CONCENTRIC TUBE HEAT EXCHANGER WITH SINTERED METAL MATRIX

Filed Oct. 14, 1964 3 Sheets-Sheet 1

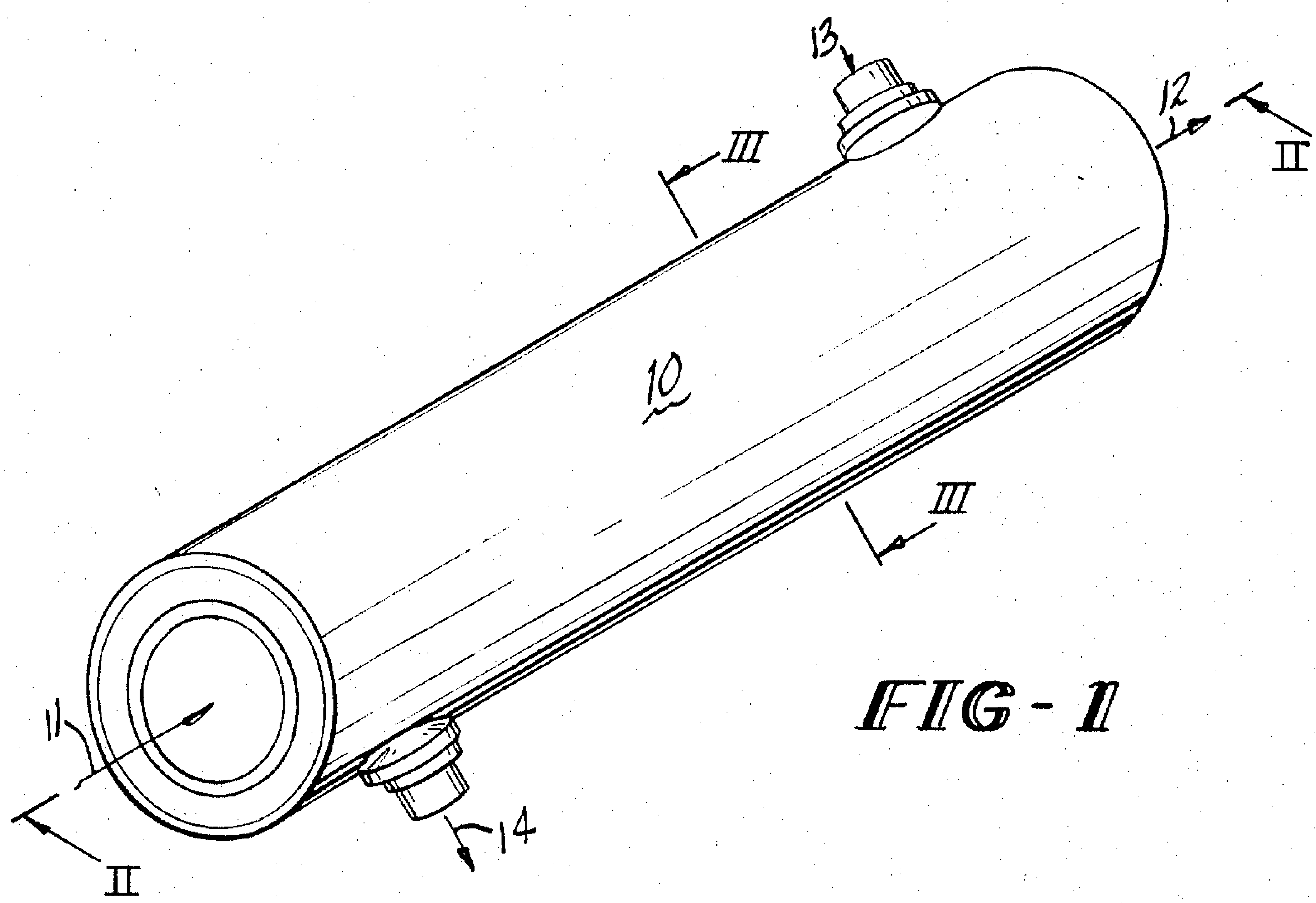

FIG - 1

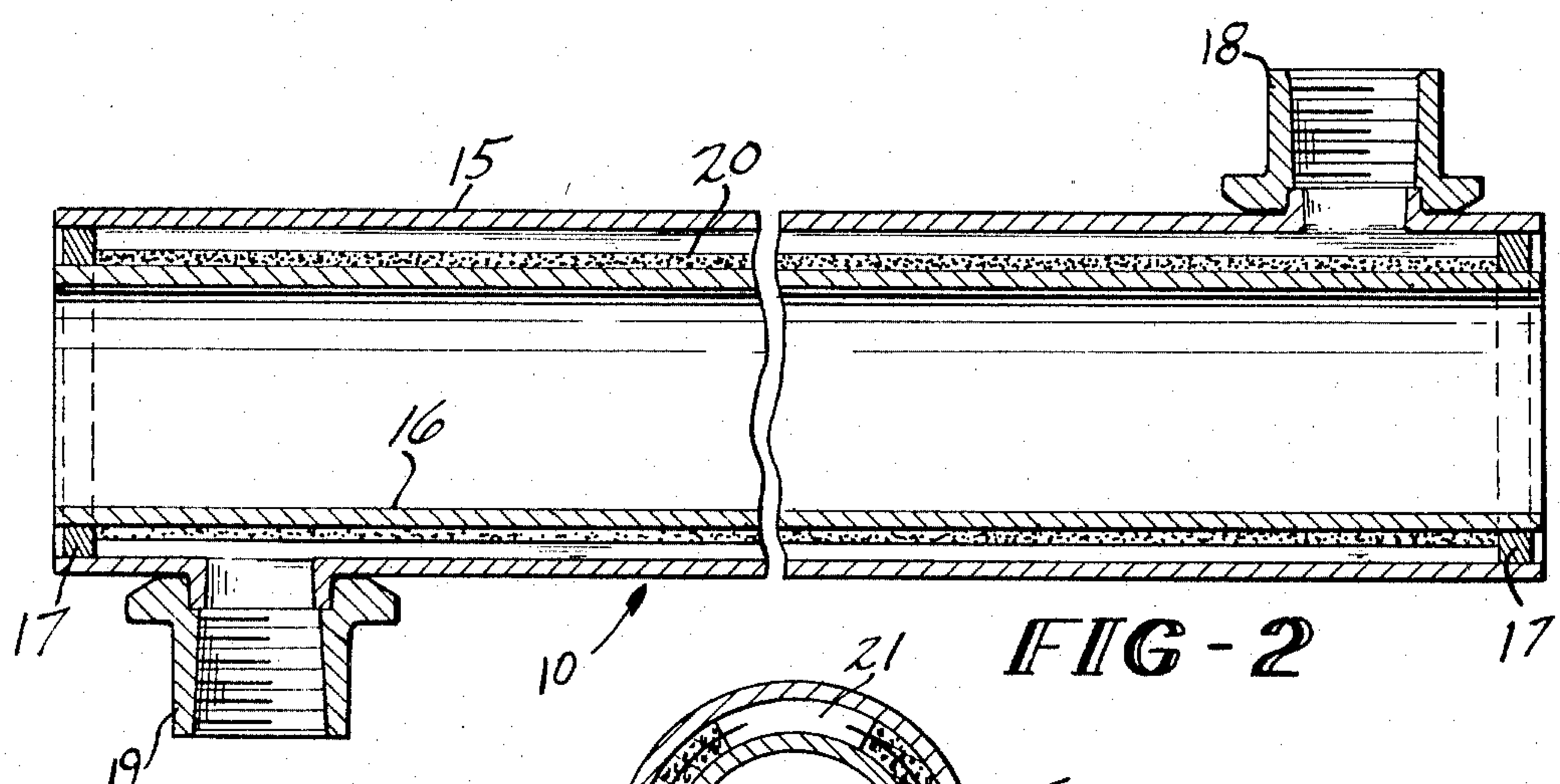

FIG - 2

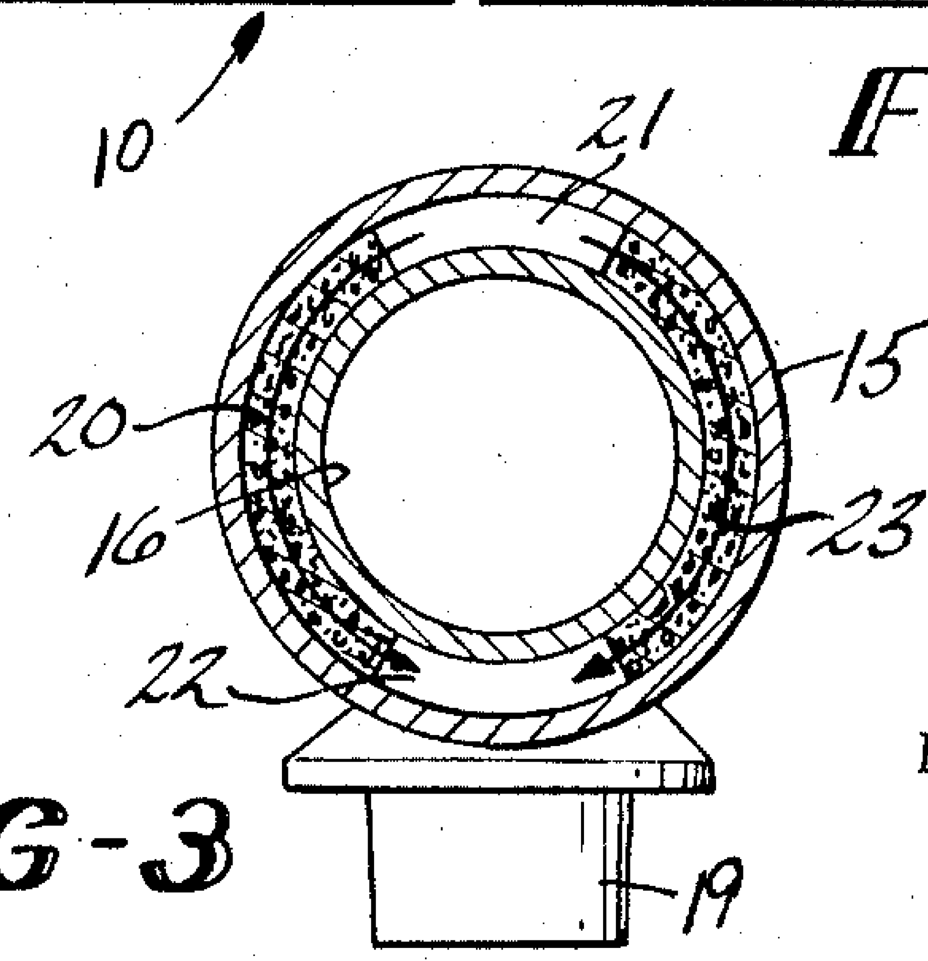

