



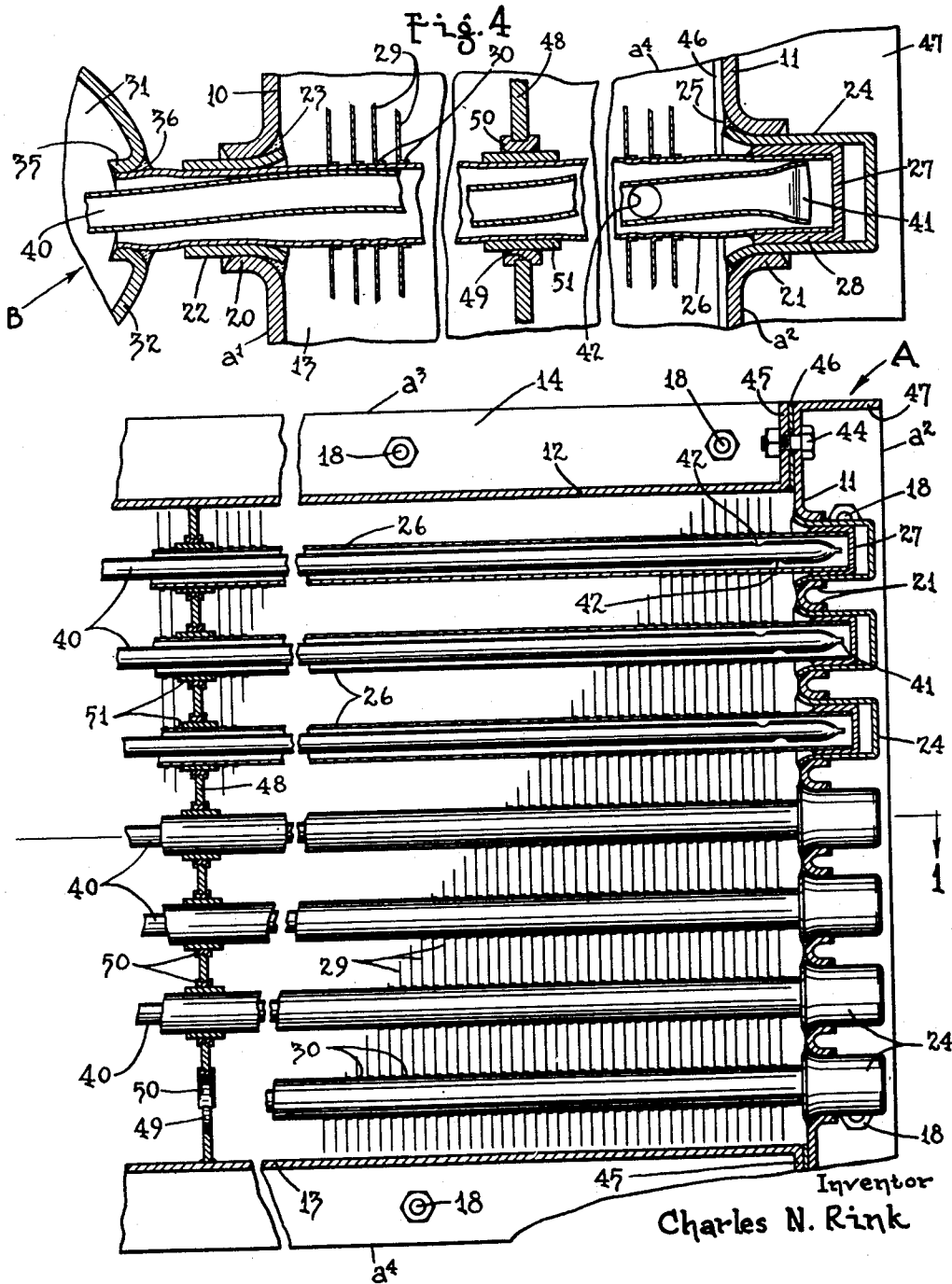
March 7, 1950

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HEAT EXCHANGE DEVICE

2,499,608

Filed July 31, 1944

2 Sheets-Sheet 2



## UNITED STATES PATENT OFFICE

2,499,608

## HEAT EXCHANGE DEVICE

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Application July 31, 1944, Serial No. 547,417

3 Claims. (Cl. 257—136)

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My invention relates generally to improvements in heat exchange devices and more particularly, though not exclusively, to heat exchange units for incorporation in conduits conveying fluids to be temperature affected, an object of the invention being to provide a simple, durable and efficient unit of such character which is easily installed and capable of withstanding severe shocks caused by heavy vibrations or otherwise in the transportation, installation and use thereof.

