Dec. 3, 1940. O. JABELMANN 2,223,688

HEAT EXCHANGE APPARATUS

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Fig. 5

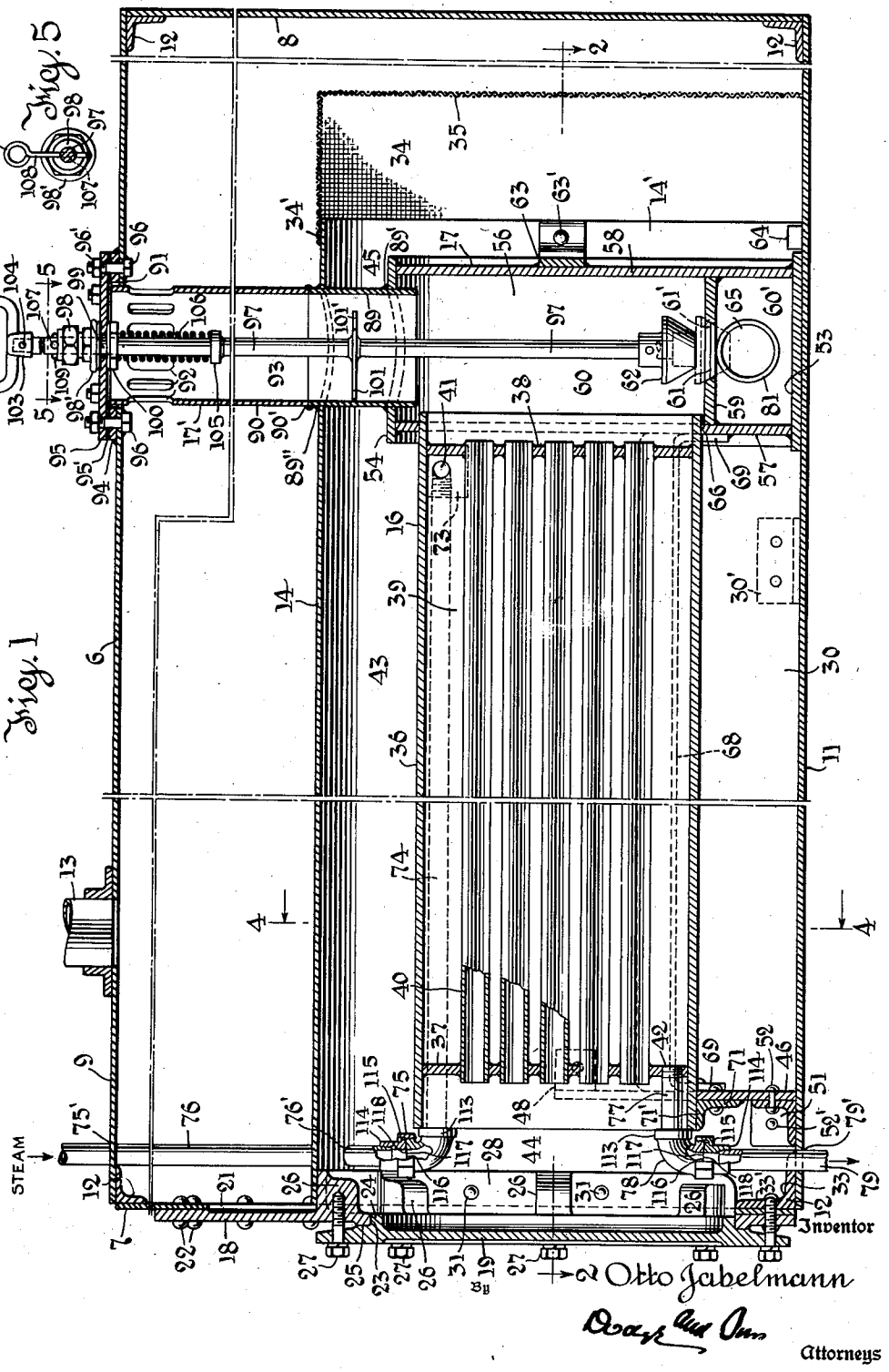


Fig. 1

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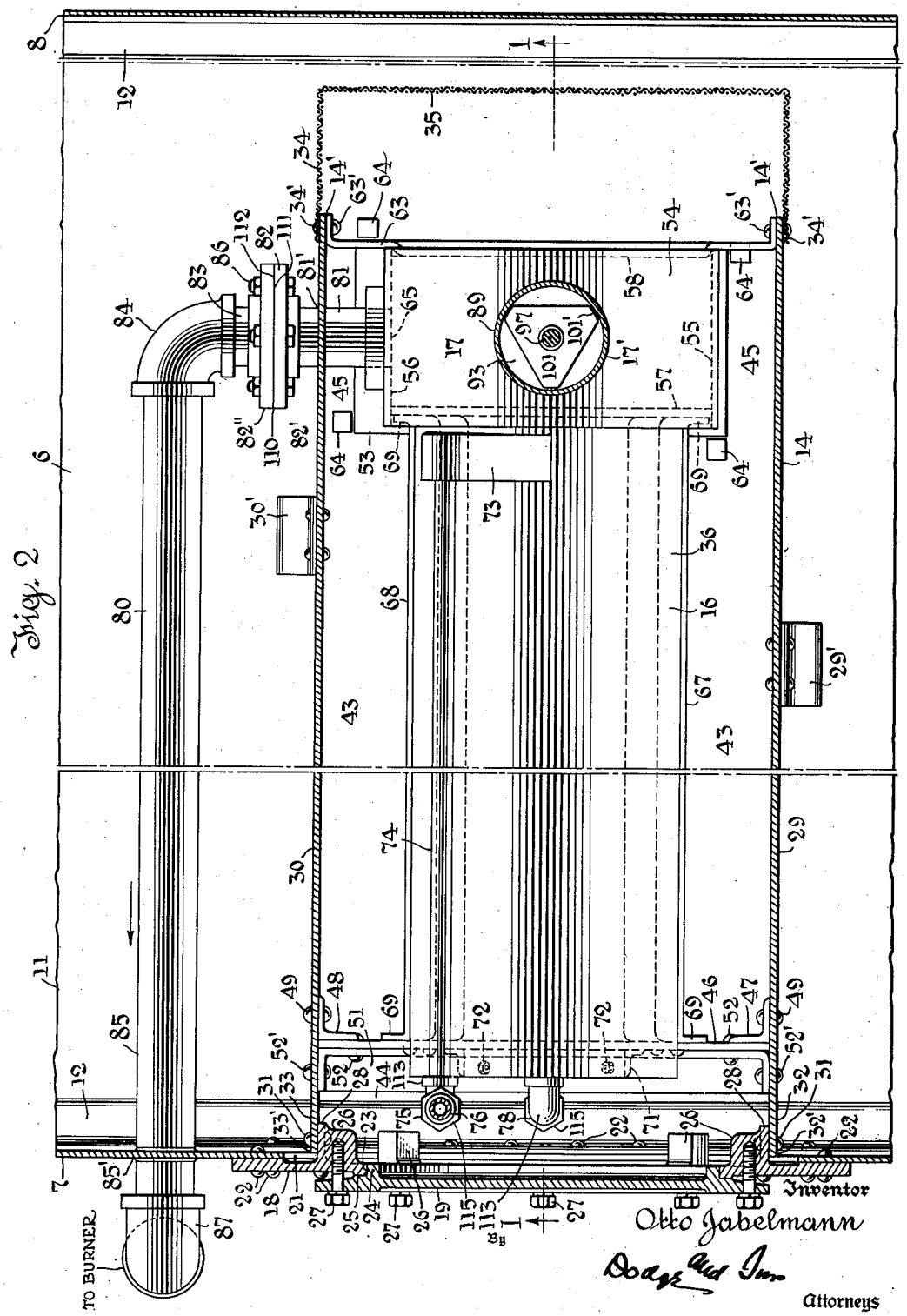