FIG - 3

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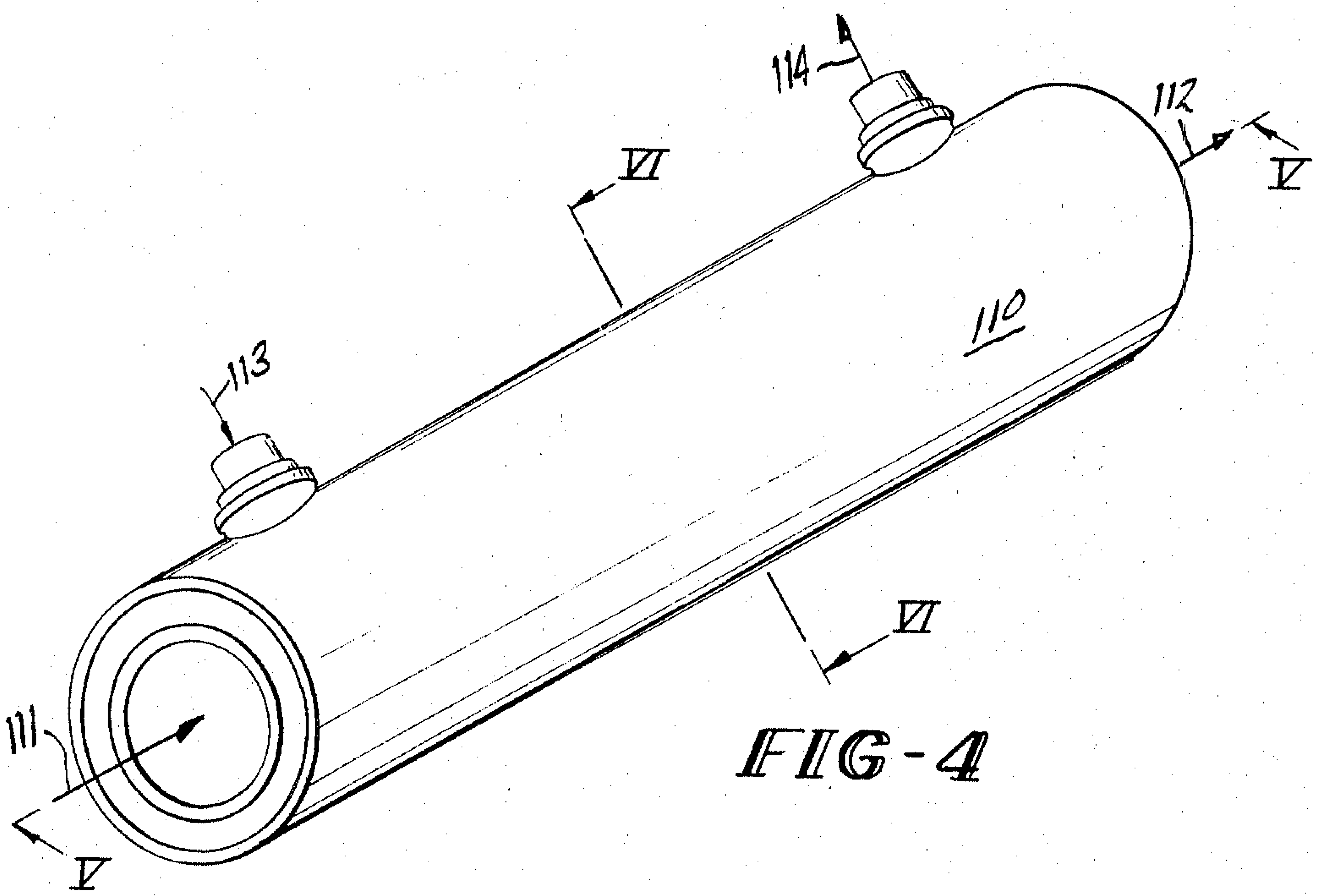