A further object of the invention resides in supplying a heat exchange device constructed to provide a coupling for joining together companion sections of a conduit for conveying a fluid to be temperature affected.

Another object of the invention is to provide a heat exchanger having a fluid-tight coupling-forming frame and heat exchange tubes for a temperature affecting medium traversing the frame and carried thereby in a manner freely accommodating changes in the lengths of said tubes by contraction and expansion.

An additional object of the invention is to supply a heat exchange device of the instant nature constructed to provide for the controlled unequal distribution of the temperature affecting medium to the various heat exchange tubes, and, more specifically, to provide for such distribution of the temperature affecting medium, whereby the transfer of heat to or from the fluid under treatment will be substantially uniform across the conduit in the plane of the device.

Other objects of the invention reside in the novel combination and arrangement of parts and in the details of construction hereinafter illustrated and/or described.

In the drawings, Fig. 1 is a fragmentary sectional view illustrating a device in embodiment of the present invention and showing adjacent portions of companion conduit sections coupled together by said device, said view being taken as on the lines 1—1 of Figs. 2 and 3; Figs. 2 and 3 are fragmentary sectional views in detail taken as on the line 2—3 of Fig. 1, and Fig. 4 is a fragmentary sectional view similar to Fig. 1, but on an enlarged scale and showing the intermediate tube support omitted from Fig. 1.

Reference being had to the accompanying drawings wherein similar parts are designated by similar reference characters throughout the several views, it will be seen that the illustrated embodiment of my invention includes a rectangular frame A consisting of four channel-like members  $a^1$ ,  $a^2$ ,  $a^3$  and  $a^4$  united to provide an

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open-ended structure, wherein the webs of two of the members  $a^1$ ,  $a^2$  comprise facing sides 10, 11 and the webs of the other two members  $a^3$ ,  $a^4$  comprise facing sides 12, 13. The flanges extending longitudinally of said channel-like frame members extend outwardly of the frame A and provide at each end of said frame a continuous attaching flange 14. In uniting the three channel-like members  $a^1$ ,  $a^3$  and  $a^4$  forming the sides 10, 12 and 13 of said frame A, said members  $a^1$ ,  $a^3$  and  $a^4$  are preferably mitered and welded together (Fig. 2), the remaining member  $a^2$  forming the side 11 of the frame A being fastened by bolts 44 (Fig. 3) to the frame members  $a^3$  and  $a^4$ . These bolts 44 pass through flanges 45 disposed transversely of the frame members  $a^3$ ,  $a^4$ , and through the web proper of the frame member  $a^2$ , and also through gaskets 46 interposed between said transverse flanges 45 and said web of said frame member  $a^2$ . In each of the frame members  $a^3$ ,  $a^4$ , the transverse flange 45 is formed by outwardly turning an extended portion of the web and welding it to the longitudinal flanges. Flanges 47, similar to the transverse flanges 45, are formed on the frame member  $a^2$  to strengthen the same.

The frame A will correspond dimensionally with the dimensions of a conduit with which my heat transfer unit is to be employed, and such conduit will include sections, as at 15, 16, having outwardly turned flanges 17 matching the attaching flanges 14 of said frame A. These flanges 17 of the conduit sections 15, 16 are fastened to the flanges 14 of the frame A by bolts 18, gaskets 19 being interposed between said flanges 14 and 17 to provide fluid tight connections between the frame A and conduit sections 15, 16. Thus, said frame A, in the nature of an insert, becomes a coupling between the sections proper of a conduit through which a fluid is to be conveyed and altered in temperature as it passes such coupling.

