

July 25, 1944.

B. BURNS

2,354,362

OIL COOLER HAVING PROTECTIVE AND CONTROL MEANS

Filed July 27, 1942

2 Sheets-Sheet 1

Fig. 1.

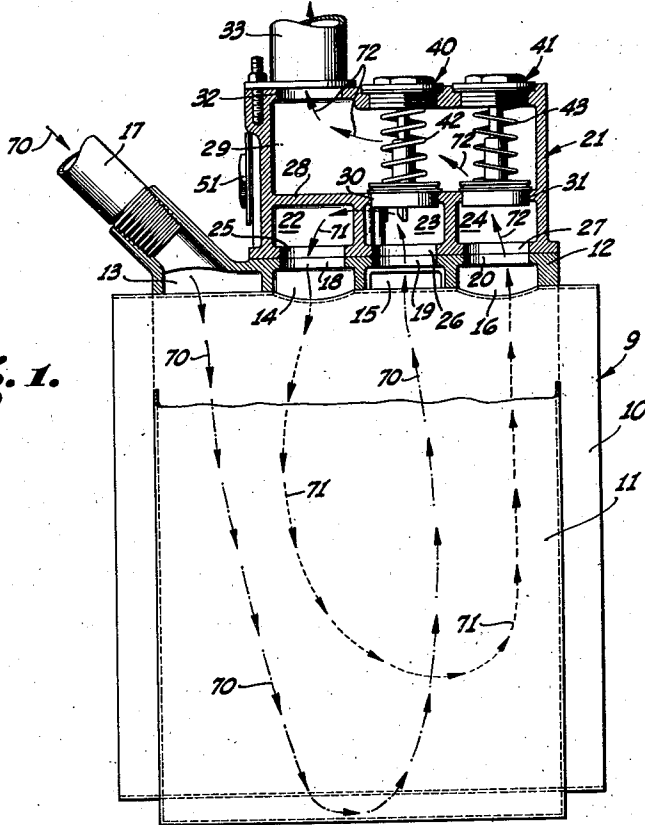


Fig. 4.

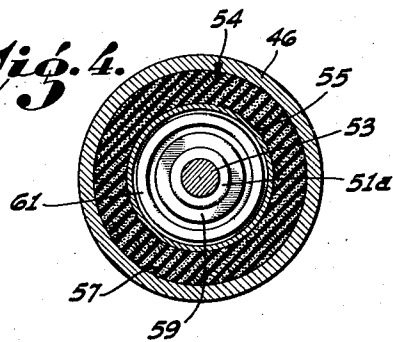
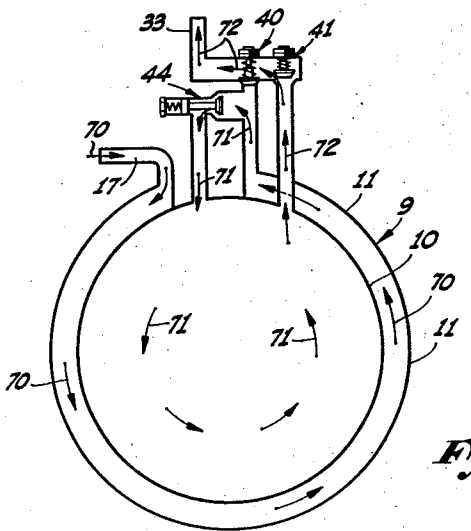


Fig. 5.