FIG-4

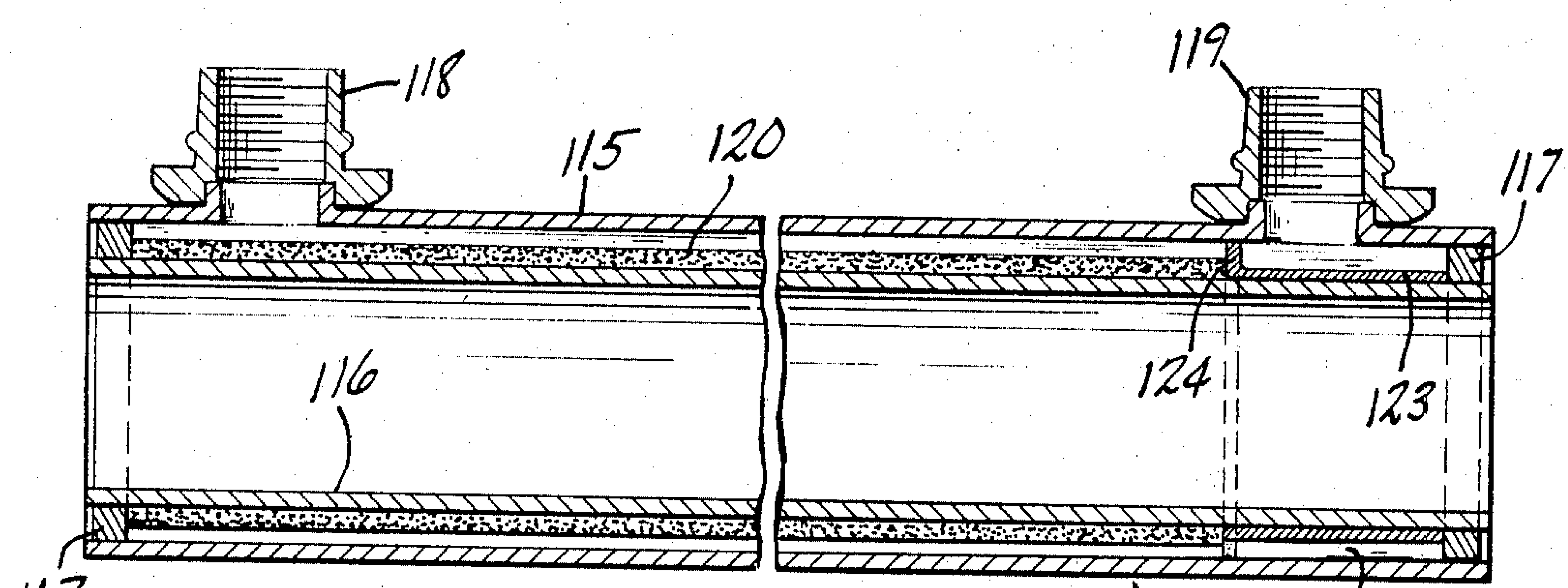

FIG-5

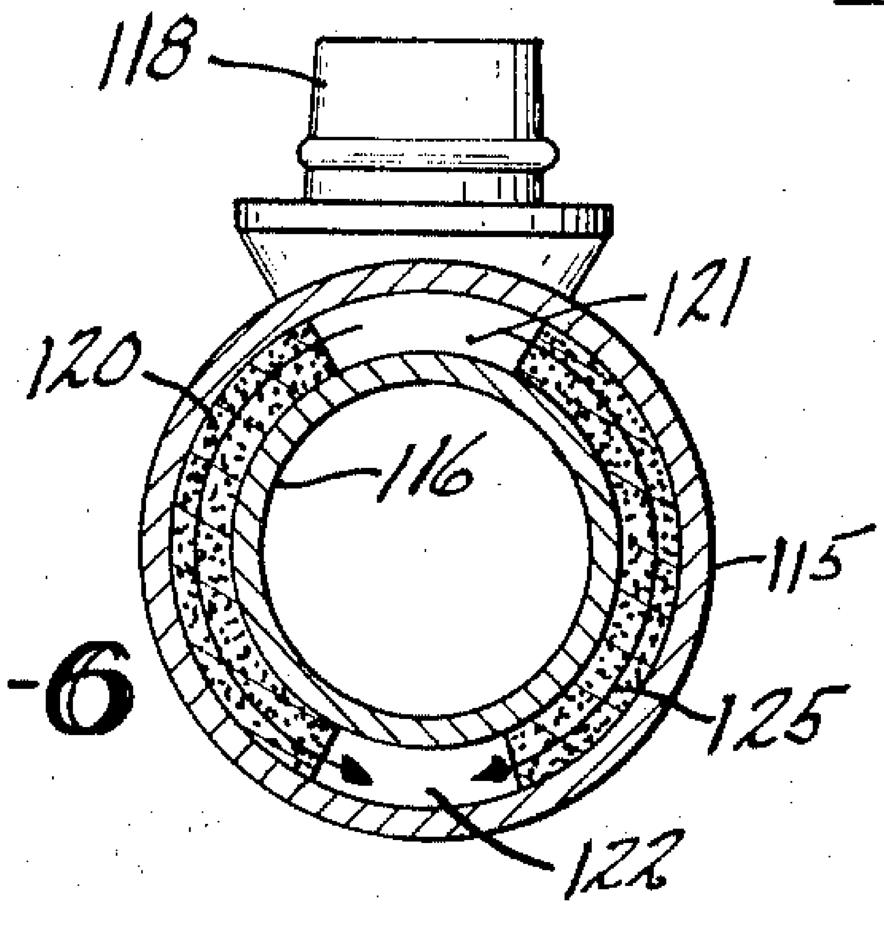

FIG-6

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CONCENTRIC