In the facing sides 10, 11 of the frame A along lines intermediately of the attaching flanges 14, are formed spaced openings, the marginal portions of said sides 10, 11 about said openings being outwardly punched to provide annular flanges 20, 21. Lining the annular flanges 20 are open-ended sleeves or bushings 22 which are brazed or soldered, as at 23 (see Fig. 4), to the side 10 of the frame A. Lining the annular flanges 21 are bushings 24, closed at one end or cup-shaped, said bushings 24 opening into the interior of the frame A and being brazed or soldered, as at 25, to the side 11 of said frame.

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Thin-walled tubes 26 traversing the frame A are mounted in said bushings 22, 24. As shown, corresponding ends of said tubes 26 extend through said open-ended bushings 22 and terminate shortly beyond the same outside of the frame A, while the opposite ends of said tubes 26 are positioned within said cup-shaped bushings 24. These latter ends of said tubes 26 are closed by means of caps 27 brazed or soldered thereto and the skirts 28 of said caps 27 snugly slidably fit their respective bushings 24. Fins 29, strung upon the tubes 26 in the usual manner, are formed with annular flanges 30 encircling said tubes. Expanded in known manner, under internal pressure, these tubes 26 are forced outwardly into intimate contact with the flanges 30 of said fins 29 and with the inner surfaces of the bushings 22, whereby said tubes are tightly fitted both to said fins 29 and to said bushings 22. The ability of the caps 27 to slide in their respective bushings 24 provides for the accommodation of any elongation or shortening of the tubes 26 by contraction or expansion.

In installations in which the tubes 26 are relatively long, a supporting structure is provided to brace said tubes intermediately thereof and, likewise, the frame members  $a^3$ ,  $a^4$ . This supporting structure includes a brace-plate 48 (Figs. 3 and 4) welded at its ends to the webs of said frame members  $a^3$ ,  $a^4$ , said brace-plate 48 being formed with openings 49 therein through which the tubes 26 extend. Said openings 49 in said brace-plate 48 are lined with bushings or grummet-guides 50 wherein bearing sleeves 51, which encircle the tubes 26, are snugly slidably fitted. The grummet-guides 50 and bearing-sleeves 51 are preferably of metal of the same characteristics and said bearing-sleeves 51 are rendered immovable relative to the tubes 26 in expanding the same as above noted. Equipped with the bearing-sleeves 51 slidably in the grummet-guides 50 in the brace-plate 48, the fin-bearing tubes 26 are effectively braced intermediately thereof, without interfering with the lengthening and shortening of the same under expansion and contraction.

Outside of the frame A and extending along the side 10 thereof is an outer header B comprising a hollow cylindrical body  $b$  with end heads 31 brazed or soldered therein. This header-body  $b$  consists of semi-cylindrical body sections 32, 33 brazed or soldered together, as at 34, the one section 32 having a series of holes punched therein with the marginal portions thereof about said holes formed into inwardly extending annular flanges 35. These annular flanges 35 receive the termini of the tubes 26 at the end portions thereof which extend through the open-ended bushings 22, said tubes 26 being brazed or soldered to said annular flanges 35, as at 36. A pipe connection applied to the header B consists of an internally threaded nipple 37 brazed or soldered to the header-body  $b$  and communicating with the interior of said header through an opening, as at 38 therein.

In the outer header B is a hollow bullet-shaped inner header C which is inserted nose foremost into said outer header B through an opening in the body member 33, said inner header C being brazed or soldered near the butt thereof to the outer header B and having the extremity of said butt, outside of said outer header, threaded externally, as at 39, to provide a pipe connection for said inner header C. This inner header C is located midway between the ends of the outer

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header B and is axially aligned with the intermediate tube 26.

Contained within the tubes 26 are inner tubes 40 which reach from the capped ends of the outer tubes 26 to the opposite ends thereof and continue, in the form of leads 40<sup>a</sup>, through the outer header B to the inner header C. Said leads 40<sup>a</sup> of the inner tubes 40 are connected with the inner header C and said tubes 40, at their ends opposite said leads, communicate with the outer tubes 26 at the capped ends thereof.