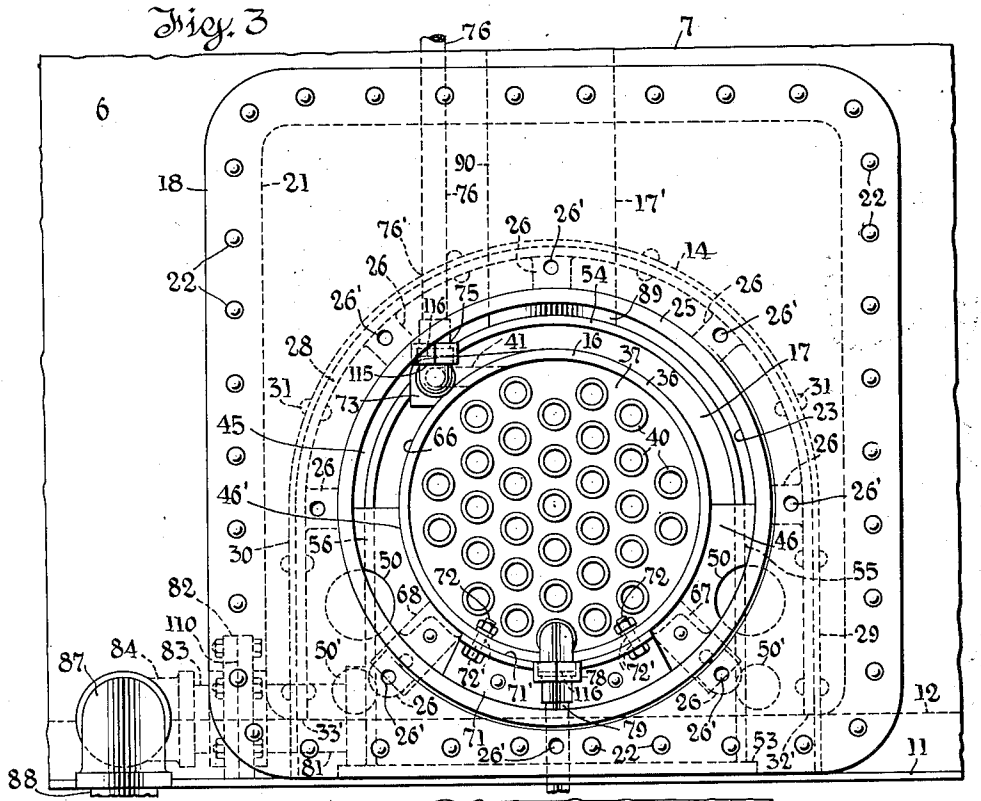
Fig. 2

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HEAT EXCHANGE APPARATUS

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Fig. 3



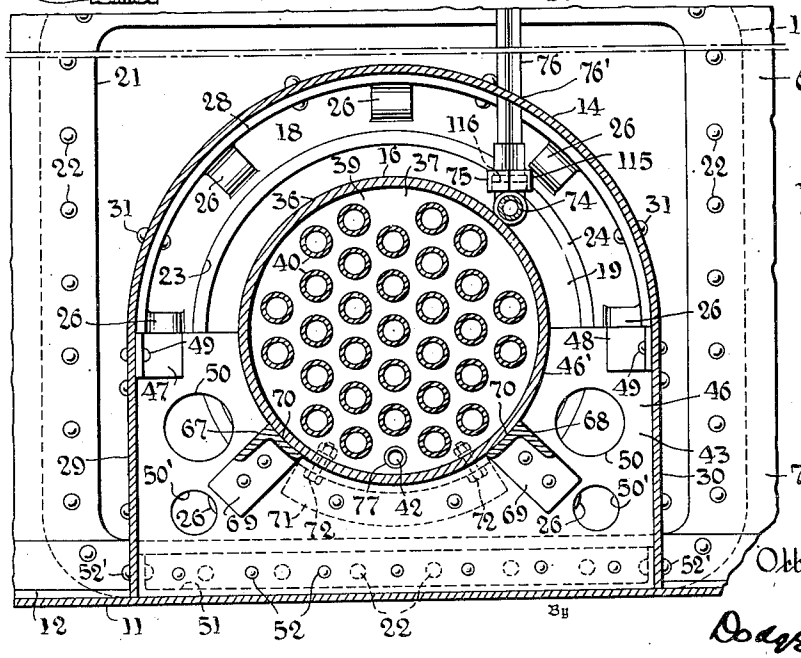


Fig. 4

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UNITED STATES PATENT OFFICE

2,223,688

HEAT EXCHANGE APPARATUS

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Application April 10, 1939, Serial No. 267,089

19 Claims. (Cl. 257—199)

This invention relates to heat exchange apparatus and especially to apparatus of this character which includes a fluid-receiving receptacle and indirect or surface type fluid-heating means located therein.

