlet section of said enclosure; and
- a second fin sheet positioned within said outlet section of said enclosure.

3. The modular heat exchanger of claim 2 and in addition a plurality of individual fin sheets, an individual fin sheet positioned between adjacent individual core elements.

4. The modular heat exchanger of claim 1 wherein said first section and said second section of said heat exchanger core case are boltably secured to each other.

5. The modular heat exchanger of claim 1 and in addition resilient material pads interposed between said heat exchanger core and said heat exchanger core case at points of support.

6. The modular heat exchanger of claim 1 and in addition a fluid cooled operably associated with said heat exchanger and wherein said first section of said heat exchanger core case is an integral part of said engine.

7. A modular heat exchanger for a congealable fluid comprising:
- a modular heat exchanger core having a plurality of substantially identical individual core elements, and individual core elements comprising:
- a first tube plate;
- a second tube plate substantially identical to said first tube plate, the outer periphery of said first tube plate joined at the outer periphery of said second tube plate to form an enclosure between said first and said second tube plate;
- restricting means disposed within said enclosure defining an inlet section extending the length of one side of said enclosure and an outlet section extending the length of the opposite side of said enclosure, said inlet section communicating with said outlet section at the bottom of said enclosure;
- said inlet section of said enclosure having an inlet header at the upper end thereof, said inlet header having an inlet on one side thereof and an outlet on the opposite side thereof, said inlet adapted to communicate with the outlet of the inlet header and an adjacent core element on one side of said inlet header and said outlet adapted to communicate with the inlet of the inlet header of an adjacent core element on the opposite side of said inlet header;
- said outlet section of said enclosure having an outlet header at the upper end thereof, said outlet header having an inlet on one side thereof and an outlet on the opposite side thereof, said inlet adapted to communicate with the outlet of the outlet header of an adjacent core element on one side of said outlet header and said outlet adapted to communicate with the inlet of the outlet header of an adjacent core element on the opposite side of said outlet header;
- a first fin sheet positioned within said inlet section of said enclosure, and
- a second fin sheet positioned within said outlet section of said enclosure;

a plurality of individual fin sheets, an individual fin sheet positioned between adjacent individual core elements below said inlet and outlet headers;

a heat exchanger core case positioned around said core and having a first section at one end of said core and a second section at the other end of said core and boltably attached to the first case section, said first case section having an inlet to provide a flow of congealable fluid to said core and two outlets to receive a flow of congealable fluid from said core;

a warm up tube interposed between said first case section and said heat exchanger core;

restricting means disposed within said warm up tube defining an inlet section extending the length of one side of said warm up tube and an outlet section extending the length of the other side of said tube, said inlet section communicating with said outlet section at the bottom of said tube;

said inlet section of said warm up tube having an inlet to receive a flow of congealable fluid to the inlet section of said warm up tube from the inlet of said first section of said case and an outlet opposite said inlet to communicate with the inlet of the inlet header of the adjacent individual core element;

said outlet section of said warm up tube having an outlet to permit a flow of congealable fluid from the outlet section of said warm up tube to the first outlet of said first section of said case and conduit means through said outlet section of said warm up tube to provide communication between the outlet of the outlet header of the adjacent individual core element and the second outlet of the first section of said case;

a plurality of fins positioned within said inlet and said outlet sections of said warm up tube, said fins to provide less resistance to the flow of congealable fluid than said first and said second fin sheets in the inlet and outlet sections of the individual core elements; and

heat responsive valve means in the first outlet of said first section of said case to permit the flow of cold congealable fluid and restrict the flow of warm congealable fluid.

8. The modular heat exchanger of claim **1** wherein said first and said second fin sheets positioned with the inlet and outlet sections of said individual core elements are offset rectangular fins positioned to provide maximum resistance to flow, said plurality of fins positioned within said inlet and outlet sections of said warm up tube are individual fins positioned across the flow in the warm up tube to provide minimum resistance to flow, said individual core elements are brazed together with said plurality of individual fin sheets between said core elements and with said warm up tube to form an integral heat exchanger core.

9, The modular heat exchanger of claim **7** and in addition resilient material pads interposed between said heat exchanger and said heat exchanger core and said heat exchanger core case at points of support.

10. The modular heat exchanger of claim **7** and in addition a source of congealable fluid to be cooled.

11. The modular heat exchanger of claim **10** wherein said source of congealable fluid to be cooled in a congealable fluid cooled engine and said first section of said case is integral with said engine.

12. The modular heat exchanger of claim **10** wherein said congealable fluid is a lubricating oil.

* * * * *

UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,635,283 Dated January 18, 1972

Inventor(s) David L. Satchwell

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

In the Specification:

Col. 1, line 31, after "case" insert --which--

Col. 1, line 75, after "their" insert --outer--

Col. 3, line 31, after "resistance" insert --of--

In the Claims:

Claim 2, line 7, after "said" insert --first and said--

line 12, change "he" to --the--

Claim 6, line 2, after "cooled" insert --engine--

Claim 7, line 4, change "and" to --said--

line 8, change "at" to --to--

line 21, change "and" to --of--

Claim 8, line 1, change "1" to --7--

line 8, after "flow," insert --and--

Claim 9, line 3, cancel "and said heat exchanger"

Signed and sealed this 27th day of June 1972.

(SEAL)
Attest:

EDWARD M.FLETCHER,JR.
Attesting Officer

ROBERT GOTTSCHALK
Commissioner of Patents

FORM PO-1050 (10-69)

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