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(54) **OIL COOLER AND PRODUCTION METHOD**

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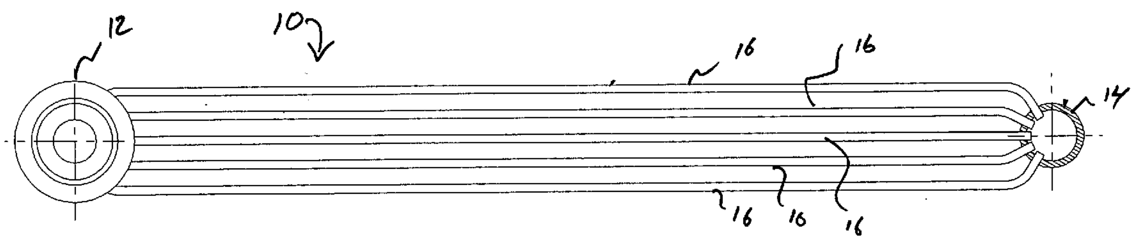
(52) **U.S. Cl.** **165/148**

(57) **ABSTRACT**

The present invention uses a plurality of extruded tubes **8** to lead the oil from one oil cooler tank to the other oil cooler tank (one tank is the inlet tank of the oil cooler and the other one is the outlet tank of the oil cooler). In one application, the oil cooler tanks are identical. One tank functions as an inlet tank and the other tank functions as an outlet tank. Typically the ends of the tanks are threaded or equipped with some type of connector that allows the connection to the hydraulic lines leading the oil. The complete oil cooler is immersed in the cooling medium (the radiator coolant, typically a mixture of 50% water and 50% glycol). The heat of the oil is transferred through the tube walls to the cooling medium, so that the temperature of the oil leaving the oil cooler is significantly lower than the temperature of the oil flowing into the oil cooler.