While not limited to such use, the present improvements are primarily concerned with the provision of a fuel oil supply or storage tank for an oil burner and efficient fluid-type heating means arranged in the tank for heating fuel oil therein prior to passage of the oil to the burner. More specifically, the invention is directed to the pre-heating of fuel oil in a locomotive oil burner supply or storage tank located on the tender of an oil-burning locomotive. The novel heating means employed are specially designed to raise the temperature of the oil to a point which will produce proper atomization for efficient combustion at the burner of low gravity fuel oils or residue obtained from crude oils by the so-called "cracking process" of distillation. The heating means preferably utilize steam from the locomotive boiler as the heating medium for the fuel oil.

An important object of the invention is the designing of the fluid heating means as a completely assembled unitary structure or heating unit separate from the tank or other fluid receptacle, so that the rigid heater assembly may be applied as a unit to the tank through an opening provided in a wall thereof and fastened securely in place in said opening ready for operation after the necessary pipe connections are made.

Since a drum-type heater is especially suitable for the purpose, particularly because of its highly efficient operating characteristics, the novel heating unit employed in the present apparatus is of this general type, that is, the heating unit involves the use of a heat exchanger element or core comprising a drum having spaced tube sheets and a nest of open-ended tubes mounted therein through which the fluid to be heated passes, while the heating fluid flows around the outside of the tubes. After the installed heating unit has been in operation for some time, the heat exchanger element or drum unit may require cleaning or repair of leaks therein. An outstanding feature of my improved heating unit is the provision for ready removal of the heat exchanger element or drum assembly as a unit for cleaning, repair or other purposes. Such removal, as well as re-insertion of the drum element, is accomplished without disturbing any of the other parts of the heater and involves the breaking or making of a minimum number of readily-operated connections. Suitable guide and supporting means are provided in the heating unit to aid in both removal and re-insertion of the heat exchanger drum.

The heating unit, which includes a discharge header for the heated fluid having a delivery pipe connection to the outside of the tank, also features the provision of adequate anchorage of the drum-type heat exchanger therein, while at the same time permitting free lengthwise expansion and contraction of the drum unit resulting from variations of the temperature thereof.

Another important object is the inclusion in the apparatus of adequate and continuously functioning expansion and venting means for the heated fluid and the gases escaping therefrom.

A further object is the provision of a quick-release, quick-acting type, discharge valve controlled from outside of the tank, whereby flow of hot fluid from the heating unit to the delivery pipe may be stopped instantaneously. This valve is arranged so as not to interfere with proper operation of the expansion and venting means above-mentioned. Provision is also made for ready removal of the valve for repairing or renewing.

Additional features comprise the use of welded joints and connections in order to insure sealed joints and rigid construction; provision for preventing entrance of foreign material into the heating unit and resulting stoppage of oil flow therethrough; and special designing of the heating unit for cooperation with the tank so as to provide for maximum heat transference to the fluid heated, and also to insure proper attachment and sealing of the heating unit in its mounting opening in the tank wall. Other objects and advantages will appear from the detailed description given hereinafter.

Reference is made to the accompanying drawings which illustrate a practical embodiment of my invention as applied to a locomotive oil-burner supply tank located on the tender of an oil-burning locomotive, and in which:

Figure 1 is a longitudinal vertical section taken on line 1—1 of said embodiment as it appears in Fig. 2, the oil heating unit being shown mounted in operating position in the fuel oil tank. The open position of the heated oil outlet valve of the heating unit is shown in full lines and its closed position in dotted lines. Some of the tubes in the heat exchanger drum are omitted for sake of clearness.

Fig. 2 is a fragmentary horizontal longitudinal section taken on line 2—2 of Fig. 1.

Fig. 3 is a fragmentary front elevation of the assembled tank and heating unit as shown in the above figures, but with the inspection cover of the heating unit removed to show certain internal details.

Fig. 4 is a fragmentary transverse vertical section taken on line 4—4 of Fig. 1 with the inspection cover of the heating unit in place.

Fig. 5 is a section on line 5—5 of Fig. 1 showing certain details of the oil outlet-valve control means.

In general, the embodiment of the invention illustrated includes a fuel oil tank provided with fuel oil inlet means, steam inlet and outlet pipes and a heating-unit receiving opening, together with the elongated heating unit which is mounted horizontally in the tank in sealing relation with said opening and connects with the steam pipes and a hot oil delivery pipe leading to the exterior of the tank.

The fuel oil tank consists of a sheet metal receptacle 6 having a vertical front wall 7, a vertical rear wall 8, a horizontal top wall 9 and a horizontal bottom wall 11, the vertical end walls of the tank not being shown. In order to form a rigid liquid-tight receptacle, angle members 12 are used at the junctures of the several walls where the parts are preferably welded together. Inlet means 13 on top wall 9 provide for filling the tank with fuel oil.

The rigid heating unit or assembly comprises, in general, a horizontal outer shell or casing 14, a removable drum-type heat-exchanger element 16 mounted horizontally in casing 14, an outlet header 17 also mounted in casing 14 and connected to heat-exchanger element 16 to receive hot oil therefrom, a vertical front plate or attaching frame 18 to which shell 14 is connected at its front end, and a removable inspection cover 19 mounted on front plate 18. All of this is shown clearly in Figs. 1 and 2.

In order to permit bodily insertion of the completely assembled heating unit into tank 6 during installation, the tank is provided in its front wall 7 with a rectangular opening 21 of proper size for free passage of the unit. While the bulk of the heating unit is located within the tank after installation, the front end of the unit projects through opening 21 with the attaching plate 18 and its inspection cover 19, which form the front wall of the unit, located on the outside of the tank. Front plate 18, which is rectangular, abuts against the outer surface of tank wall 7 entirely around opening 21 and is tightly secured in sealing relation therewith by rivets 22.

Disk-shaped cover 19 serves to close a circular inspection opening 23 in front plate 18 and is provided with an annular guide flange 24 projecting into this opening. Attaching or flange plate 18, which is cast, is formed on its inner face with an annular series of lugs 26. Plate 18 and these lugs are tapped at 26' from the outer face of the plate to receive studs 27 which extend through openings provided around the rim of cover 19. When studs 27 are tightened, cover 19 is forced into close sealing contact with an annular seat 25 formed on plate 18 around opening 23. Thus inspection cover 19 and plate 18 together form a complete closure for the unit insertion opening 21 in the tank wall and tightly seal this opening against all possible leakage of fuel oil therethrough.

Closure or attaching plate 18 is provided on its inner face with an inverted U-shaped flange 28 (see Figs. 3 and 4). This flange partially surrounds inspection opening 23 and projects inwardly through opening 21 in the tank wall. The upper curved portion of flange 28 is concentric with opening 23 and the depending portions thereof extend to the bottom of opening 21 in the tank wall. All of the tapped lugs 26, except the two lowest ones as shown in Fig. 3, are formed integrally with flange 28.