TUBE HEAT EXCHANGER WITH SINTERED METAL MATRIX

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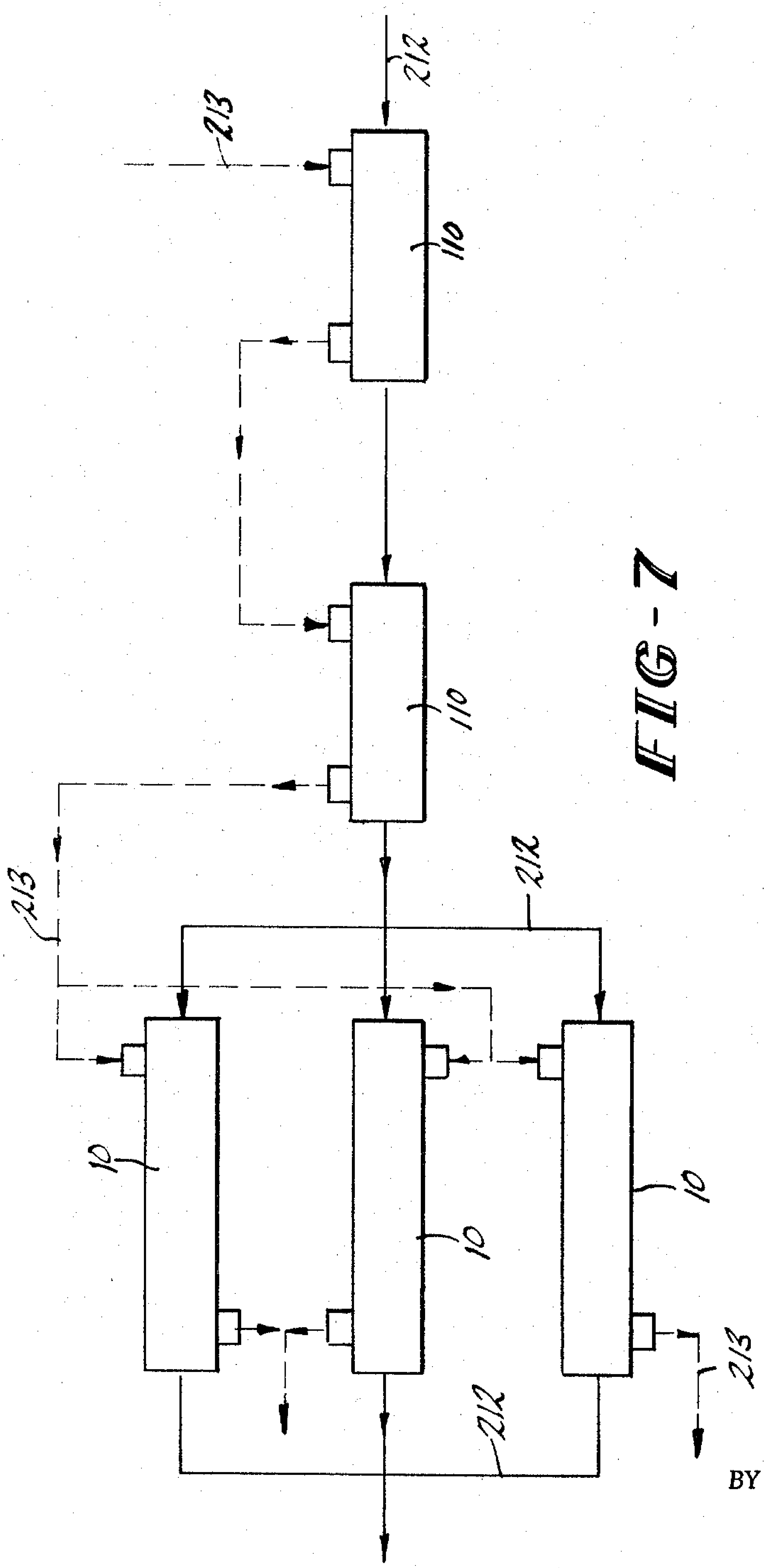