From the foregoing, it will be understood that a temperature affecting medium introduced into the inner header C will pass therefrom through the leads 40<sup>a</sup> and inner tubes 40, thence into the spaces between said inner tubes and the outer tubes 26, thence along said outer tubes to the outer header B and, finally, out of the opening 38 in said outer header. Also it will be understood that a reverse flow of such medium through such parts will be caused if the same is introduced to the outer header B instead of said inner header C. In either case, the temperature of a fluid conveyed through the frame A of the unit will be altered upon the movement of such fluid past the heat exchange tubes 26 and fins 29.

Each inner tube 40 is of sinuous formation and is sprung by forcible insertion into its respective outer tube 26 to cause it to bind against the inner wall of such outer tube and thus become firmly held thereby along the same. This feature together with the close-coupling of the outer header B to the frame A through all of the tubes 26 renders the unit strongly rigid throughout and capable of withstanding severe shocks however caused in the transportation, installation and use thereof. As shown, said inner tubes 40 are serpentine in form, the bends of each tube occurring in a common plane and engaging the inner wall of its respective outer tube at intervals therealong. Another and practical sinuous shape for said inner tubes 40 is a helical formation (not shown) of relatively high pitch and which is conveniently provided by gathering several straight tubes together and twisting them about each other. An inner tube, thus shaped, will have line-contact with the inner wall of its respective outer tube helically along the same.

In promotion of the longevity of the device in use involving the introduction of high pressure steam to the inner manifold C, the ends of the inner tubes 40 are crimped, as at 41, or otherwise closed and each such inner tube 40, near its closed end, is provided with an opening 42 in the side thereof, the diameter of which is approximately that of the inner diameter of said tube. Preferably, two, rather than one of such openings 42 will be provided in each of said inner tubes 40. In a tube of serpentine formation, the openings 42 will be disposed at opposite sides of the plane in which the tube is bent, while in a tube of helical formation the openings therein will be inwardly offset from the contact line of such tube. Thus unobstructed, such openings 42 will afford free communication between the interior of the inner tube 40 and the interior of its respective outer tube 26. Said openings 42 in the inner tubes 40 are relatively large in diameter to enable the passage therethrough of any matter that may enter said tubes. The employment of said openings 42 in the sides of the tubes 40 and their disposition somewhat removed from the closed ends of said tubes provide in each pair of inner and outer tubes for a change in direction of steam or other temperature affecting medium as it leaves

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the interior of the inner tube 40 to enter the interior of the outer tube 26, and further results in the establishment of a cushion in the end of the inner tube 40 consisting of a trapped quantity of such medium against which the oncoming medium impinges. By this arrangement, wear of the structure by erosion is effectively minimized.

In conformity with conduit sections 15, 16 that are oblong in cross-section, the coupling-frame A will be similarly shaped with the sides 10, 11 thereof of lesser extent than the sides 12, 13. And the tubes 26 will extend across the long dimension of said frame. In a conduit structure of such cross-section, the movement of a fluid there-through, due to friction along the wide conduit walls, will be marked by the progressively slower travel of such fluid oppositely toward such wide walls from a plane intermediately thereof. Uniformly to alter the temperature of such fluid under such conditions, my improved construction provides a compensating unequal distribution to the tubes 26 of the temperature affecting medium introduced through the inner header C. In this construction, the wall of the bullet-shaped inner header C is formed along the same with apertures 43 therein axially disposed substantially at right angles to said wall and these apertures receive the ends of the leads 40<sup>a</sup> of the inner tubes 40, said leads being soldered or brazed to said header-wall. In fitting the leads 40<sup>a</sup> to said inner header C, the selection of apertures 43 for the respective leads 40<sup>a</sup> is such that the lead 40<sup>a</sup> of the intermediate tube 40 will be the shortest and the leads 40<sup>a</sup> for the next adjacent tubes 40 of the two groups X and Y thereof for the two groups X<sup>1</sup> and Y<sup>1</sup> of return tubes 26 at opposite sides of the return tube for said intermediate tube 40 will be next shortest and so on to the end that the longest leads 40<sup>a</sup> are those of the tubes 40 most remote from said intermediate tube or, in other words, more nearly proximate to the wide walls of the conduit. Furthermore, the location of said apertures 43 in the header C and their selection for the respective leads 40<sup>a</sup> are such that the inlet opening or mouth of the lead 40<sup>a</sup> for the intermediate tube 40 will lie in a plane at right angles to the axis of said header C, and such that the inlet openings or mouths of the respective leads 40<sup>a</sup> of each of said two groups of tubes 40 will lie in places more or less inclined with respect to said axis in accord with the relative nearness of their respective tubes 40 to the corresponding wide wall of the conduit.