The outer shell or casing 14 of the heating unit is arranged at right angles to tank wall 7 and consists of an elongated open-ended sheet-metal member of inverted U-shape in transverse section (see Figs. 3 and 4). The lower edges of parallel side walls 29, 30 of casing 14 rest directly on bottom 11 of the fuel tank so that the latter supports the heating unit in place and completely closes the open bottom thereof. The U-shaped flange 28 on front plate 18 projects into the front end of shell 14 and a series of rivets 31, extending through the flange and the shell, serves to rigidly connect the shell to the front plate 18. The lower front corners of side walls 29, 30 of shell 14 are notched at 32, 33, respectively, to accommodate the angle member 12 at each of these points. Slots 32', 33', formed on the heating unit by notches 32, 33, respectively, front plate 18 and the lower ends of flange 28 on the front plate, receive and closely embrace both angle member 12 and tank wall 7 at the bottom of opening 21.

The rear open end 14' of shell 14, through which the fuel oil in the tank enters the heater, is completely covered by a wire-netting strainer 34 mounted on the end of the shell and rigidly secured thereto by welding around its inner edge 34'. This strainer, which has an end wall 35, is formed as a prolongation of shell 14 and rests on the bottom of the tank. Thus increased straining area is provided with assurance that foreign material cannot enter the heating unit and interfere with free flow of oil therethrough. A pair of angle members 29', 30', riveted to the sides 29, 30, respectively, of shell 14 and welded to the bottom of the fuel tank, serves to rigidly anchor the elongated heating unit in place in the tank perpendicular to tank wall 7 and with the lower edges of shell 14 and strainer 34 in close contact with the tank bottom.

Heat exchange element or core 16 of the heating unit, which is removably mounted in shell 14, comprises an elongated horizontal cylindrical drum 36 having spaced tube sheets 37, 38 welded in place inwardly of the ends of the drum. This provides a steam circulating chamber 39 between the tube sheets through which extends a number of oil conducting tubes 40 with their open ends mounted and welded in place in openings in the tube sheets. Steam chamber 39 has a live steam inlet port 41 and a condensate outlet port 42.

Drum 36, which is shorter and substantially smaller transversely than shell 14, is mounted in the middle of the shell in spaced relation both to the shell and the bottom 11 of the tank, as appears in Figs. 3 and 4. The drum is arranged concentrically with reference to the semi-cylindrical top of shell 14, and its longitudinal axis is at right angles to front plate 18 and in alinement with the axis of inspection opening 23 therein. The diameter of drum 36 is smaller than that of opening 23 in order to permit removal of the drum unit therethrough as explained later. In this manner there is formed an annular fuel

oil space or passage 43 completely surrounding drum 36 for substantially its entire length. The front end of the drum unit is spaced from front plate 18 and cover 19, and thus provides a fuel oil chamber or space 44 communicating both with the open front ends of tubes 40 and fuel oil passage 43 around the drum.

The supporting means for drum unit 16, which includes hot oil outlet header 17, will now be described. A transverse supporting and reenforcing partition or saddle 46 is rigidly mounted between sides 29, 30 of shell 14 at the front end of the heating unit and parallel to attaching frame 18. This saddle, which engages the tank bottom and has its upper edge level with the longitudinal axis of drum 36, is secured to shell 14 by upper angle members 47, 48. These are welded to the saddle and secured to the shell by rivets 49. An angle-type brace 51, attached by rivets 52 to saddle 46 and by rivets 52' to shell 14, secures the lower portion of the saddle in place. A semicircular recess 46' in the upper edge of saddle 46 snugly, but removably, receives drum 36 and thus supports the front end thereof. Large openings 50, 50 and smaller openings 50', 50' in saddle 46 provide for free passage of fuel oil therethrough from oil space 43 around the drum into oil chamber 44 at the front of the unit.

The rear end of drum unit 16 is supported by outlet header 17 which latter is rigidly secured in the rear end of shell 14 in parallel relation to front plate 18. This header, which rests on the bottom of the fuel tank, comprises a bottom member 53, an inverted U-shaped member 54 forming the arched top and vertical side walls 55, 56 of the header, a front member 57 and a rear member 58. All of these parts are welded together to form an integral structure with fluid-tight joints. A partition member 59, also welded in place, divides the interior of the header into a main or hot-oil receiving chamber 60 and a smaller hot-oil discharge chamber 60'. A port 61 in partition 59 establishes communication between chambers 60 and 60' and is adapted to be controlled by a tapered plug-type shut-off valve 62.

Header 17, which like drum 36 is smaller transversely than shell 14, is equally spaced from the sides 29, 30 of the shell, while its arched top is concentric with the arched top of the shell, as appears in Fig. 3. This provides an inverted U-shaped oil space 45 between shell 14 and the header, which joins the rear oil inlet end 14' of the shell with oil space 43 surrounding drum 36. A bar 63, welded to the rear face of header 17 and attached by rivets 63' to the sides of shell 14, assists in rigidly securing the header in place in the shell. Lugs 64, welded to the bottom of tank 6 and coacting with bottom member 53 of the header, further anchor the entire heater unit against horizontal shifting and, as will appear later, assist in the original installation of the unit.

Front wall 57 of header chamber 60 has a circular opening 66 therein in which the rear end of drum 36 is snugly, but slidably fitted. Thus header 17 supports the drum unit with the rear ends of oil tubes 40 in communication with oil chamber 60. It is important to note that the longitudinal axes of opening 66 in the header, inspection opening 23 in front plate 18 and drum-receiving recess 46' in saddle 46, are alined with each other lengthwise of the heating unit. This insures proper mounting of drum unit 16 and facilitates its removal and re-insertion, when desired.

Extending between and rigidly attached at their ends to saddle 46 and header 17 is a pair of longitudinal drum-supporting angle-type members 67, 68. Each of these members has integral leg extensions 69, 69 at its opposite ends which are riveted or welded to the saddle and the header. Members 67, 68, as shown in Figs. 3 and 4, are located at opposite sides of the longitudinal axis of drum 36. They are arranged at an angle so that the drum-engaging surface 70 of each member is substantially flush with, or alined lengthwise of the heater with, the edge of wall 57 surrounding header opening 66 and the curved portion of the upper edge of saddle 46 which forms recess 46'.