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2 Sheets-Sheet 2

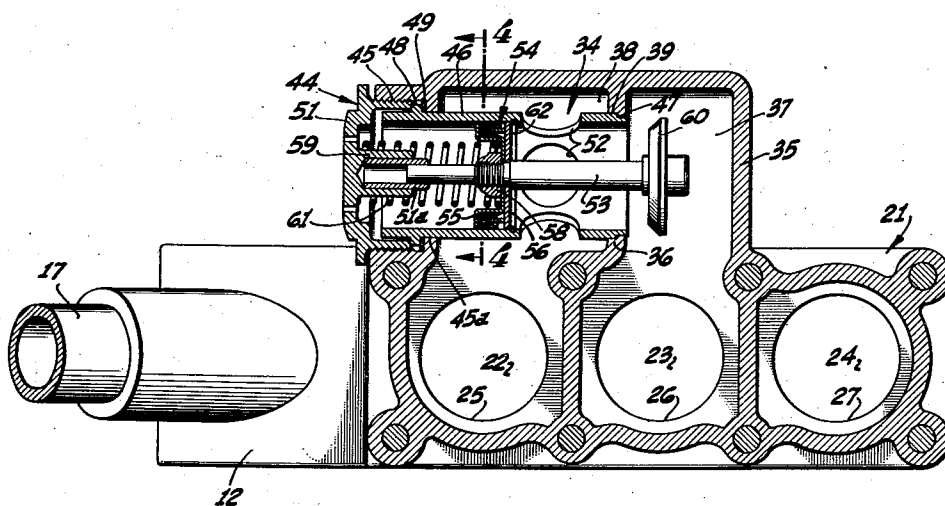
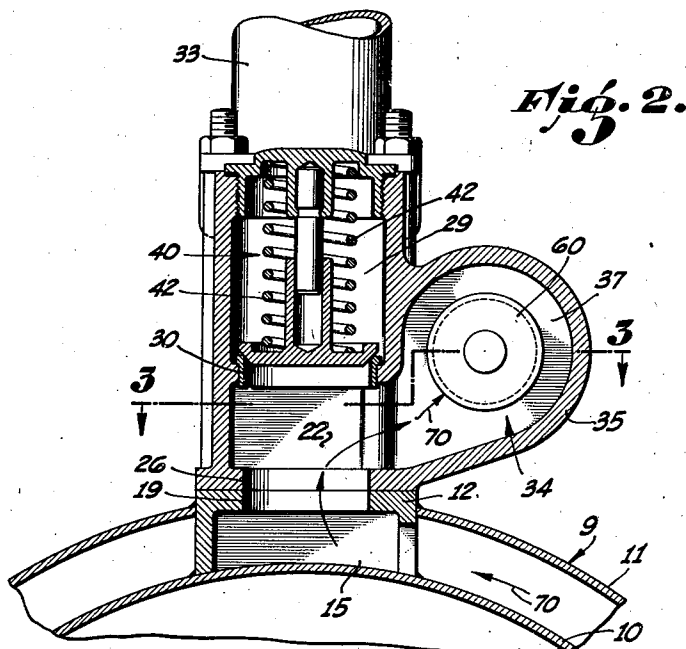


Fig. 3.

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UNITED STATES PATENT OFFICE

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OIL COOLER HAVING PROTECTIVE AND CONTROL MEANS

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4 Claims. (Cl. 257—2)

This invention relates in general to oil cooling systems for internal combustion engines, and relates in particular to a cooler having means for protecting the cooler proper, or heat exchanger, from the destructive effects of excessive pressures or pressure surges in the oil circulating system associated therewith.

Oil coolers of the type now generally employed for aircraft installation consist in a cellular type of heat exchanger having inlet and outlet openings which are respectively connected in series with the oil circulating system, in which the oil pressure changes in accordance with varying conditions. It is an object of the invention to provide in conjunction with a heat exchanger in an oil cooling system of the class described, means which will automatically close at least the inlet opening of the heat exchanger when a heavy pressure is built up in, or a heavy pressure surge occurs in the oil circulating system.

It is an object of the invention to provide an oil cooling device which has oil flow control valve parts associated with the inlet and outlet openings of the cooler, and has cooperating parts which are actuated by oil pressure applied in the oil circulating system, the cooperating valve parts of the device functioning as the result of automatic response to prescribed high pressure conditions to prevent the flow of oil into the interior of the heat exchanger through either the inlet or the outlet openings of the heat exchanger. Accordingly, the invention not only provides a protective device for use with coolers other than the ones specifically disclosed herein, but will enable reduction in the weight of oil coolers now employed in aircraft, this reduction in weight being made possible by the fact that where the invention is employed the bursting strength of the cooler may be reduced, and the protective mechanism may be adjusted so as to prevent from reaching the interior of the cooler any pressure which might be close to the pressure limits established for the cooler.

An object of the invention is to provide in an oil cooler a protective device which will be actuated by a pressure in the oil circulating system not greatly in excess of the maximum normal operating pressure, and will protect the heat exchanger or core from any higher pressure which may be produced in the oil circulating system.

A further object of the invention is to provide a protective unit which may be readily secured to the fitting of the heat exchanger containing the inlet and outlet openings therefor, and which unit has inlet and outlet ports for connection to

the hot oil supply piping and the return piping of the oil circulating system.