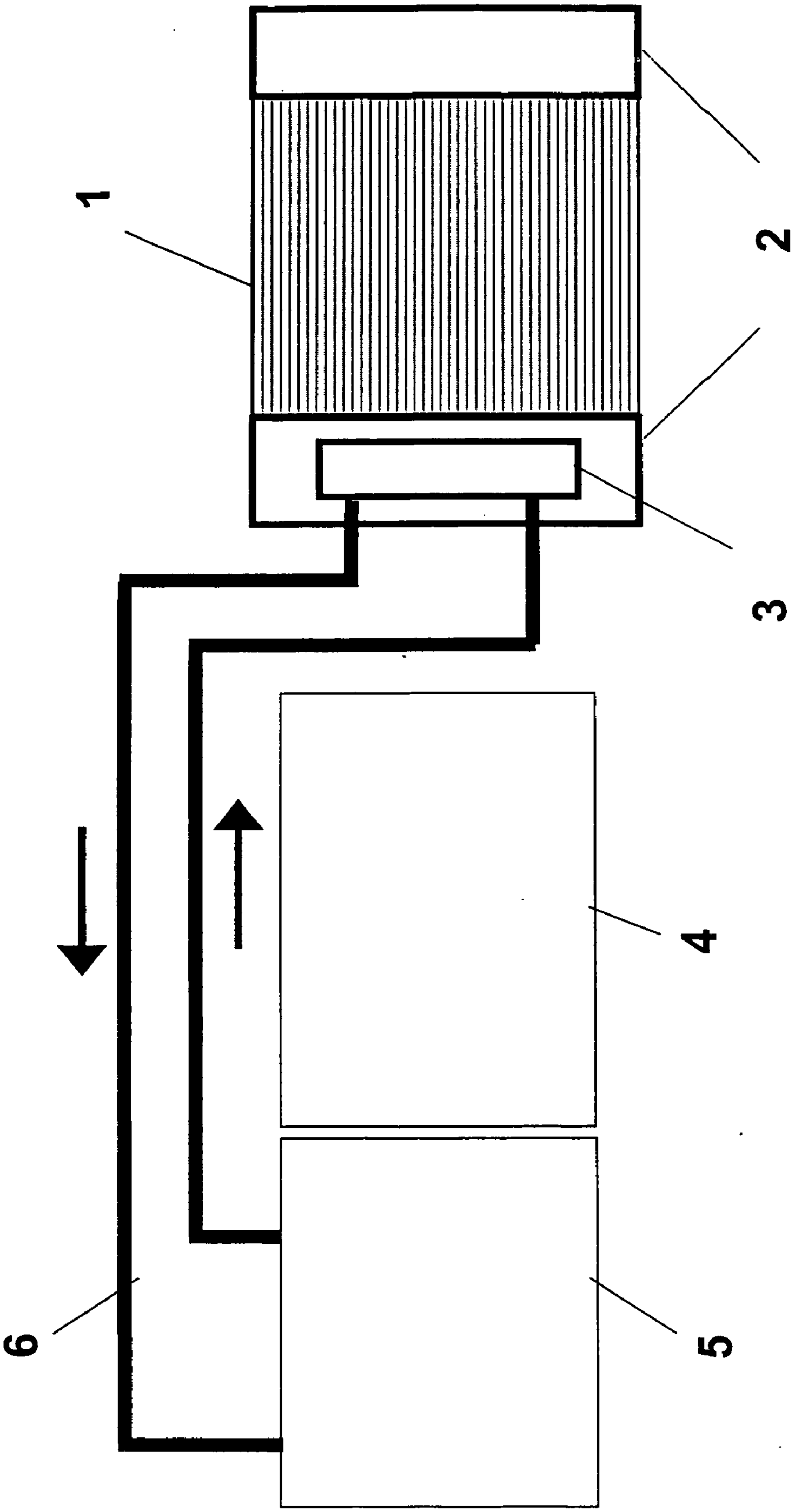


Fig. 1 Prior Art

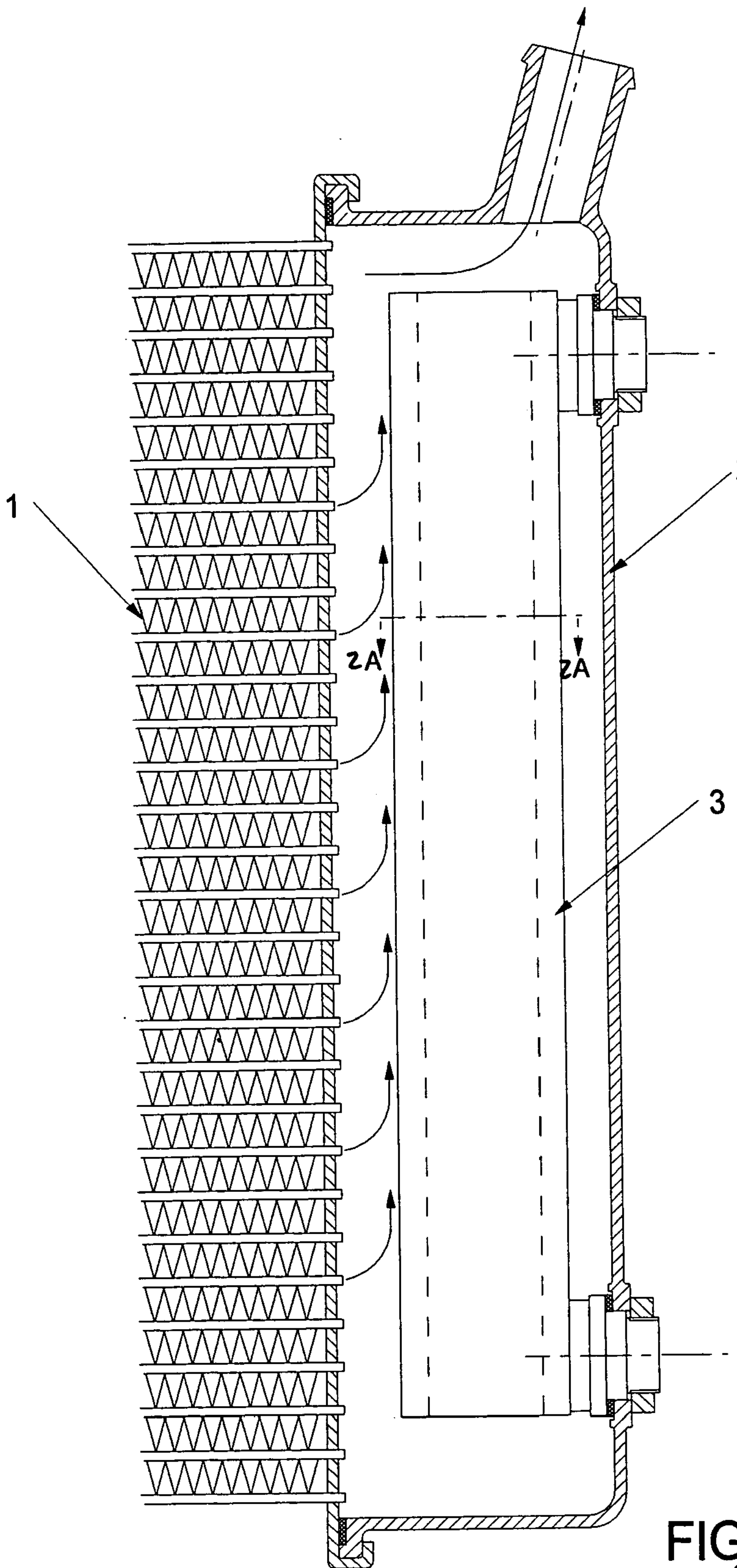


FIGURE 2
Prior Art

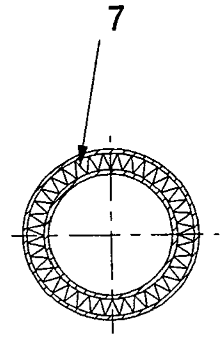


FIGURE 2A

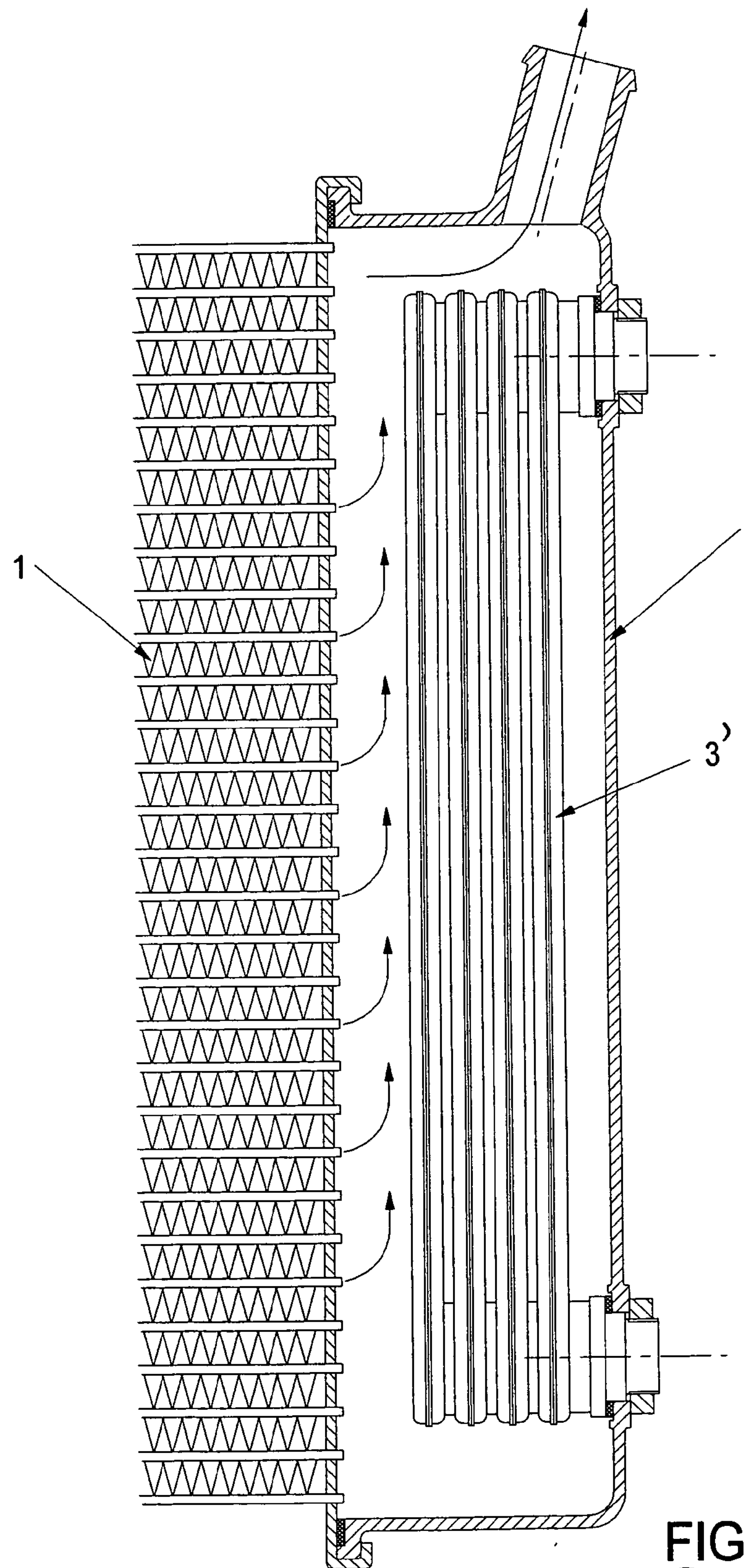


FIGURE 3
Prior Art

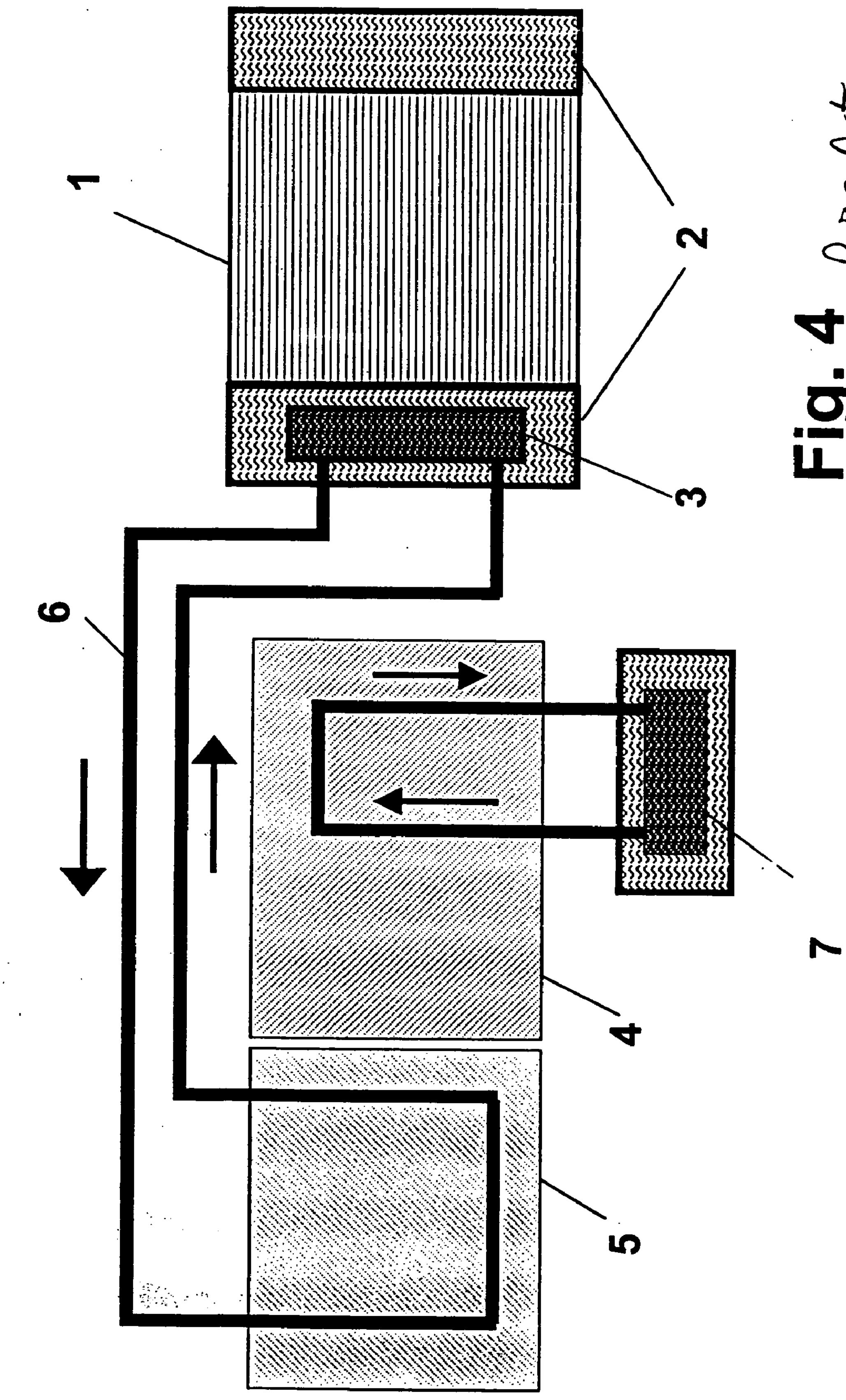


Fig. 4 Prior Art

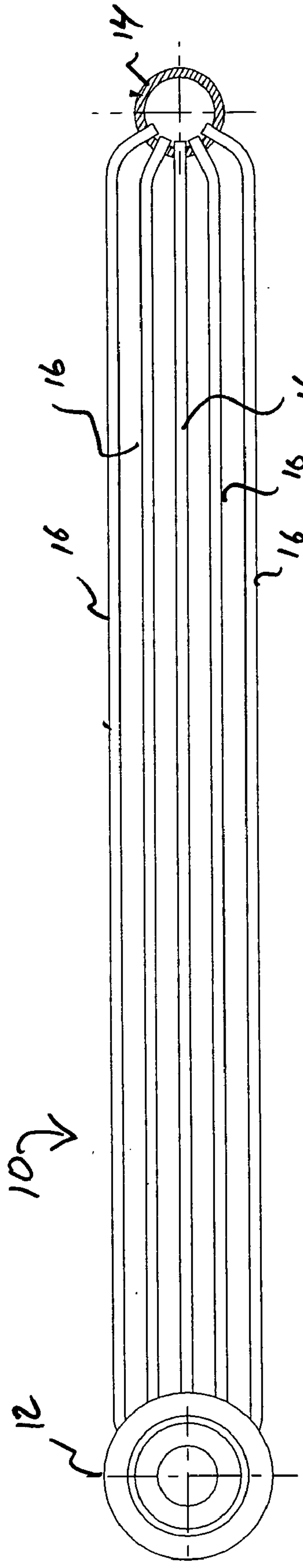


FIG. 5

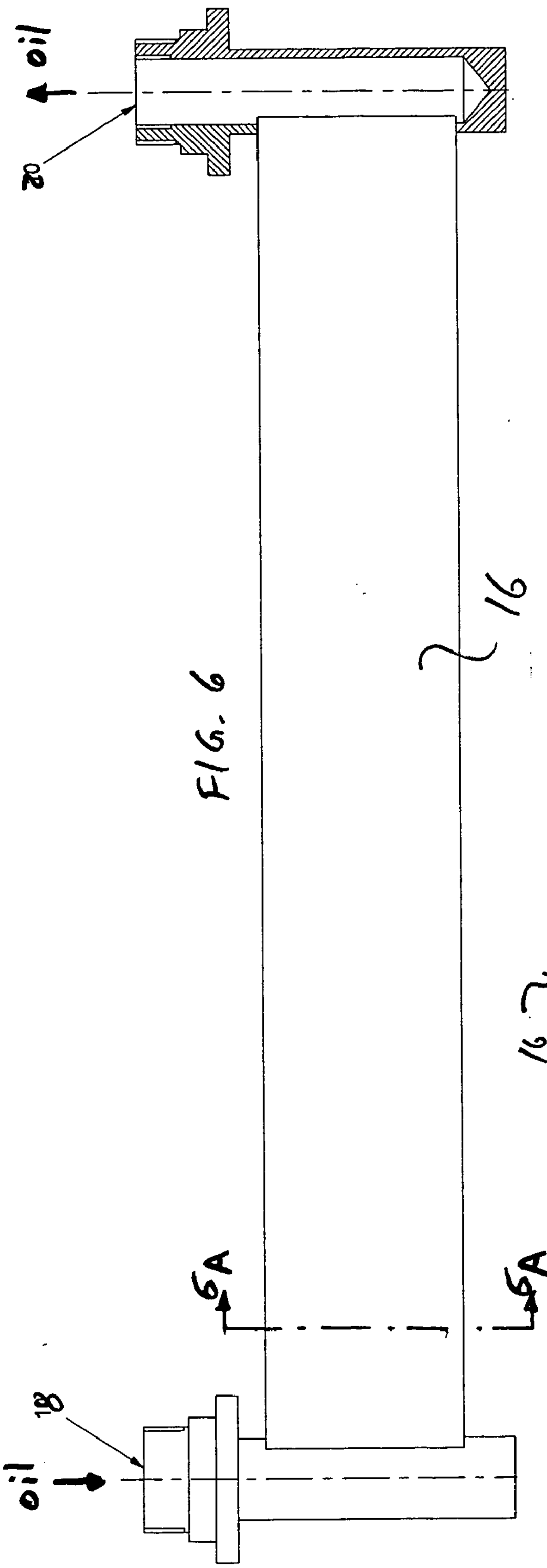


FIG. 6