An arcuate angle-type drum-supporting member 71 is attached by rivets to the front of saddle 46 with the upper drum engaging surface 71' thereof flush with the recessed edge portion of saddle 46. A pair of bolts 72, 72, extending through registering openings 72', 72' in drum 36 and supporting member 71, serves to detachably secure the drum in place.

It will thus be seen that drum unit 16 is firmly anchored at its front end in the heating unit. However, because of the slidable connection between the drum and header 17 at opening 66, the rear end of the drum is entirely free to move back and forth horizontally in this opening to any extent necessary to accommodate lengthwise expansion or contraction of the drum unit resulting from the variations of temperature to which it is subjected. This is an important feature in the practical operation of the heating unit.

In order to supply steam to heat exchanger element 16, an inlet connection 73, welded to drum 36 at inlet port 41, connects with a pipe 74 running along the top of the drum. Pipe 74 connects, by means of a conventional elbow-type union coupling 75, with a steam inlet pipe 76 at the front of the unit. Pipe 76, which extends from the source of steam supply, preferably the locomotive boiler, is mounted, as by welding, in an opening 75' provided in the top 9 of the fuel tank and extends downwardly into shell 14 through an opening 76' in the top of the latter. A valve (not shown) controls the passage of steam through pipe 76. Steam condensate outlet 42 in drum 36 supports a pipe 77 which connects, by means of a second conventional elbow-type union coupling 78, with a discharge pipe 79. Pipe 79 is mounted, as by welding, in an opening 79' formed in the bottom wall of the fuel tank and leads to the atmosphere through a suitable choke (not shown) provided in the pipe.

Chamber 60' in oil header 17 has a hot-oil outlet port 65 to which is connected a delivery pipe line 80 leading to the exterior of the fuel tank. Pipe line 80 includes a pipe 81 mounted in port 65 and projecting through an opening 81' in shell 14, a pipe coupling 82, pipe 83, elbow 84 and a pipe 85 extending through and welded in an opening 85' in the front wall of the tank. Pipe coupling 82 comprises a flanged member 82' mounted on pipe 81 and a similar member 82'' mounted on pipe 83, these members bearing on the tank bottom and being separably connected by bolts 86. Annular line of separation 110 and joint surfaces 111, 112 of coupling 82 lie in vertical planes extending lengthwise of the heating unit and perpendicular to tank wall 7. Outside the tank, an elbow 87 connects pipe 85 with

a hot-oil delivery pipe 88 leading to the oil burner in the fire box of the locomotive boiler.

A vertical tube section 89 is mounted in place, by welding, in an opening 89' in the top of header 17 and in an opening 89'' in the top of shell 14. Tube section 89 projects slightly above shell 14. Mounted on the flat upper end of the tube section and forming a continuation thereof is another but longer vertical tube section 90 rigidly secured to tube section 89 at annular welded joint 90'. The upper end of tube section 90 fits relatively loosely and without attachment into a circular opening 91 in top wall 9 of the fuel tank. An annular series of elongated, gas-escape and oil-overflow apertures 92 near the upper end of tube section 90 places the interior thereof in communication with the upper part of the fuel tank above the normal level of the fuel oil therein. Thus tube sections 89 and 90 together constitute a riser 17' for header 17 which provides an elongated expansion chamber 93 communicating at its lower end with header chamber 60 and of substantial volume, especially if the fuel tank is deep.

A ring 94 surrounds opening 91 in the top of the tank and is welded in place. A disk-shaped plate 95 closes tank opening 91 and also the upper end of riser 17'. An annular gasket 95' is located between cover 95 and ring 94. An annular series of bolts 96 extends through openings in the tank, ring 94, gasket 95' and cover 95, with the heads of the bolts welded to the inside of the tank top. Thus bolts 96 form threaded studs on which nuts 96' are secured to clamp and seal cover 95 in place.

Shut-off valve 62 has a detachable elongated operating stem or rod 97 extending upwardly through riser 17' and above the top of the tank. A stuffing box 98, having a clamping flange 98', a tubular threaded extension 99 and a jam nut 100 mounted on the latter, is removably mounted in a central opening in cover 95 and seals with the cover by means of suitable interposed gaskets. The upper end of valve rod 97 is slidably mounted in stuffing box 98, whereby valve 62 is supported for reciprocatory movement in vertical alinement with port 61 and its tapered valve seat 61'. Welded on valve rod 97 is a triangular spacer plate 101 having rounded corners 101'. Plate 101 fits relatively loosely in riser 17' and coacts with the latter, as shown in Fig. 2, to assist stuffing box 98 in maintaining valve 62 in alinement with port 61.

A valve operating handle 102, having a socket 103 in which the upper reduced extremity of valve rod 97 is located, is detachably connected to the rod by a cotter pin 104 extending through suitable openings in the parts. Mounted under compression on valve rod 97 between a flange 105 on the rod and jam nut 100 is a coil spring 106. With valve 62 raised by handle 102 to its normal full open position as shown in full lines in Fig. 1, a transverse passage 107 extending through valve rod 97 is located just above stuffing box 98. In order to support valve 62 in this position, a readily removable pin 108 is positioned in passage 107 and bears on the top of stuffing box 98 as appears in Figs. 1 and 5. Pin 108 has a ring-shaped end 109 which may serve either as a handle or as a means of attaching suitable operating means to the pin whereby to facilitate quick removal of the pin, when desired, to release the valve so that it may close. It will thus be clear that, instantly upon removal of pin 108, valve 62 will drop and close port 61 as indicated in dotted lines in Fig. 1. This quick closing action is caused automatically by the expansion action of coiled spring 106 on valve rod 97 aided by the weight of the valve and its operating parts. The expansive action of spring 106 also maintains valve 62 in tight sealing engagement with its tapered seat 61'.

In describing the operation of the complete heat exchange apparatus illustrated, it will be assumed that the various parts are in the normal operating positions shown in the drawings, except that pin 108 has been removed and outlet valve 62 is closed. Fuel oil is first fed into tank 6 at inlet 13 until the tank is filled to a level somewhat below riser openings 92. As a result, the fuel oil flows through strainer 34 into the heating unit and completely fills, with the exception of header chamber 60' and pipe 81, all of the oil space in the unit including communicating oil passages 45, 43 and 44 in shell 14, oil tubes 40, header oil chamber 60, and riser chamber 93 up to the level of the oil in the tank proper. Live steam, entering steam chamber 39 in drum 36 at inlet 41, condenses as heat is given up to the fuel oil in pipes 40 and the oil space surrounding drum 36 and the exterior of the heating unit, and the resulting water of condensation discharges through drum outlet port 42.