A further object of the invention is to provide a protective valve structure which has the character of a separate unit, the installation of which requires a minimum of machining of the housing of the protective and control unit.

In oil cooling devices of the type now generally employed with aircraft engines, the heat exchanger element comprises both a cooler proper having a chamber usually of cylindrical shape through which refrigerant air is passed in tubes arranged parallel to the axis of the chamber and a cylindrical shell encircling the cooler to provide a warm up jacket or muff through which oil may be selectively passed with respect to the cooler proper when oil in the lubricating system is cold at the time the engine is started or when due to imperfect temperature regulation, the oil passages of the cooler have become obstructed by coatings of congealed oil on the air tubes.

It is an object of this invention to provide a cooler having a muff which forms a warm up passage substantially surrounding and in series relationship with the cooler core so that during operation the cooler is at all times subject to the warming action of the hot-oil flowing through the warm-up passage.

It is another object of the invention to provide means protecting the muff from pressures of destructive value in the return piping which carries the cooled oil back to the engine. Excessive pressures in the muff may either act outwardly to burst the outer wall of the muff or inwardly to crush the wall of the cooler.

Other objects and purposes of the invention will appear from a reading of the following description and drawings.

Referring to the drawings which are for illustrative purposes only.

Fig. 1 is an elevational view of a cooling device embodying the invention, showing the protective and control unit in vertical section.

Fig. 2 is an enlarged sectional view taken as indicated by the line 2—2 of Fig. 1.

Fig. 3 is a section taken as indicated by the line 3—3 of Fig. 2.

Fig. 4 is a cross sectional view taken as indicated by the line 4—4 of Fig. 3.

Fig. 5 is a schematic view illustrating the flow of oil through the heat exchange elements and the protective and control unit.

As shown in Fig. 1, my invention includes a heat exchanger 8 having an outer cylindric shell or drum 10 surrounded by a warm-up reservoir

or muff 11. The chamber of the drum, in keeping with known practices, is provided with refrigerant air tubes (not shown) around which the oil is caused to circulate by means of suitably disposed baffle plates (not shown). The upper ends of the muff 11 are spaced apart to receive a fitting 12, the walls of which are formed to provide four chambers 13, 14, 15 and 16. The chamber 13 forms a communicating connection between the hot oil delivery pipe 17 and one end of the muff 11. The chamber 15 receives oil from the other end of the muff. Chambers 14 and 16 communicate with the inlet and outlet openings respectively of the cooler 10. The upper wall of the fitting 12 is formed with ports 18, 19, and 20 for the chambers 14, 15, and 16 respectively.

A protective control unit generally designated by the numeral 21 comprises a housing having exterior and suitably located partition walls to provide a row of chambers 22, 23, and 24 having ports 25, 26, and 27 registering with the ports 18, 19, and 20 respectively of the chambers of the fitting 12. Between a horizontal partition wall 28 and the upper wall of the protective unit lies the chamber 29 extending across and above all three of the chambers 22, 23, and 24. This chamber 29 communicates with the chambers 23 and 24 below it through ports 30 and 31 respectively in the wall 28. Oil in the chamber 29 is returned to the engine through the port 32 and the cooled oil return piping 33.

The chambers 23 and 22 are connected at their rear sides by a communicating passageway 34, as shown in Fig. 3. This passageway is provided by means of a chambered rearwardly extending projection 35 of the housing 21. The passageway 34 is divided by a partition wall 36 of the housing into an inlet chamber 37 and an outlet chamber 38 connected by a circular opening 39 in the wall 36.

Flow of oil from the muff through chambers 15 and 23 to the chamber 29 is controlled by a check valve assembly 40 mounted in the upper wall of the housing 21, and weighted by a spring 42. Outward flow of oil from the cooler drum 10 through the chambers 16 and 24 to the chamber 29 is controlled by a similarly mounted check valve assembly 41 which is weighted by a spring 43.

Flow of oil through the passageway 34 from the muff and chambers 15 and 23 to chambers 22 and 14, and thence into the oil cooling drum 10, is controlled by a valve assembly insert 44, which is shown in Fig. 3 of the drawings. The side wall of the housing 21 has an opening 45 through which the valve assembly insert 44 may be installed.