FIG-7

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CONCENTRIC TUBE HEAT EXCHANGER WITH SINTERED METAL MATRIX

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3 Claims. (Cl. 165—154)

This invention relates to heat exchangers, and more particularly to a heat exchanger having a body of pervious material therein.

As is known in the heat exchanger art, the greatest heat exchange is achieved by providing the maximum possible area of material across which the desired heat exchange may take place. Various devices have been employed to so increase the material area such as, for example, fins or corrugations across which pass the media between which the heat exchange is to take place. However, it has been found that greatly increased heat transfer surfaces can be achieved by instead employing a body of pervious material, or a porous body having interconnected voids. Such a body of pervious material presents a large number of faces for heat exchange purposes, as well as other advantages to be discussed shortly.

By the instant invention there is provided a unique configuration and arrangement of such a pervious body within a heat exchanger which has been tested and found to result in greatly increased heat exchange properties. The concept may be employed in heat exchangers of any desired shape, but is particularly adapted to tubular heat exchangers. As known in the art, the use of heat exchangers of a tubular configuration is highly advantageous in certain environments where the exchanger is so situated that it is immersed in one of the heat exchange media. The tubular heat exchangers presently in use in such an environment commonly comprise two concentric tubes, often with corrugations in the annulus between the tubes to turbulate the circulated medium; the flow path in the annulus is substantially axial along the tubes.

In the concept of the instant invention there is provided a heat exchanger in which not only the heat exchange area is increased but the medium flow is directed in a peripheral path through the annulus formed by the concentric tubes. The advantages resulting are achieved by the provision of a body of pervious material in the space between the tubes. By a particular configuration and arrangement of the pervious body to be discussed hereinafter, channels are provided to serve as inlet and outlet means for a heat exchange medium and to permit uniform distribution of the medium through the pervious material in a peripheral path through the annulus.

While the usual expedient is to arrange the tubes so as to be concentric, the concept of this invention is equally applicable to any arrangement of a tube or tubes within a tube.

As will be understood, various combinations of metals may be utilized in forming the heat exchangers according to the instant invention; and accordingly the solid portions and the pervious body may be of the same metal or alloy, or the pervious structure and the solid member may be comprised of different compositions. For example, both the pervious body and solid portions may be formed of the same stainless steels, coppers, brass, carbon steels, aluminums or various combinations thereof. As will be evident, the ultimate use of the resultant structure determines the specific combination of alloys to be employed. The production of the pervious body is most flexible; for example, it may be produced by a process wherein particles, frequently spherical, are poured by gravity into an appropriately shaped confined space and usually vibrated to cause the particles to compact uniformly. As is obvious, the choice of particle size will largely determine the size of openings of the resulting pervious body. The body of particles so packed is then treated in accordance with any of the well known metallurgy practices—e.g. sintering, welding, brazing or soldering employing an appropriate coating—to produce a metallic bond between the particles. Thus, there is provided a pervious body whose bulk density, or apparent density, is but a fraction of the density of the metal or alloy from which the particles are obtained. Furthermore, such process results in a metallic bond between the pervious body and its container.