With the steam flowing through drum chamber 39 and outlet valve 62 raised and secured in open position by means of pin 108, it will be seen that fuel oil from the tank flows continuously through the heating unit and is pre-heated therein to the desired temperature before it passes into pipe line 80 leading to the oil burner. The oil from the tank, entering the rear open end 14' of heater shell 14 after passing through strainer 34, flows through inverted U-shaped passage 45 around header 17 and then through communicating tubular passage 43 surrounding drum 36. In space 43 the initial heating of the oil by the steam in drum chamber 39 takes place by conduction from drum 36. Steam inlet pipe 74 also aids in heating the oil.

From space 43 the partially heated oil flows, both over saddle 46 and through openings 50, 50 and 50', 50', therein, into communicating space 44 at the front of the unit. Here the oil is further heated by conduction from drum element 16 and the steam pipes. It then flows into and through steam heated tubes 40, but in a direction reverse to its flow through tubular space 43. In tubes 39, the oil is brought to the maximum temperature desired preliminary to passage to the oil burner. The hot oil from these tubes discharges into header chamber 60, whence it flows past valve 62, through port 61 and into chamber 60', and then through delivery pipe line 80 and pipe 88 to the oil burner.

The maximum rate at which oil may flow through discharge port 61, i. e., the fluid discharge capacity of the port, is obviously limited by the clearance or effective oil discharge area between the port and its control valve 62 when in open position. Because of their number and size, the combined cross-sectional area of the interior of oil pipes 40 is greatly in excess of the area of port 61 or its effective oil discharge area. Thus the total maximum rate at which tubes 40 can discharge oil into chamber 60, or in other words the combined capacity of the tubes for discharging oil into this chamber, is considerably greater than the rate at which oil can discharge through port 61. This, together with heating of the oil to the proper temperature in tubes 40, insures

that chamber 60 will receive hot oil from the tubes of such temperature and at such a rate that chamber 60 will continuously provide an adequate supply of hot oil for discharge through port 61 at the desired temperature and rate of discharge.

Riser chamber 93 serves as an expansion chamber whereby the heated fuel oil may readily expand at the discharge end of drum unit 16. while riser openings 92 function as a gas release or vent to permit free escape of generated gases from the hot oil before the oil passes through port 61 to the burner. The hot oil discharged into chamber 60 circulates therein and into riser chamber 93 past spacer 101 so that the oil in both of these chambers is heated. The hot gases from the oil escape from riser openings 92 into the free space in the tank above the main body of oil therein and thus aid in pre-heating the latter. If the expansion of the hot oil in riser chamber 93 is sufficient to raise the oil level therein to the level of riser openings 92, these openings will function as a return outlet or overflow for the fuel oil, which outlet leads from the heating unit back into the main compartment of the tank above the body of oil therein. The hot oil thus overflowing through openings 92 will mix with the oil in the tank and further aid in pre-heating the same.

The described expansion and vent means are particularly important because their presence prevents the heating unit from becoming gas-bound. In other words, if such means were not provided, the gases generated in the oil would be trapped in the hot oil outlet portion of the heating unit and thus would be carried along with the oil in the hot oil delivery line to the oil burner in such quantities as to interfere with proper operation of the burner. The expansion and vent means also preclude excessive internal or bursting stresses being set up by the heated oil and gases in the hot oil outlet portion of the heating unit.

Heated oil in riser 17', delivery pipe line 80 and heater shell 14 and steam pipe 76, by conduction of heat from these parts, aids in pre-heating the oil in the tank before it enters the heating unit. As it enters the heating unit, the oil is also preliminarily heated through conduction by the hot oil in header 17, riser 17' and outlet pipe 81.

It will be noted that the exterior of heat exchanger drum 36, in effect, constitutes a secondary heating surface for the oil, since it simply serves to preliminarily heat the oil. The primary heating surface is provided by tubes 40 through which the pre-heated oil subsequently passes and in which the greatest heat transference takes place between the oil and the steam in chamber 39. Location of live steam inlet 41 at the inner or header end of drum 36 has a two-fold purpose. First, since this location is at the point where the oil entering the heating unit first contacts with the drum, the coolest oil passing through the heating unit is thus subjected to the intense heating action of the live steam entering at port 41. Second, and most important, such location of steam inlet 41 causes the live steam entering at inlet 41 to act first on the header or discharge ends of oil tubes 40 through which is passing the hottest oil just before its discharge into header 17. This insures delivery to the burner of oil heated to the proper temperature. The entire arrangement also insures maximum rate of heat transference and, taken with the other features of construction and operation described, provides novel fluid heating apparatus of exceptionally high efficiency.

Tank cover 95, as stated, seals opening 91 and closes the upper end of riser 17'. This prevents oil from spilling out of the tank when the oil in the tank proper and in the riser surges due to movement of the tank, as would be the case when the tank is mounted on a locomotive tender.

Due to the quick-release, quick-acting nature of shut-off valve 62, as already described, the flow of hot oil from header chamber 60 to delivery line 80 and the oil burner may be stopped instantly. This furnishes a safety arrangement that prevents the oil burner from getting out of control. It will be noted that the quick action of valve 62 in closing port 61 is aided by the action thereon of the hot oil flowing towards and through the port at the time. A further important feature is the fact that the liquid and gas expansion and vent means provided by riser 17' and riser openings 92 always operate to perform their described functions even though valve 62 has been closed to stop the discharge of hot oil. Obviously this advantage is especially important if steam is still fed to drum 36 after valve 62 is closed.

An additional feature of valve 62 and its operating parts is that they are easily and quickly removed from repairing or renewing. Upon removal of nuts 96', handle 102 may be grasped, and the entire valve assembly, including cover 95, lifted as a unit from the tank and riser 17'. This unit may be disassembled by removing cotter pin 104 and handle 102, whereupon removal of pin 108 will permit valve rod 97 to be withdrawn downwardly out of the cover through stuffing box 98. After repairs the parts may be readily reassembled in the reverse order described and the unit quickly reinstalled in the tank opening ready for operation.

It is particularly advantageous that the oil inlet to the heating unit is always open to the tank and hence, even though discharge valve 62 be closed to cut off flow of oil to the delivery line, heating of oil in the unit may be continued, especially in view of the presence of the expansion and venting means described. When the valve is again opened, the hot oil will be discharged into header chamber 60' and delivery pipe line 80 which are maintained in partially heated condition by the oil in the heating unit and the tank. Location of valve 62 and most of its operating parts in riser 17' provides a compact arrangement, protection of the valve mechanism, and easier and more reliable operation because of the presence of the heated oil and gases.