Due to arrangement of the mouths of the leads 40<sup>a</sup> in planes varying in angular disposition relative to the axis of the header C, varying resistance is encountered by the temperature affecting medium upon its entry into the various leads 40<sup>a</sup> so that said medium is fed therein with varying force, the result being that the volume of such medium reaching the tubes 40 of each group of tubes is reduced progressively according to the relative proximity of said tubes to their respective wide wall of the conduit. Due also to the varying lengths of the leads 40<sup>a</sup> and the attending variance in frictional resistance set up therein to the flow therethrough of the heat exchange medium, the volume of such medium reaching the tubes 40 through their respective leads 40<sup>a</sup> is reduced progressively in each of the two groups of tubes in accord with the relative proximation of said tubes to their respective wide wall of the conduit. With the parts appropriately proportioned and arranged in relation to the natures of and to the pressures applied to the fluid in the

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conduit and the heat exchange medium employed, accurate control of the distribution of said medium to the tubes 40 will be had. Thus, air or other fluid conveyed along conduit sections coupled together by my heat exchange unit will be substantially uniformly heated or cooled, depending upon the nature of the temperature affecting medium employed, as such fluid passes the unit.

In fabricating an embodiment of the present invention, constructed as shown in the accompanying drawings, the bushings 22, 24 will be brazed or soldered in place in the annular flanges 20, 21 of their respective frame members  $a^1$ ,  $a^2$ . The frame members  $a^3$ ,  $a^4$  will be welded to the frame member  $a^1$  and the brace-plate 48, equipped with its grummet-guides 50 will be welded to said frame members  $a^3$ ,  $a^4$ . Taken separately, the member 32 of the outer header B will be secured to the outer tubes 26 and said tubes 26 will be threaded into place, collectively, by directing them through their respective bushings 22, thence through the annular flanges 30 of the fins 29 at the near side of the brace-plate 48, thence through the bearing-sleeves 51 placed in the grummet-guides 50 and, finally, through the annular flanges 30 of the fins 29 at the far side of said brace-plate 48. To the ends of the tubes 26 projecting beyond the last of the fins 29, the caps 27 will then be soldered or brazed. The frame member  $a^2$  will then be bolted to the frame members  $a^3$ ,  $a^4$ , the caps 27 being directed into the bushings 24 as said frame member  $a^2$  is put in place. Then or at a later time in the process of the assembly, the tubes 26 will be subjected to internal pressure to expand them into tightly fitting contact with the bushings 22, the bearing-sleeves 51 and the annular flanges 30 of the fins 29. The inner tubes 40, attached through their leads 40<sup>a</sup> to the inner header C, will then be collectively inserted into the outer tubes 26. Thereafter, the member 33 of the outer header B will be joined to said first member 32 thereof. Then, the heads 31 of said header B will be secured in place and, finally, the butt of the inner header C will be brazed or soldered to the outer header member 33 about the opening in said member through which said butt extends.

From the foregoing it will be readily comprehended that the present invention lends itself to embodiment in a particularly durable heat exchanger that is relatively simple and inexpensive in construction and one that is readily incorporated in a conduit structure and therein adapted uniformly to affect the temperature of a passing fluid conveyed along such structure.

Changes in the specific form of my invention, as herein described, may be made within the scope of what is claimed without departing from the spirit of my invention.