While the above described process is perferred in the instant invention, other processes may be employed. For example, it is possible to blend intimately a particulate material with either a combustible substance or a soluble material whose melting point exceeds the melting temperature of the particulate material. After the blend is compacted and treated to achieve a metallic bond, the combustible substance may be burned away or the soluble material removed by leaching or dissolving with a liquid. A still further method of producing the pervious body comprises melting a metal or alloy and casting it into the interstices of a loose aggregate of a particulate soluble material whose melting point exceeds that of the metal, preferably having a specific gravity of the molten metal. Upon solidification of the metal, a component is produced which contains the network of the soluble material interspersed within the solid metal which soluble material is thereupon removed by leaching or dissolving, leaving behind it interstices that interconnect and form a pervious network within the resultant metal body. A still further method of producing such pervious bodies comprises weaving of knitting metal wire into a mesh arranged in a plurality of layers. According to this process, a control of porosity is obtained by appropriate choice of wire diameters and openings arranged between adjoining wires as well as the juxtapositioning of superimposed layers of the woven or knit mesh.

It is to be understood that the concept of this invention need not be limited to the particular configuration indicated above. For example, tubes need not be exclusively employed; any desired shape of exchanger may be provided, with the pervious body shaped accordingly to fit. Furthermore, any number of tubes may be employed, the exchanger may be used for either heating or cooling, and the tubes may be of any desired cross-section.

It is accordingly an object of this invention to provide a heat exchanger which is compact and yet capable of high efficiency and low pressure drop.

It is a further object of this invention to provide such a heat exchanger having a body of pervious material situated therein.

It is a still further object to provide such a heat exchanger of concentric tubular members having a body of pervious material bonded within the annulus between the tubular members.

Other objects and advantages will become apparent to those skilled in the art from a consideration of the details of several specific embodiments illustrated in the drawings, in which:

FIGURE 1 is a perspective view of a first embodiment of heat exchanger contemplated in this invention,

FIGURE 2 is a longitudinal cross-section of the embodiment of FIGURE 1, taken along the lines II—II thereof,

FIGURE 3 is an axial cross-section of the embodiment of FIGURE 1 taken along the lines III—III thereof,

FIGURE 4 is a perspective view of a second embodiment of this invention,

FIGURE 5 is a longitudinal cross-section of the embodiment of FIGURE 4 taken along the lines V—V thereof,

FIGURE 6 is an axial cross-section of the embodiment of FIGURE 4 taken along the lines VI—VI thereof, and

FIGURE 7 is a schematic view of an assembly embodying a plurality of heat exchangers according to this invention.

A first embodiment of heat exchanger employing the concept of this invention is shown in FIGURE 1, and is designated generally by **10**. As indicated hereinbefore, the heat exchanger **10** is to be employed in applications where it is immersed in one of the heat exchange media. Thus, a first heat exchange medium, for example that to be employed in heating or cooling, surrounds the heat exchanger **10** and is also introduced into the heat exchanger **10** at one end, as shown by the arrow **11**, and exits from the opposite end of the heat exchanger **10** as shown by the arrow **12**. Obviously, required fittings, not shown, may be employed. A second heat exchange medium, for example the medium to be cooled or heated, enters the heat exchanger **10** through any suitable fitting in the direction of the arrow **13**, is circulated through the heat exchanger, and exits through a suitable fitting in the direction of the arrow **14**. Thus, heat exchange may take place between the second medium and (a) the first medium surrounding the exchanger, and (b) the first medium flowing through the heat exchanger. It will be obvious that any desired mediums might be employed in the instant heat exchanger; for example, in application in an automotive cooling system, the medium introduced at **11** may be water and the medium introduced at **13** may be oil.

The construction of the heat exchanger **10** is shown in detail in FIGURES 2 and 3, wherein it may be seen that the heat exchanger **10** comprises two concentric tubes **15** and **16** having therebetween a body of pervious material **20**. Suitable inlet and outlet fittings **18** and **19** are provided at opposite ends of the heat exchanger. The annulus between tubes **15** and **16** is closed off at its opposite ends, for example by annular seals **17**. Whatever method of producing the pervious body **20** is employed, the body **20** is formed so that there exists two channels **21** and **22** spaced 180° apart, for example as shown in FIGURE 3, to form the body **20**. These channels may be achieved, for example, by providing in the concentric tubes **15** and **16** two appropriately shaped cores prior to the addition of the porous material **20**. Following the required subsequent processing of the material **20**, the cores—which are shaped the same as the desired channels **21** and **22**—may be removed. It will be evident that the pervious body **20** will be securely bonded to the tubes **15**, **16**, and that channel **21** communicates with the inlet **18**, and the channel **22** with the outlet **19**. Thus, the medium introduced at the inlet **18** flows through the channel **21** and distributes uniformly along the length of tube **16**, thence around the tube **16** as shown by the arrows **23** of FIGURE 3 through the circuitous paths within the pervious material **20** to the lower channel **22**, where it may pass through the outlet **19**. It will be evident that the provision of the pervious body **20** not only presents increased heat exchange surfaces for contact by the circulated medium but, due to the circuitous peripheral flow paths presented, also provides uniform distribution through the entire pervious structure with a minimum pressure drop.