The heating unit, being rigidly constructed itself and rigidly secured in place in the tank as described, forms a unitary part thereof. In fact, since front plate 18 and inspection cover 19 together close and seal unit insertion opening 21 in tank wall 7, they constitute a portion of the tank wall.

With the described construction it is a simple matter to remove heat exchanger or drum element 16 from the heating unit for repairs, cleaning, etc. and then to reinstall the same. After the steam has been turned off and the oil drained from the apparatus, cover 19 may be removed for inspection purposes. If it is found desirable to remove drum element 16, the drum ele-

ment may readily be withdrawn lengthwise upon removing the two bolts 72, 72 and disconnecting the two steam pipe union couplings 75, 78, since these are the only fastenings for the drum element.

Each of couplings 75 and 78 comprises a threaded elbow portion 113, a sleeve 114 registering therewith, and an internally threaded collar 115 swiveled on sleeve 114. The annular line of separation 116 of each coupling and abutting joint surfaces 117 and 118 of elbow 113 and sleeve 114, respectively, of each coupling lie in horizontal planes parallel to the axis of drum element 16 but are out of longitudinal alinement with the drum element (see Fig. 1). Thus, when collar 115 of coupling 75 is unscrewed and raised on pipe 76 and collar 115 of coupling 78 is unscrewed and lowered on pipe 79, drum element 16 may be pulled axially, without rotation, out of opening 66 in header 17, joint surface 117 of each steam coupling shifting laterally of the opposing joint surface 118 and in substantially parallel relation therewith to permit this movement. Upon continued lengthwise movement, drum element 16 may be completely withdrawn from the tank through inspection opening 23 in front plate 18.

Such removal is possible because of the smaller diameter of drum element 16 and the fact that the steam connection parts remaining thereon at this time, including the two elbow portions 113, 113 and steam inlet connection 73, are longitudinally alined with inspection opening 23, as shown in Figs. 1 and 3, so as to permit free passage of the drum element and attached pipe connections therethrough; also because of the fact that steam pipes 76 and 79 and attached sleeves 114, 114 are located outside of the path of movement of drum element 16 and proper operating clearance is provided between these sleeves and the aforementioned steam connection parts on the drum element so as to prevent interference with lengthwise movement of the drum.

Removal of drum element 16 is facilitated by the drum supporting and guiding functions performed by angle members 67 and 68 and saddle member 46 as the drum element is withdrawn axially from header 17 and out of the tank. These members act as a sort of cradle for the drum without however interfering appreciably with direct heat transmission between the drum and fuel oil in passage 43. The same members function similarly when the drum element with its attached pipe connections is slid back into place after cleaning, and also perform the additional important function of supporting and axially guiding the element so that the rear end of the element alines exactly with opening 66 in header 17 and registers with and slips into this opening as the drum element is shoved into its final or operative position. It will be observed from Figs. 1 to 3 that the arrangement and proportioning of the parts are such that, as drum element 16 approaches its operative position, alinement with each other lengthwise of the drum of the two pairs of bolt holes 72' in drum 36 and member 71 effects substantial alinement, lengthwise of the drum, of joint surfaces 117 and 118 of couplings 75 and 78; also that the proportioning and arrangement are such that, when the drum element is then moved axially, without rotation, into its operative position with bolt holes 72' in registry, each elbow 113 will register with its corresponding sleeve 114, joint surface 117 of each coupling shifting across opposing joint surface 118 and in substantial parallel relation therewith to permit this final movement of the drum element. Bolts 72 are now replaced, unions 75 and 78 secured by their swiveled collars 115, 115, and inspection cover 19 replaced ready for resumption of operation of the apparatus.

Original installation of the heating unit in the tank is readily accomplished. This involves horizontal bodily insertion of the rigid assembled unit into opening 21 in tank wall 7, securing the unit rigidly in place and then connecting it up ready for operation. As adapted for insertion into opening 21, the heating unit comprises shell 14 with attached angles 29', 30', strainer 34, front plate 18, header 17 with attached riser tube 89 and delivery pipe 81 and its coupling member 82', and drum element 16 together with its supporting means and the steam connection parts extending from steam inlet 41 and outlet 42 to and including the two union coupling elbows 113, 113. Cover 19 preferably is not in place on the unit at this time, because this would necessitate removing it after the unit is inserted in the tank in order to make the steam connections. Steam pipes 76 and 79, riser cover 95, and valve 62 and its operating parts, as shown in Fig. 1, are not put into place until after installation of the heating unit, nor is riser tube 90 which is adapted to be inserted through tank opening 91 and welded to tube 89. Lugs 64 on the bottom of the tank are already in place.

Insertion into the tank of the assembled heating unit, as just described, requires that the unit first be located outside of the tank with shell 14 and strainer 34, and also pipe coupling member 82' and angle member 30', in longitudinal alinement with tank opening 21, so as to permit free passage of the unit therethrough as it is now moved lengthwise into the tank. After coupling member 82' and angle member 30' have entered the tank, the heating unit is shifted slightly crosswise of opening 21 to permit free passage therethrough of angle member 29' as the lengthwise insertion movement of the unit is continued.

Lengthwise movement of the unit into the tank is completed as front plate 18 abuts against the front of the tank. With the holes for rivets 22 in front plate 18 and the corresponding holes in tank wall 7 in vertical alinement with each other and header bottom 53 vertically alined with lugs 64, the heating unit is now lowered into its final operative position on the bottom of the tank so as to bring all of the holes for rivets 22 into registry and also locate header bottom 53 between lugs 64. This lowering movement is permitted by slots 32', 33' of the heating unit slipping over the lower edge of tank opening 21 and by proper operating clearance between lugs 64 and header bottom 53. It is important that the arrangement and proportioning of the parts are such that, when all of the holes for rivets 22 are in registry and header bottom 53 is in position between lugs 64, coupling member 82' on the heating unit is in position for registry with coupling member 82'' on delivery pipe 83. The general direction of insertion of the elongated heating unit into the tank is lengthwise of the unit and at right angles to tank wall 7, thereby facilitating location of the unit in its final operative position normal to tank wall 7.

Rivets 22 are now put in place in front plate

18 and angles 29', 30', welded to the tank bottom to rigidly secure the unit in place. Pipe coupling 82 is secured by bolts 86 to connect up the oil delivery line. Riser tube 90 is inserted in tank opening 91 and welded at 90' to riser tube 89. Valve 62, with cover 95 mounted on its stem, is then inserted into riser chamber 93 in open position and the cover secured as heretofore described.