The valve assembly has a cylindrical member or valve cage 46 which, with its associated parts, is inserted through the opening 45, its inner end fitting within the opening 39 in the wall 36 and its outer end portion snugly engaging a portion 45a of reduced diameter of the opening 45. The inner end of the cage 46 is step-shouldered at 47 for abutting engagement with a correspondingly formed shoulder in the opening 39 to limit inward movement of the cage and form a fluid tight joint with the wall 36. The outer end portion of the cage 46 is formed with an annular flange 48 which similarly engages the outer wall of the reduced portion 45a of the opening 45, a gasket 49 being disposed between the flange 48 and the housing to form a fluid tight joint. The valve cage 46 is held in position by a nut 51 which has threaded engagement with the bore of the

opening 45 and which also serves as a protective cover for the parts of the valve assembly 44.

The valve cage 46 has, adjacent its inner end, ports 52 through which oil may flow from the interior chamber of the valve cage into the chamber 38. A valve stem 53 has mounted upon it a piston 54 which may reciprocate in sliding engagement with the bore surface of the valve cage 46. This piston may be of any suitable design and may be secured to the valve stem in any suitable manner. As shown in the drawings, it comprises a cup 55, a washer 56, and packing 57 held between the cup and washer and it is secured to the valve stem by means of a nut 58 threaded upon the stem and arranged to clamp the cup and washer against a stepped shoulder on the valve stem.

A centrally bored inwardly extending boss 59 of the end nut 51 holds a guide sleeve 51a for the outer end of the valve stem 53. The inner end of the valve stem 53 carries a valve 60 which may be moved outwardly when oil pressure upon the inner face of the piston 54 causes the piston and valve stem to move outwardly against the pressure of a spring 61, which engages the nut 51 and the outer face of the piston 54 at its respective ends. An outward movement of the piston under the pressure of oil causes the valve 60 to engage the inner end of the valve cage 46 which forms a valve seat for the valve 60. A ring 62 of spring wire limits inward movement of the piston 54 and valve 60.

The oil from the engine enters the muff 11 from the hot oil delivery piping 17 through the chamber 13 in the fitting 12 and after passing through the chamber of the muff or completely around the drum 10, as indicated by arrows 70 in Figs. 1 and 5, is delivered to the protective unit 21 through the chamber 15 of the fitting 12 through ports 19 and 26 into the inlet chamber 23 of the protective unit. Normally oil flows from the chamber 23 past the open valve 60 of valve structure 44 in passageway 34 through the cooler inlet chamber 22 and thence into and through the cooler 10, as indicated by arrows 71. From the cooler, the oil flows through the chambers 20 and 24, lifting the valve 42 and passing through the unit outlet chamber 29 into the return piping 33 as indicated by the arrows 72.

The spring 61 associated with the valve structure 44, Fig. 3, is of such strength that it will resist valve closing movement of the piston 54 against the fluid pressure in the chambers 23 and 37 somewhat greater than the normal operating pressure of the circulating system, but considerably less than the maximum safe working pressure of the cooler drum 10. Should heavy pressure be built up in the chambers 23 and 37, such pressure will be transmitted to the inner face of the piston 54, causing the piston 54 to move outward or leftward against the force of the spring 61. The valve 60 will be thereby moved toward the inner end of the valve cage 46, and as the valve 60 approaches the valve seat formed by the inner end of the cage, the friction of oil passing through the reduced space between the valve periphery and the valve seat, together with the pressure exerted against the rightward face of the valve 60, will move the valve 60 into contacting engagement with the valve seat, thereby cutting off communication between the muff and the cooling drum 10. This closing of the valve 60 occurs when a prescribed increase in pressure is developed in the hot oil delivery piping and muff. The pressure of fluid thereafter

delivered through the hot oil piping 17 may increase dangerously above the pressure required to operate the valve 60, but cannot be transmitted through the passageway 34 to the cooling chamber within the drum 10.

The spring 42 of the check valve structure 40 between the chamber 23 and the outlet chamber 29 is gauged so that the valve thereof will yield from its position, closing the port 30 at a pressure slightly greater than the pressure required for the closing of the piston controlled valve 60. Accordingly, closing the valve 60 does not act to stop the flow of oil through the oil circulating system, but the oil may then pass directly from the delivery piping 17 through the port 30 into the chamber 29 and return piping 33, bypassing the cooling chamber within the drum 10 and returning directly to the engine.