A second modification of the instant invention is depicted in FIGURES 4–6. In this embodiment, there is provided an appropriate manifold so that the exchanger may be employed in applications where it is desirable that the inlet and outlet be on the same side of the exchanger. As was the case with the exchanger of FIGURES 1–3, the heat exchanger **110** is immersed in a first heat exchange medium, which enters the exchanger in the direction of the arrow **111** of FIGURE 4, and exits at the opposite end as shown by the arrow **112**. However, in this embodiment, the second medium may enter and exit from the same side of the exchanger, as shown at **113** and **114**.

Referring now to FIGURES 5 and 6, it will be evident that the tubes **115** and **116**, the annular seals **117**, and the pervious body **120** having channels **121** and **122** are analogous to the structure of the first embodiment referenced by the respective characters, **15**, **16**, **17**, **20**, **21**, and **22**. However, the inlet **118** and outlet **119** are situated on the same side of the heat exchanger **110**. A manifold is provided near the outlet **119** comprising a ring **123** surrounding the inner tube **116** and having a peripheral flange **124**. The flange **124** covers the entire annulus between the tubes **116** and **115** except for an area in alignment with and matching the configuration of the channel **122**. Thus, it will be seen that the second medium, e.g., that to be heated or cooled, enters through the fitting at **118** and distributes uniformly along the length of the tube **116** within the channel **121**, thence around the tube **116** as shown by the arrows **125** of FIGURE 6, through the circuitous paths provided in the pervious body **120**, collecting in the channel **122**, from which it is forced within the annulus **126** between the ring **123** and tube **115** from the lower portion thereof to the upper portion thereof, where it exits through the fitting provided at **119**. The flange **124** prevents such medium from entering the ring **123** except at the desired point, that is, at the lower portion thereof through the channel **122**.

The second embodiment of this invention may be fabricated in the same manner as that indicated hereinbefore with respect to the first embodiment.

In FIGURE 7 there is illustrated the adaptability of the heat exchanger of the present invention to an installation requiring a plurality of heat exchangers. Thus, the heat exchanger of the instant invention may be employed where one or both of the heat exchange media is desired to be in either series or parallel flow, or any combination thereof. As shown schematically in FIGURE 7, either of the heat exchangers **10** or **110** may be provided with appropriate conduits, not shown, to achieve the desired flow. For example, a heat exchange medium may take the central path through the exchangers as shown by the solid arrows **212** in serial flow through any number of heat exchangers **110** and/or in parallel flow through any number of exchangers **10**. It will be understood first that by appropriate conduit arrangement the heat exchangers **10** and **110** may be interchanged, and secondly, that the flow of the second heat exchange medium in the peripheral path may be in the conventional manner through each of the exchangers as a separate unit.

Or, if so desired, the second heat exchange medium may be in series and/or parallel flow through the peripheral path of each of the heat exchangers, with the first medium in series and/or parallel flow or in the conventional manner through each of the heat exchangers as a separate unit. Thus, as shown by the dotted arrows **213**, series flow may be accomplished through a number of heat exchangers **110** and/or parallel flow through a number of heat exchangers **10**.

While we have shown and described different desirable embodiments of this invention, it is to be understood as for the purpose of illustration only and that various changes and modifications, as well as the substitution of equivalent elements for those herein shown and described, may be made without departing from the spirit and scope of the invention as set forth in the appended claims.

We claim:

1. A heat exchanger for circulation of a plurality of heat exchange media comprising

A. a first conduit means for conveying a first heat exchange medium,

B. a second conduit means surrounding said first conduit means for conveying a second medium in the space between said first and second conduit means,

C. a body of pervious material in said space between said first and second conduits and in heat exchange relationship with said first and second conduit means, said body of pervious material being joined by a metallic bond to said first and second conduit means and including

(1) a first channel for controlled distribution of said second medium entering the heat exchanger,

(2) a second channel for controlled collection of said second medium leaving the heat exchanger, said second channel being spaced from said first channel, and

D. manifold means within said space between said first and second conduits sealing one end of said first channel and in open communication with said second channel for receiving the flow of said second heat exchange medium from said second channel such that the second medium flows from said first channel circumferentially through the pervious material to said second channel, and

E. inlet and outlet means in said second conduit.

2. A heat exchanger in accordance with claim **1** wherein said manifold means comprises a ring surrounding said first conduit means and having a flange extending throughout said space between said first and second conduit means, said flange having an aperture in communication with said second channel.

3. A heat exchanger in accordance with claim **2** having inlet means in said second conduit means in communication with said first channel, outlet means in said second conduit means spaced from said second channel, said manifold means joining said second channel to said outlet means.

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