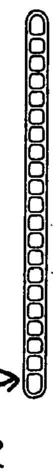


FIG. 6A

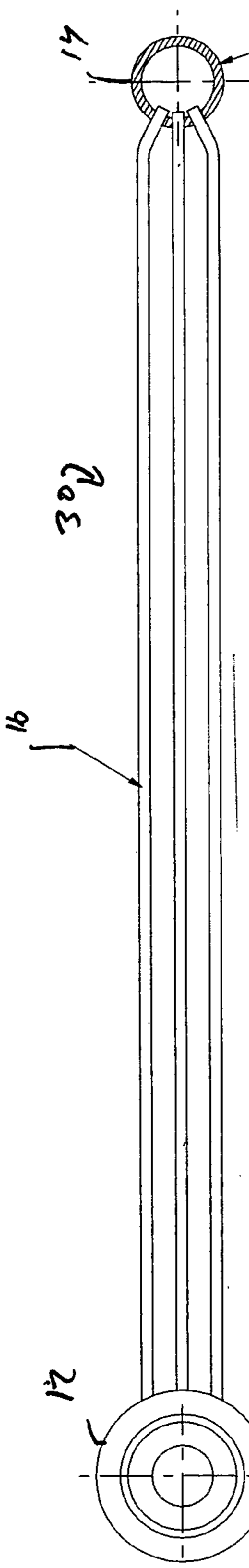


Fig. 7

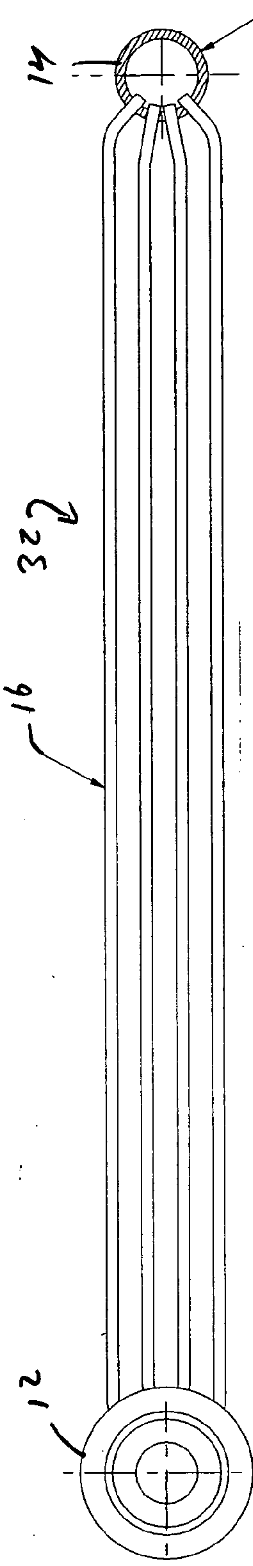


Fig. 8

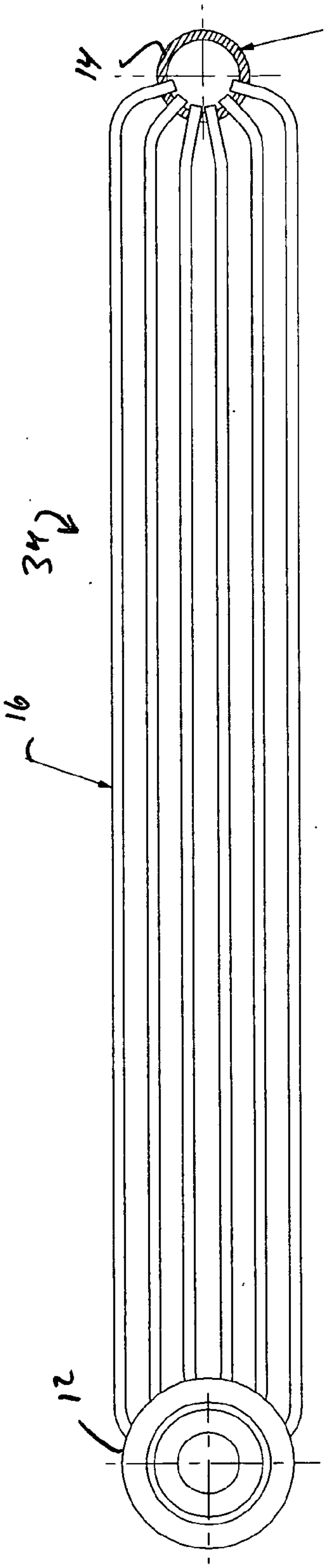


Fig. 9

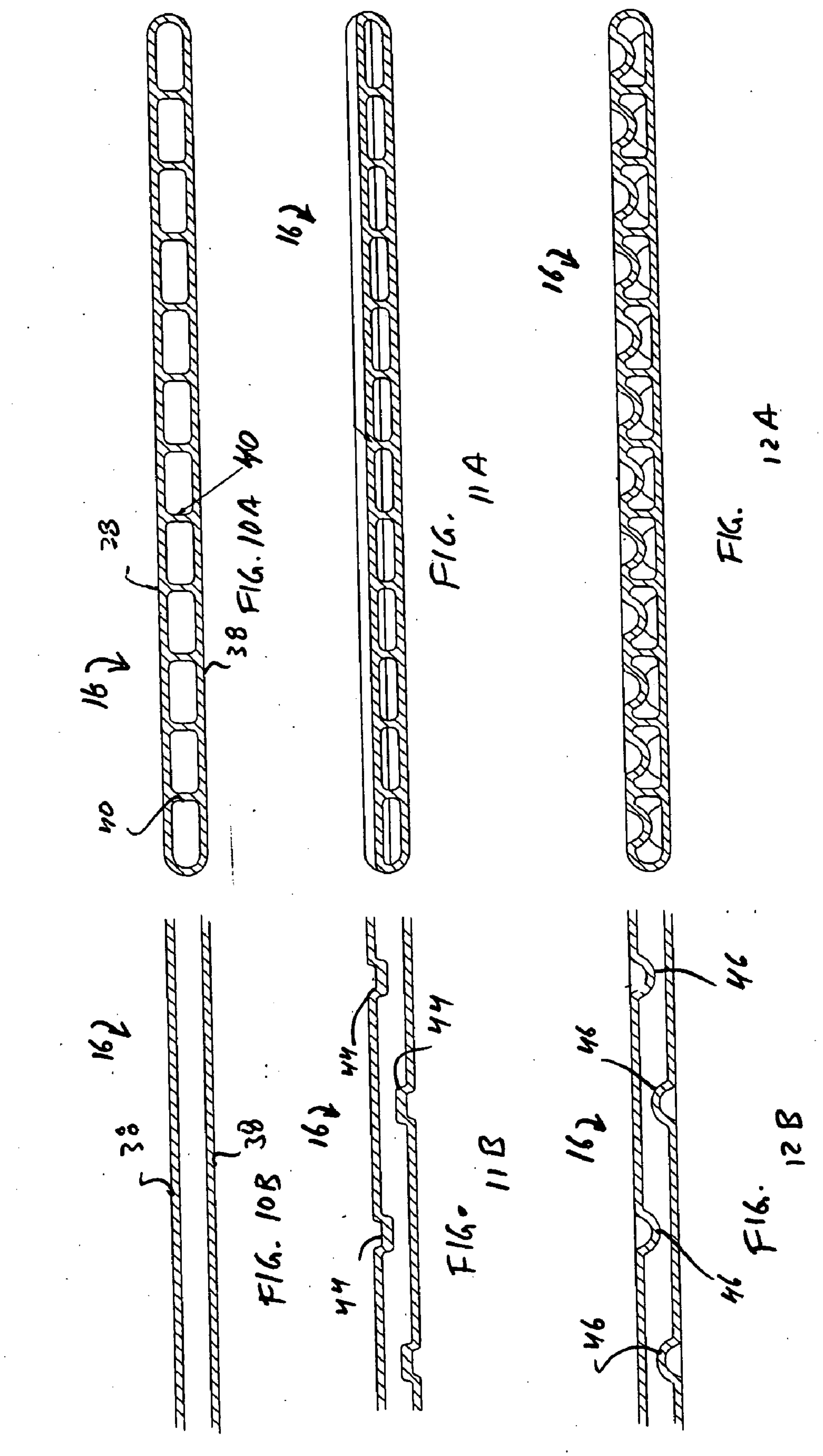


FIG. 10A

FIG. 11A

FIG. 12A

FIG. 10B

FIG. 11B

FIG. 12B

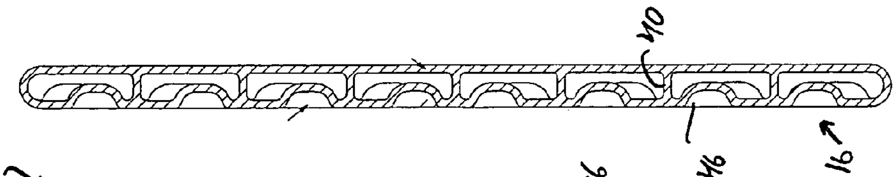


FIG. 13A

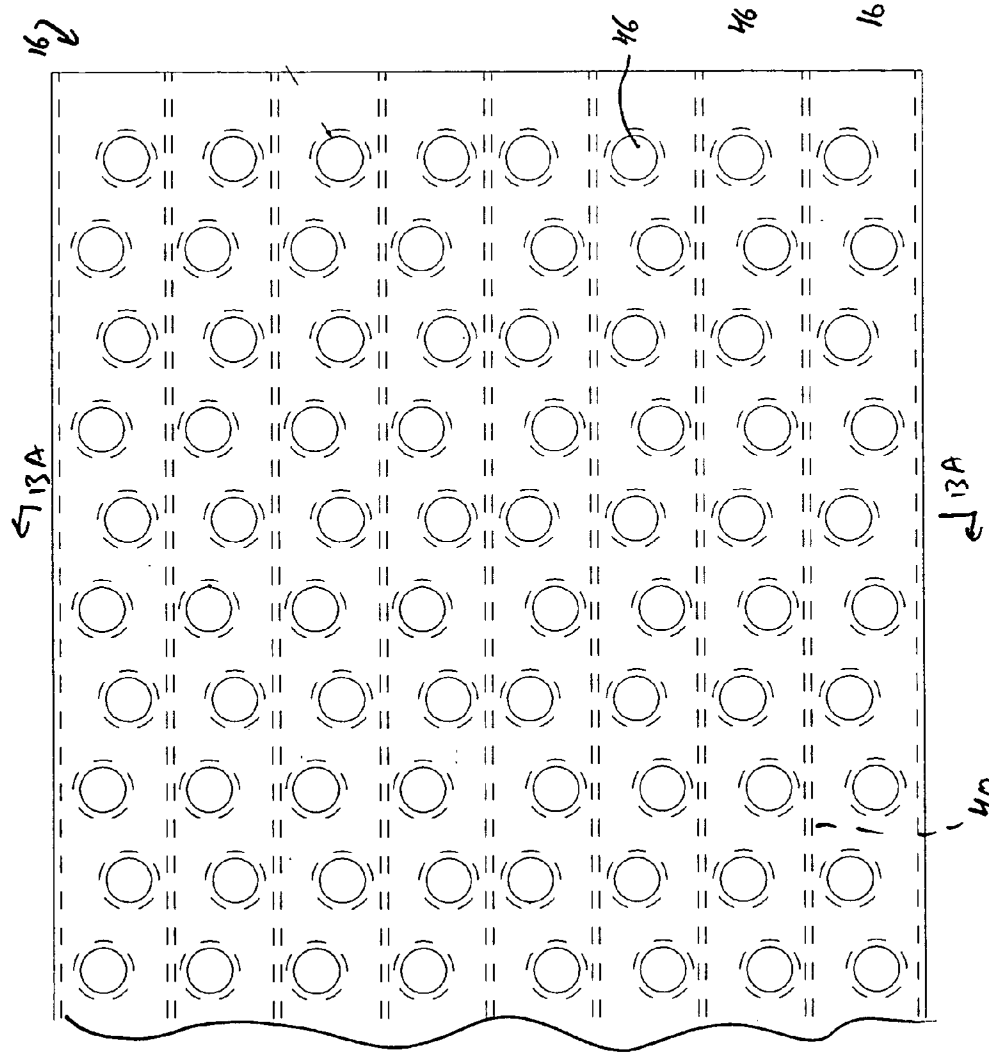


FIG. 13

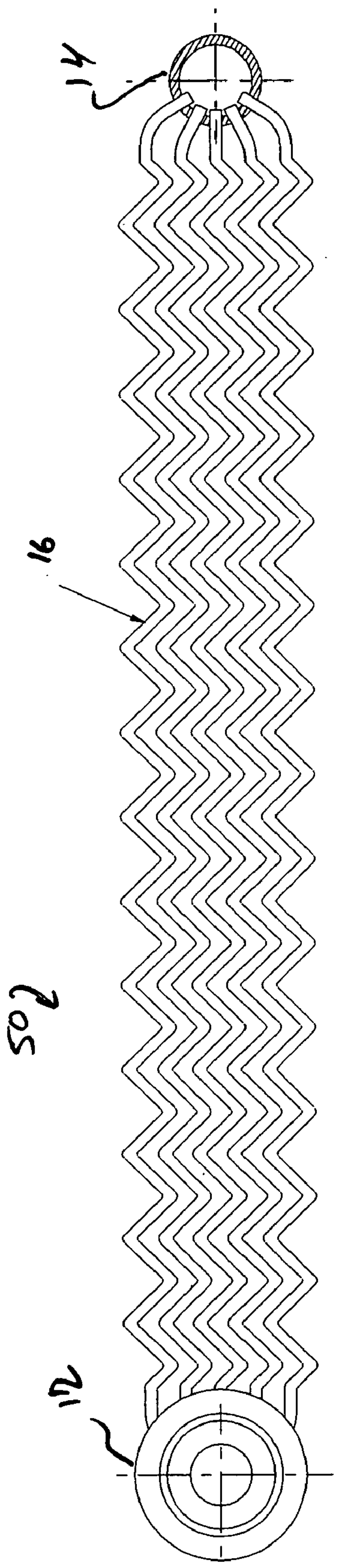