The spring 43, associated with the check valve structure 41, will yield upwardly, opening the port 31 in response to a relatively small pressure drop between the chambers 24 and 29. On the other hand, any increase in pressure in the chamber 29 above that in the chamber 24, however slight, will allow the spring 43 to close the port 31, giving assurance when a high pressure surge is transmitted to the chamber 29 from the return piping the valve of the check valve structure 41 will close the port 31, protecting the oil cooler against destructive pressures existing at any point beyond the outlet port 32 of the protective and control unit 21.

The check valve structure 40 similarly protects the muff 11 from excessive pressures in the return piping 33. The check valve structure 40 therefore has the dual purpose of opening a bypass for the oil around the cooler when, due to a high pressure in the delivery piping system or due to stoppage within the cooler, it is of advantage to break the connection between the delivery piping system and the cooler, and also of protecting the muff from excessive oil pressure in the return piping.

The cooler is protected from high pressure in the delivery piping by the valve assembly 44 and from high pressure in the return piping by check valve structure 41.

As schematically shown in Fig. 5, in a cooling device constructed in accordance with this invention, the oil from the engine, which is always warm after a few moments following the starting of the engine, passes through the muff 11 in a position of heat exchange relation with the drum 10. This passage of warm oil around the cooling drum is a condition which obtains at all times whether the valve assembly 44 is in open or closed position, excepting only those times when the bypass valve structure 40 and the valve structure 41 are both closed, a situation which will obtain only for brief intervals of time when back pressure surges develop in the return piping.

The cooler is thus subjected to the warming action of the drum whether or not oil is passing through the cooler. This is a desirable feature of the invention. When the oil flowing through the cooler is being unduly cooled by the refrigerant, the muff prevents loss of heat from the oil in the cooler checking the temperature drop and inhibiting waxing of the oil. When the oil passing through the cooler is at too high a temperature, a portion of the heat passing from the oil in the muff to that in the cooler is readily absorbed by the refrigerant air and the rise in

temperature of the oil due to any unabsorbed heat has no very serious effect on the engine.

When the oil is stationary within the cooler drum 10 due to the opening of the bypass valve 40 between the muff and the return piping, the cooler is still subject to the warming action of the muff. If the opening of the bypass is occasioned by congealing of oil within the cooler, the heat of the muff will accomplish a melting of the congealed oil more quickly than otherwise. Similarly, if the bypass is opened because of a heavy pressure drop through the cooler due to the high viscosity of cold oil within it, the heat from the muff will warm the oil within the cooler.

The arrangement by which the muff is in series with either the cooler or the cooler bypass, and the disposition of the valve controls as has been described, provide that the cooler is under substantially all conditions warmed by hot oil flowing through the muff, that both the cooler and the muff are protected from pressure surges in the return piping, that the cooler is protected from high pressures in the delivery piping, and that the muff is provided with a safety relief from excessively high pressures in the delivery piping.

I claim as my invention:

1. In a protective device for connecting to the hot oil delivery piping and the cooled oil return piping of an oil cooling system, a heat exchanger having a cooling chamber with an inlet opening and an outlet opening, said protective device having inlet passage means connecting said delivery piping to said inlet opening, outlet passage means connecting said return piping to said outlet opening, bypass passage means connecting said inlet passage means with said outlet passage means and bypass valve means for said bypass passage means operating in response to excess pressure in said inlet passage means to permit a flow through said bypass passage means to said outlet passage means, said inlet passage means comprising walls forming a restricted first circular opening intermediate its ends, and a second circular opening connecting with the outside the interior space of said inlet passage means downstream from said first opening, said second opening being axially aligned with said first opening and being of a diameter at least equal to that of said first opening, a protective valve assembly for installation from the outside through said second opening, comprising in combination: a hollow cylinder open at its inner end, having a fluid tight engagement with the walls of said openings and formed with a port intermediate its ends and downstream from said first opening; a valve stem in said cylinder projecting inwardly from the open end of said cylinder; a piston on said valve stem slidably engaging the bore surface of said cylinder outwardly from said port; stop means limiting inward movement of said piston toward said port; means resiliently urging said piston toward said stop means; a valve on the inner end of said stem of a diameter not greater than the outside diameter of said cylinder for closing the inner end of said cylinder; and means for securing said cylinder against longitudinal movement with respect to said openings.