Having described my invention, what I claim as new and desire to protect by Letters Patent is:

1. The combination with a conduit having two relatively wide parallel walls and adapted to conduct a fluid therealong, of a unit incorporated in the structure of said conduit for heating said fluid uniformly inwardly from the surfaces of said wide walls, said unit including two groups of return tubes traversing the conduit and paralleling said walls, one group being relatively proximate to one wall and the other group being relatively proximate to the other wall, the return tubes in each group being arranged progressively proximate to its respective wall, an elongated outer manifold disposed apart from the interior

of said conduit and connected along its side from end to end thereof with corresponding ends of the return tubes, said return tubes being closed at the opposite ends thereof and means for effecting the controlled unequal distribution of a heating medium to said return tubes, said means including an elongated inner manifold adapted to conduct axially therealong the heating medium supplied to the unit therethrough, said inner manifold being disposed within said outer manifold medially thereof, feed tubes, one for each return tube, each feed tube, in part, being disposed within its respective return tube and having a portion thereof providing a lead extending along the interior of the outer manifold and connected with said inner manifold, such lead having a mouth lying in a plane and exposed to the interior of said inner manifold, the planes occupied by the mouths of the leads of the feed tubes of each group thereof being progressively inclined decreasingly relative to the axis of said inner manifold in accord with the relative proximity of their respective return tubes to their respective conduit wall, said leads of said feed tubes of each group being of relative greater length progressively in accord with the relative proximity of said return tubes to their respective conduit wall, thereby to compensate, in the heating effect of said tubes, for the retardation of flow of said fluid frictionally induced by said wall.

2. The combination with a conduit having two relatively wide parallel walls and adapted to conduct a fluid therealong, of a unit incorporated in the structure of said conduit for heating said fluid uniformly inwardly from the surfaces of said wide walls, said unit including two groups of return tubes traversing the conduit and paralleling said walls, one group being relatively proximate to one wall and the other group being relatively proximate to the other wall, the return tubes in each group being arranged progressively proximate to its respective wall, an elongated outer manifold disposed apart from the interior of said conduit and connected along its side from end to end thereof with corresponding ends of the return tubes, said return tubes being closed at the opposite ends thereof, and means for effecting the controlled unequal distribution of a heating medium to said return tubes, said means including an elongated inner manifold adapted to conduct axially therealong the heating medium supplied to the unit therethrough, said inner manifold being disposed within said outer manifold, feed tubes, one for each return tube, each feed tube having a portion thereof providing a lead extending to and connected with said inner manifold, said lead having a mouth lying in a plane and exposed to the interior of said inner manifold, the planes occupied by the mouths of the leads of the feed tubes of each group thereof being progressively inclined decreasingly relative

to the axis of said inner manifold in accord with the relative proximity of their respective return tubes to their respective conduit wall, thereby to compensate, in the heating effect of said tubes, for the retardation of flow of said fluid frictionally induced by said wall.

3. The combination with a conduit having two relatively wide parallel walls and adapted to conduct a fluid therealong, of a unit incorporated in the structure of said conduit for heating said fluid uniformly inwardly from the surfaces of said wide walls, said unit including two groups of return tubes traversing the conduit and paralleling said walls, one group being relatively proximate to one wall and the other group being relatively proximate to the other wall, the return tubes in each group being arranged progressively proximate to its respective wall, an elongated outer manifold disposed apart from the interior of said conduit and connected along its side from end to end thereof with corresponding ends of the return tubes, said return tubes being closed at the opposite ends thereof, and means for effecting the controlled unequal distribution of a heating medium to said return tubes, said means including an inner manifold disposed within said outer manifold medially thereof, feed tubes, one for each return tube, each feed tube, in part, being disposed within its respective return tube and having a portion thereof providing a lead extending along the interior of the outer manifold and connected with said inner manifold, said leads to the feed tubes of each group of tubes being of relative greater length progressively in accord with the relative proximity of said return tubes to their respective conduit wall, thereby to compensate, in the heating effect of said tubes, for the retardation of flow of said fluid frictionally induced by said wall.

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