FIG. 14

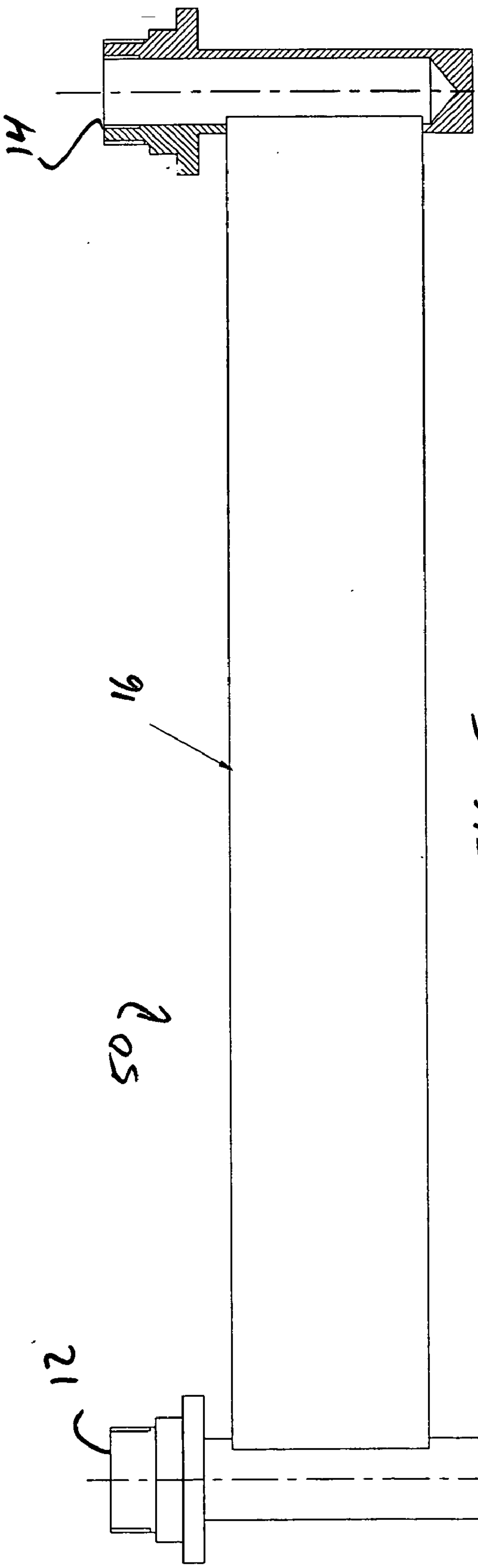


FIG. 15

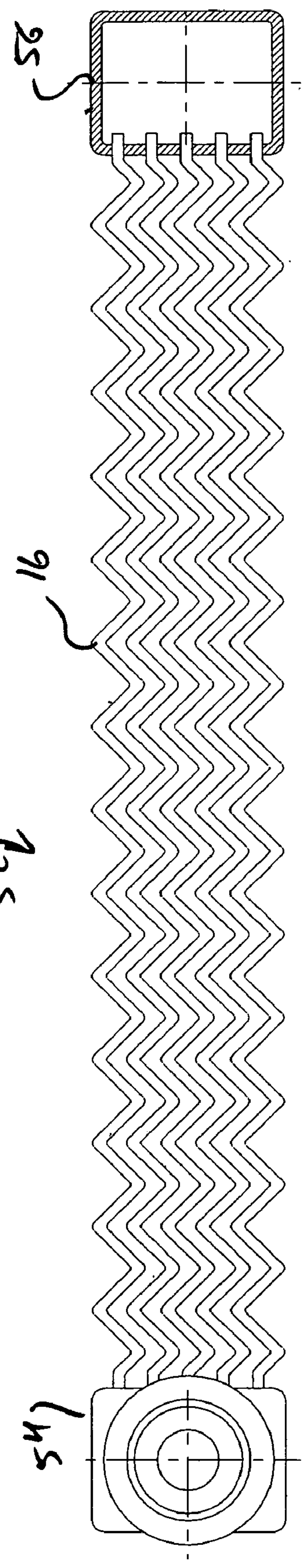


FIG. 16

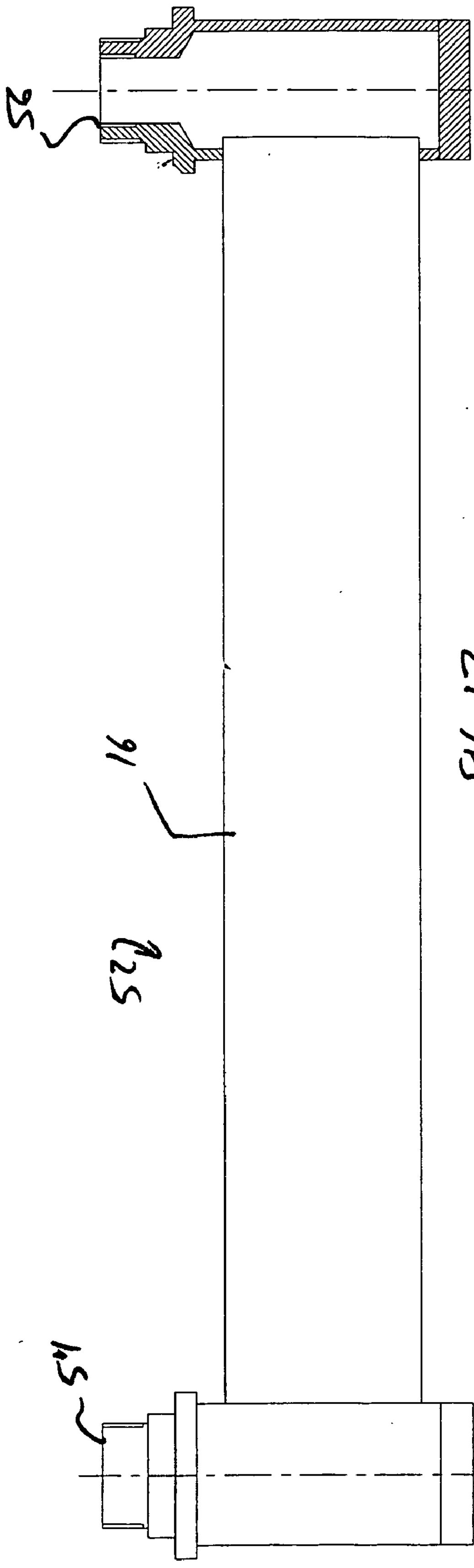


FIG. 17

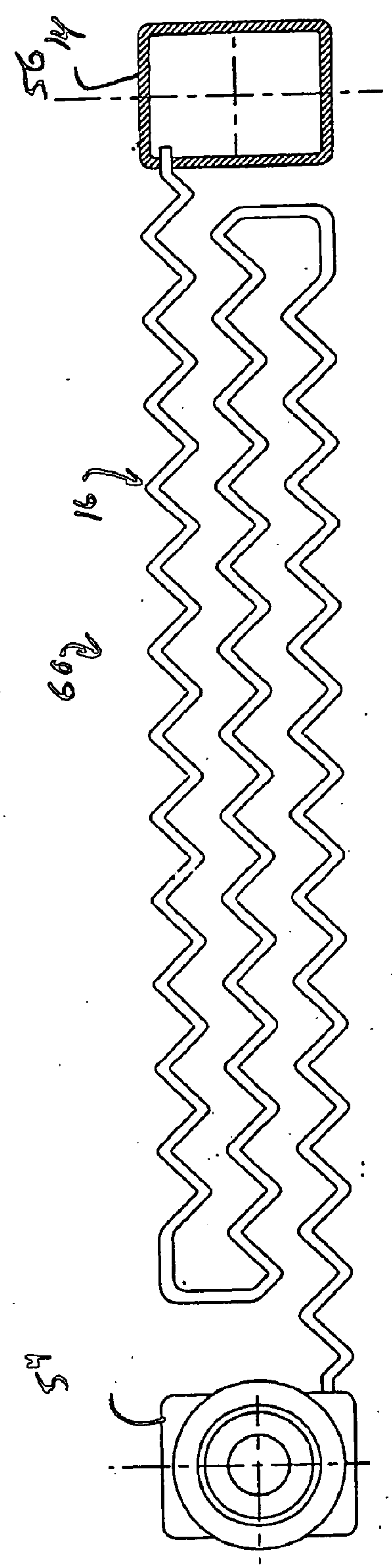


FIG. 18

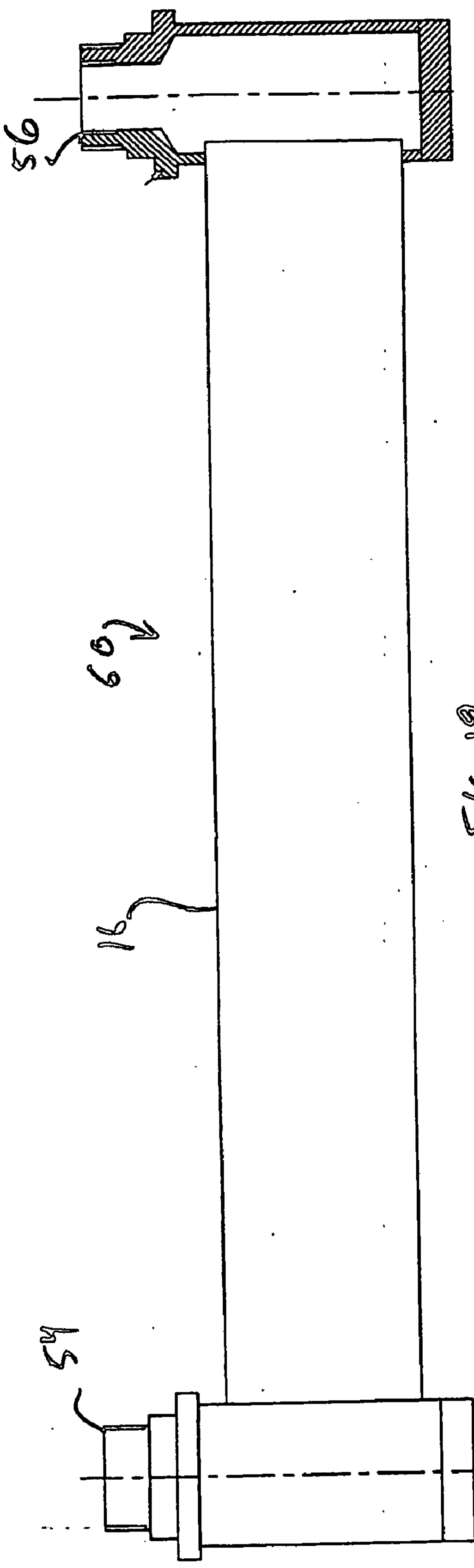


FIG. 19

OIL COOLER AND PRODUCTION METHOD

FIELD OF THE INVENTION

[0001] The present invention relates to the area of cooling of the fluids that are used in machinery such as engines, transmissions and other power equipment to lubricate components and/or transfer power. In one application, the present invention more particularly relates, but is not limited to, the area of cooling of transmission oil and/or engine oil in automotive applications. Numerous other applications exist in diverse areas such as railways, ships, aircraft, machine tool, power generation equipment and others.

BACKGROUND OF THE INVENTION

[0002] In the automotive industry it is necessary to cool the oil used in automatic transmissions. The automotive transmission fluid (ATF) reaches high temperatures in the operation of the transmission. These high temperatures need to be reduced to avoid breakdown of the fluid. A device called a transmission oil cooler is conventionally used for that purpose.