2. In a protective device for connecting to the hot oil delivery piping and the cooled oil return piping of an oil cooling system, a heat exchanger having a cooling chamber with an inlet opening and an outlet opening, said protective device having inlet passage means connecting said de-

livery piping to said inlet opening, outlet passage means connecting said return piping to said outlet opening, bypass passage means connecting said inlet passage means with said outlet passage means and bypass valve means for said bypass passage means operating in response to excess pressure in said inlet passage means to permit a flow through said bypass passage means to said outlet passage means, said inlet passage means comprising walls forming a restricted first circular opening intermediate its ends, and a second circular opening connecting with the outside the interior space of said inlet passage means downstream from said first opening, said second opening being axially aligned with said first opening and being of a diameter at least equal to that of said first opening, a protective valve assembly for installation from the outside through said second opening, comprising in combination: a hollow cylinder open at its inner end, having a fluid tight engagement with the walls of said openings and formed with a port intermediate its ends and downstream from said first opening; a valve stem in said cylinder projecting inwardly from the open end of said cylinder; a piston on said valve stem slidably engaging the bore surface of said cylinder outwardly from said port; stop means limiting inward movement of said piston toward said port; stop means fixing the position of said cylinder inwardly of said openings; a removable closure means for said second opening fixing the position of said cylinder outwardly of said openings; a coiled spring on said valve stem acting between said closure means and said piston; and a valve on the inner end of said stem of a diameter not greater than the outside diameter of said cylinder for closing the inner end of said cylinder, said spring yielding to excessive fluid pressures on the inner face of said piston to close said valve.

3. In a protective device fitting for connecting to the hot oil delivery piping and the cooled oil return piping of an oil cooling system, a heat exchanger assembly having a cooler with an inlet port and an outlet port and having a port connected to the delivery piping, said ports being arranged in alignment substantially in the same plane in an upper exterior wall of said assembly, the combination of: walls formed to provide in the lower portion of the fitting a cooler inlet chamber, a cooler outlet chamber and a delivery piping chamber, said three chambers being aligned in juxtaposition with and having port communication with said inlet port, outlet port and delivery port respectively and formed to provide further an elongated upper chamber above and across said three chambers, a first port and a second port connecting said upper chamber with said delivery piping chamber and said cooler out-

let chamber respectively and a port connecting said upper chamber with said return piping; a laterally projecting wall structure providing in conjunction with said walls a passageway at the rear of said three aligned chambers connecting said delivery piping chamber with said cooler inlet chamber and providing a transverse wall in said passageway having a first opening, one end wall of said wall structure being formed with a second opening axially aligned with said transverse wall opening; a spring weighted normally open check valve structure supported in and sealing said second opening for closing said first passageway; a normally closed check valve structure supported in an opening in the upper wall of said upper chamber for opening said first port in response to excessive pressure in said delivery piping chamber; and a check valve structure supported in an opening in the upper wall of said upper chamber for closing said second port in response to a reverse pressure drop across said second port.

4. In a protective unit for connecting to the hot oil delivery piping and a cooled oil return piping of an oil cooling system, a heat exchanger having a cooler with an inlet and an outlet, the combination of: a housing having walls providing a unit inlet chamber for connection to said delivery piping, a cooler inlet chamber for connection to said cooler inlet, a cooler outlet chamber for connection to said cooler outlet, a passageway connecting said cooler inlet and cooler outlet chambers, a unit outlet chamber for connection to said return piping, at least one wall of each of said passageway and said unit outlet chamber being an exterior wall of said unit, a first port between said unit inlet chamber and said unit outlet chamber, a second port between said cooler outlet and said unit outlet chambers; a check valve structure mounted in an exterior wall of said passageway having a normally open valve for closing said passageway, and a spring weighted piston responsive to excessive oil pressure in said passageway to move said valve to close said passageway; a check valve structure mounted in the exterior wall of said unit outlet chamber having a normally closed relatively heavily spring weighted valve for opening said first port in response to excessive pressure in said unit inlet chamber; and a check valve structure mounted in the exterior wall of said housing having a relatively lightly spring weighted valve for closing said second port in response to a reversely acting pressure differential between said unit outlet chamber and said cooler outlet chamber.

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