[0003] With reference to the simplified prior art view of **FIG. 1, a** typical transmission cooler **3** is illustrated in an automotive application. The exemplary application is shown to generally include an engine **4** and a transmission **5**. The oil cooler **3** is typically located inside one of the tanks **2** of a radiator **1**. The coolant inside the tanks **2** is used as the cooling medium for the oil cooler **3**. This is possible despite the fact that the coolant itself is relatively hot, because the oil temperature is substantially higher. The temperature differential between the coolant in the radiator tank **2** and the oil in the oil cooler **3** is used to cool the oil. The oil circulates through hydraulic lines **6** between the transmission **5** and the oil cooler **3**, and the oil gets cooled in the oil cooler **3**.

[0004] **FIG. 2** illustrates one typical transmission oil cooler **3** in further detail. The oil cooler **3** is located inside the tank **2** of radiator **1**. This type of oil cooler, which consists of concentric brass tubes between which the oil flows, is typically made by brazing, a high temperature process that requires expensive brazing equipment and complex process control. The result is a relatively expensive and heavy oil cooler. **FIG. 2A** shows the cross section of the oil cooler.

[0005] **FIG. 3** shows a more modern transmission oil cooler **3'**. The oil cooler **3'** is again located inside the tank **2** of radiator **1**. This type of oil cooler **3'** is called a plate cooler, because it basically consists of several flat plates inside which the oil flows. Plate oil coolers are typically made using aluminum strips which are joined together along their perimeter in a brazing process. The use of flat plates leads to a better heat exchange performance than a concentric tube cooler, but the result is still a relatively expensive and heavy oil cooler. The very large number and length of brazed joints creates many potential failure modes (leaks), which has a potential negative impact on the reliability of this oil cooler. **FIG. 3A** shows the cross section of the oil cooler.

[0006] **FIG. 4** shows an engine oil cooler **7**, in addition to the previously shown transmission oil cooler **3**. Some vehicles require both oil coolers. Virtually every vehicle with an automatic transmission requires a transmission oil cooler, and many high powered or high rpm engines require also an engine oil cooler. Typically the engine cooler and the transmission oil cooler are on two separate, independent cooling circuits. The engine oil circulating through the engine oil cooler **7** is typically cooled by placing the oil cooler **7** in a housing that contains coolant. Another possibility (not shown here) is to place the engine oil cooler in the second radiator tank (the first one is already occupied by the transmission oil cooler). This finishes the description of the state of the art in oil coolers.

[0007] While known oil coolers have proven to be suitable for their intended purpose, a need remains in the pertinent art for a lightweight, low cost, highly reliable oil cooler with highly efficient heat transfer characteristics.

SUMMARY OF THE INVENTION

[0008] It is a general object of the present invention to overcome the drawbacks of the prior art discussed above by providing a lightweight, low cost, highly reliable oil cooler with highly efficient heat transfer characteristics.

[0009] It is another object of the present invention to provide a simplified oil cooler that increases reliability and reduces/eliminates potential failure modes such as leaks.

[0010] It is a further object of the invention to use extruded aluminum tubes as the primary heat transfer mechanism. The advantage of the extruded tubes is the simplification of the manufacturing process, as well as the reduction or elimination of potential failure modes (leaks), which directly impact reliability, production cost, testing cost and warranty costs. The use of extruded tubes dramatically reduces the need to join surfaces through brazing in a watertight and oil tight manner. Since every joint in a pressurized heat exchanger is always a potential failure mode, the elimination or reduction in the number of joints provides a major reliability advantage.

[0011] It is another object of the present invention to further increase the heat transfer capability of the oil cooler by modifying the extruded tubes (for instance, by bending or convoluting them or creating dimples in them in order to increase turbulence in the tubes).

[0012] It is another object of the present invention to further increase the heat transfer capability of the oil cooler by modifying the geometry of the extruded tubes (for instance, by modifying the cross-section of the extruded tubes in ways that increase heat exchange).

[0013] It is another object of the present invention to provide different configurations of oil cooler inlet and outlet tanks, so that the optimal tank configuration can be chosen for each particular application. Connection of extruded tubes to tanks is by brazing or other suitable joining method.

[0014] In one particular embodiment, the present invention uses a plurality of extruded tubes **8** to lead the oil from one oil cooler tank to the other oil cooler tank (one tank is the inlet tank of the oil cooler and the other one is the outlet tank of the oil cooler). In one application, the oil cooler tanks are identical. One tank functions as an inlet tank and the other tank functions as an outlet tank. Typically the ends of the tanks are threaded or equipped with some type of connector that allows the connection to the hydraulic lines leading the oil. The complete oil cooler is immersed in the cooling medium (the radiator coolant, typically a mixture of

50% water and 50% glycol). The heat of the oil is transferred through the tube walls to the cooling medium, so that the temperature of the oil leaving the oil cooler is significantly lower than the temperature of the oil flowing into the oil cooler.

[0015] An additional advantage of the extruded tubes used in this invention is the strength of the cross-section (see **FIG. 6A**). The multiple bridges connecting the opposite walls of the tube to each other (called webs) provide high resistance to pressure, so that the oil cooler can handle the high test pressures (typically about 500 psi) to which the oil cooler will be subjected.

[0016] The oil cooler of the present invention provides a breakthrough in the manufacturing of oil coolers, with major cost and weight reductions as well as major improvements in reliability. Instead of having potential leaks along the brazed seams of each tube, as in a conventional flat plate oil cooler, now the only potential leak path is at the joint between tube and port. This represents a major reduction in potential failure modes.

[0017] Further areas of applicability of the present invention will become apparent from the detailed description provided hereinafter. It should be understood that the detailed description and specific examples, while indicating the preferred embodiment of the invention, are intended for purposes of illustration only and are not intended to limit the scope of the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

[0018] **FIG. 1** is a schematic illustration of a prior art transmission oil cooler circuit.

[0019] **FIG. 2** is a view of a prior art conventional oil cooler of concentric tube design shown in partial section.

[0020] **FIG. 2A** is a cross-sectional view taken along the line 2A-2A.

[0021] **FIG. 3** is a view of another prior art oil cooler of plate design shown in partial section.

[0022] **FIG. 3A** is a cross-sectional view taken along the line 3A-3A.

[0023] **FIG. 4** is a schematic illustration of prior art engine oil cooler and transmission oil cooler circuits.

[0024] **FIG. 5** is a top view of an oil cooler constructed in accordance with a first preferred embodiment of the present invention.

[0025] **FIG. 6** is a side view of the oil cooler of **FIG. 5**.

[0026] **FIG. 6A** is a cross-sectional view taken along the line **6A-6A**.

[0027] **FIG. 7** is a top view similar to **FIG. 5**, illustrating an oil cooler constructed in accordance with a first alternative embodiment.

[0028] **FIG. 8** is a top view similar to **FIG. 5**, illustrating an oil cooler constructed in accordance with a second alternative embodiment.

[0029] **FIG. 9** is a top view similar to **FIG. 5**, illustrating an oil cooler constructed in accordance with a third alternative embodiment.

[0030] **FIG. 10A** is a cross-sectional view of one of the tubes of the oil coolers of the present invention prior to any tube modification.

[0031] **FIG. 10B** is a cross-sectional view of the tube of **FIG. 10A** taken along a line perpendicular to the line of the **FIG. 10A** cross-section.

[0032] **FIG. 11A** is a cross-sectional view similar to **FIG. 10A**, illustrating a first tube modification.

[0033] **FIG. 11B** is a cross-sectional view of the tube of **FIG. 11A** taken along the line perpendicular to the line of the **FIG. 11A** cross-section.

[0034] **FIG. 12A** is a cross-sectional view similar to **FIG. 10A**, illustrating a second tube modification.

[0035] **FIG. 12B** is a cross-sectional view of the tube of **FIG. 12A** taken along the line perpendicular to the line of the **FIG. 12A** cross-section.

[0036] **FIG. 13** is a side view of a portion of one of the tubes **16** modified in accordance with a third tube modification of the present invention.

[0037] **FIG. 13A** is a cross-sectional view taken along the line **13A-13A**.

[0038] **FIG. 14** is a top view of an oil cooler similar to **FIG. 5**, the oil cooler including a plurality of tubes according to a fourth tube modification.

[0039] **FIG. 15** is a side view of the oil cooler of **FIG. 14**.

[0040] **FIG. 16** is a top view of an oil cooler similar in construction to the oil cooler of **FIG. 14**, the oil cooler alternatively including end tanks having a rectangular shape.

[0041] **FIG. 17** is a side view of the oil cooler of **FIG. 16**.

[0042] **FIG. 18** is a top view of an air-cooled oil cooler in accordance with the teachings of the present invention.

[0043] **FIG. 19** is a side view of the oil cooler of **FIG. 18**.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0044] The following description of the preferred embodiments is merely exemplary in nature and is in no way intended to limit the invention, its application, or uses.

[0045] With initial reference to **FIG. 5**, an oil cooler constructed in accordance with the teachings of a first preferred embodiment of the present invention is illustrated and identified at reference character **10**. The oil cooler **10** is shown to generally include first and second end tanks **12** and **14**. The tanks **12** and **14** are round. The end tanks **12** and **14** are connected by a plurality of tubes **16**. In the embodiment illustrated, the oil cooler **10** is shown to include five (5) tubes **16**. The tubes are preferably brazed to the end tanks. The first end tank **12** defines a first port **18** as the inlet of oil to be cooled and the second end tank **14** defines a second port **20** as the outlet.

[0046] It will be understood that the oil cooler **10** may be alternatively constructed to include any particular number of tubes **16**. For example, **FIG. 7** illustrates a first alternative embodiment of the same type of oil cooler **30** as shown in **FIG. 5** except three (3) tubes **16** are used when less heat transfer is required. **FIG. 8** illustrates a second alternative embodiment of the same type of oil cooler **32** as shown in **FIG. 5** except four (4) tubes **16** are used. **FIG. 9** illustrates a third alternative embodiment of the same type of oil cooler **34** as shown in **FIG. 5** except six (6) tubes **16** are used for greater heat transfer.

[0047] **FIG. 10A** is an enlarged cross-section of one of the tubes **16** before modification. The tube **16** is shown to include a pair of sidewalls **38** and internal webs **40** connecting the sidewalls **38**. The internal webs are incorporated to provide strength to the tube **16** to meet the requirement of high-pressure test the oil cooler **10** must pass for validation. **FIG. 10B** is a cross-sectional view of tube **16** of **FIG. 10A** taken along a line perpendicular to the cross-sectional line of **FIG. 10A**.

[0048] **FIGS. 11A and 11B** illustrate one of the tubes **16** modified in accordance with a first tube modification. The tube **16** has indentations **44** the full width of the tube **16** alternately spaced on both sides of the tube **16**. Turbulation of the flow through the tubes **16** occurs at each indentation **44**, increasing the heat transfer.

[0049] **FIGS. 12A and 12B** show a second tube modification. Dimples **46** are formed alternately on both sides of the tubes **16**. The dimples **16** can be of round, oval or other shapes as desired. Turbulation of the flow through the tubes **16** occurs at each dimple, increasing the heat transfer.

[0050] **FIG. 13** and **FIG. 13A** illustrate one of the tubes **16** including a third tube modification. According to the third tube modification, dimples **46** are formed in one of the sidewalls **38** of the tube **16** in a staggered or zigzag pattern. In the embodiment illustrated, the opposite sidewall does not include any dimples.

[0051] An oil cooler similar to the oil cooler **10** of **FIG. 5** is illustrated and generally identified at reference number **50**. In this particular embodiment, the oil cooler **50** includes a plurality of tubes modified according to a fourth tube modification. According to the fourth tube modification, the tubes **16** are formed into a convoluted shape. The multiple direction change of each tube **16** provides good turbulence for efficient heat transfer. This oil cooler **50** again has round end tanks **12** and **14**. Another tube modification not shown is the insertion of turbulators within the passages of the tube. These turbulators can be bent wire or bent metal strips, etc.

[0052] With reference to **FIGS. 16 and 17**, an oil cooler **52** similar in construction to the oil cooler of **FIGS. 14 and 15** is illustrated. In the embodiment illustrated, the oil cooler **52** is constructed to include first and second end tanks **54** and **56** that are rectangular in shape. Other shapes of tanks are possible, such as oval, etc., without departing from the teachings of present invention.

[0053] Turning to **FIGS. 18 and 19**, an oil cooler **80** is illustrated that is air-cooled. This is an example of an oil cooler that is not immersed in a cooling liquid, as in all previous examples, but instead it releases its heat to the surrounding air, similar to a typical engine radiator. The oil cooler **80** includes fins **82** placed between tubes **16** to provide additional cooling surface. End tanks **12** and **14** are shown as round in shape but can be rectangular, oval or any other shape desired.

[0054] The description of the invention is merely exemplary in nature and, thus, variations that do not depart from the gist of the invention are intended to be within the scope of the invention. Such variations are not to be regarded as a departure from the spirit and scope of the invention.

What is claimed is:

1. An oil cooler immersed in a cooling medium, the oil cooler comprising an oil inlet tank connected to an oil outlet tank by a plurality of substantially flat, pressure-resistant, seamless heat transfer tubes, the tubes connected to the tanks by brazing or other suitable process.

2. The oil cooler of claim 1 wherein the heat transfer tubes are aluminum extrusions with internal webs for pressure resistance.

3. The oil cooler of claim 1, wherein multiple extruded tubes allow the oil to flow from the inlet port to the outlet port, thus the oil travel distance between the inlet and outlet ports is approximately the distance between said inlet and outlet tanks, while the heat exchange area is approximately equal to the heat exchange area of one tube multiplied by the number of tubes in the oil cooler.

4. The oil cooler of claim 1, wherein the inlet and outlet tanks are approximately round, rectangular or any other suitable shape.

5. The oil cooler of claim 1, wherein the extruded tubing is modified by dimples on one or both sides of the flat sides of tubing.

6. The oil cooler of claim 6, wherein the dimples are round in shape.

7. The oil cooler of claim 6, wherein the dimples are oval, rectangular or any other suitable shape.

8. The oil cooler of claim 6, wherein the dimples are arranged in a linear fashion between the webs of said tubing.

9. The oil cooler of claim 6, wherein the dimples are arranged in a zigzag fashion.

10. The oil cooler of claim 1, wherein the extruded tubing is modified by convolutions formed by approximately 90 degree bends, or by convolutions of any other suitable angle or shape, in order to force the oil to repeatedly change its flow direction, thereby increasing turbulence and heat transfer.

11. The oil cooler of claim 1, wherein turbulators are inserted in the passages of the extruded tubes to increase heat exchange, said turbulators consisting of bent wire, formed metal strips or any other bodies placed in the oilstream with the purpose of forcing the oil to repeatedly change direction and cause turbulence leading to an increase in heat transfer.

12. The oil cooler of claim 1, wherein the cooling medium is the coolant contained in the inside of a radiator tank (water-cooled oil cooler).

13. The oil cooler of claim 1, wherein the cooling medium is air (air-cooled oil cooler).

14. The oil cooler of claim 13, wherein cooling fins are inserted between the tubes in order to increase the heat exchange area. In such a case the tubes may need to be banded together or otherwise held tightly together through brackets or other means in order to ensure tight contact between fins and tube surfaces, which is needed for efficient heat transfer.

15. The oil cooler of claim 1, that can be used to cool automatic transmission fluid (transmission oil cooler).

16. The oil cooler of claim 1, that can be used to cool engine oil (engine oil cooler).

17. The oil cooler of claim 1, that can be used to cool steering oil, hydraulic fluid, and any other fluids requiring cooling in vehicles or other machinery.

* * * * *