The steam inlet connection is made by locating inlet pipe 76 in opening 75' in the tank and opening 76' in shell 14 and mounting coupling sleeve 114 and swiveled collar 115 thereon. The pipe is then secured in proper position at tank opening 75' and union coupling 75 made tight with its elbow 113 by means of collar 115. Similarly, the steam exhaust connection is made by locating pipe 79 in tank opening 79' and mounting coupling sleeve 114 and swivel collar 115 thereon, whereupon the pipe is secured in proper position at opening 79' and union coupling 78 made tight with its elbow 113 by means of collar 115. As soon as inspection cover 19 is secured in place and valve 62 closed, the apparatus is ready to be filled with fuel oil and put into operation as previously described.

The described arrangement of the hot oil delivery line 80 and the steam inlet and outlet lines and their separable couplings provides maximum simplicity and compactness in these parts of the apparatus and, as is evident, greatly facilitates installation of the heating unit and removal or re-insertion of drum element 16.

Although the improved heat exchange apparatus has been described particularly with reference to the heating of fuel oil in the supply tank 6 by means of steam passing through drum element 16, it will be understood that the apparatus may be used for transferring heat from any desired fluid in the drum to any desired substance in the tank; also that my improvements are not to be regarded as limited to the details of construction described, since various modifications thereof obviously may be made within the scope of the invention as defined by the appended claims.

What is claimed is:

1. Heat exchange apparatus comprising a tank having a wall provided with a heating unit receiving opening; a heating unit secured and sealed at its outer end in said opening and extending into said tank, said heating unit including a drum having spaced tube sheets fixed therein, a plurality of tubes fixedly mounted in and between said tube sheets, and a stationary outlet header at the inner end of the unit, said drum being fixedly secured to the unit at the outer end of the drum and mounted in and slidably connected with the stationary header at the inner end of the drum to permit free lengthwise expansion and contraction of both the drum and the tubes, the tubes communicating with the tank at the outer end of the drum and opening into the header at the inner end of the drum; a fluid outlet connection extending from said header to the exterior of the tank; and fluid inlet and outlet connections extending from the interior of the drum to the exterior of the tank.

2. The combination in heat exchange apparatus of a drum element comprising a drum having fixed closed ends and an inlet and an outlet for the passage of a heating fluid therethrough, and at least one open-ended tube fixedly mounted in and between said drum ends for passage therethrough of a fluid to be heated; a stationary outlet header having an opening therein and a heated-fluid outlet; and stationary supporting means, said drum element being fixedly secured to said supporting means at one end of the drum and slidably mounted at the opposite end of the drum in said opening in the stationary header to permit free lengthwise expansion and contraction of the drum element including both the drum and the open-ended tube, one end of said tube being adapted to receive the fluid to be heated and the other end communicating with said header to discharge heated fluid therein.

3. The combination as claimed in claim 2, in which releasable means are provided for securing said drum element to said supporting means, whereby release of said securing means renders the drum element free for lengthwise withdrawal as a unit from said opening in the stationary header and its removal as a unit from the supporting means without disturbing the stationary header or the supporting means.

4. The combination as claimed in claim 2, in which releasable means are provided for securing said drum element to said supporting means; and wherein fluid conductors having releasable couplings are mounted in the apparatus and connected to said drum inlet and said drum outlet, whereby to render the drum element free for removal upon release of said securing means and said couplings, said releasable securing means and said couplings constituting the only positive connections between the drum element and the remainder of the apparatus.

5. The combination as claimed in claim 2, wherein a housing is provided in which the drum element, the header and the stationary supporting means are mounted, said housing having an inspection opening through which said drum element may be removed and a removable cover for said opening; wherein releasable means are provided for securing said drum element to said supporting means; and wherein fluid conductors having releasable couplings are mounted in the apparatus and connected to said drum inlet and said drum outlet, whereby to render the drum element free for removal through said inspection opening upon removal of said cover and release of said securing means and said couplings.

6. The combination as claimed in claim 2, wherein a housing is provided in which the drum element, the stationary header and the stationary supporting means are entirely located and mounted, said housing having an inspection opening from which said drum is spaced and through which said drum element may be inspected or removed as a unit; and wherein releasable means are provided for securing said drum element to said supporting means, whereby release of said securing means renders the drum element free for lengthwise withdrawal as a unit from said opening in the stationary header and its removal as a unit from the supporting means and through the inspection opening without disturbing the stationary header or the supporting means.

7. A heating unit adapted to be inserted into a fluid receptacle through an opening in a wall thereof, said heating unit comprising mounting means on the outer end of the unit adapted for attachment to said wall to secure and seal the outer end of the unit in said receptacle opening; a drum element which includes a drum having fixed closed ends and an inlet and an outlet for the passage of a heating fluid therethrough, and at least one open-ended tube fixedly mounted in

and between said drum ends for passage therethrough of a fluid to be heated; a stationary outlet header mounted in the inner end of the heating unit and having a heated fluid outlet; and stationary supporting means at the outer end of said unit, said drum element being fixedly secured to said supporting means at the outer end of the drum and mounted in and slidably connected with the stationary header at the inner end of the drum to permit free lengthwise expansion and contraction of the drum element including both the drum and the open-ended tube therein, one end of said tube being adapted to receive from the receptacle the fluid to be heated and the other end communicating with the header for discharge of heated fluid therein.

8. A heating unit as claimed in claim 7 wherein said means for attaching the unit to the receptacle wall comprises a plate having an inspection opening therein through which said drum element may be removed; and wherein releasable means are provided for securing the drum element to said supporting means, whereby to render the drum element free for removal through said inspection opening upon release of said securing means.

9. A heating unit adapted to be inserted into a fluid receptacle through an opening in a wall thereof, said unit comprising an elongated shell open at its inner end to receive fluid to be heated; means on the outer end of said shell adapted for attachment to said wall to secure and seal the outer end of the unit in said receptacle opening; an outlet header mounted in said shell at the inner end thereof and having a heated fluid outlet; and a drum element mounted in said shell with its outer end spaced from the outer end of the unit to form a chamber and its inner end supported in the header, said drum element including a drum having spaced tube sheets, a heating fluid inlet and a heating fluid outlet and a plurality of open-ended tubes mounted in and between said tube sheets, the header and the drum being spaced from the shell to form a fluid passage communicating with the inner end of the shell and said chamber, and said tubes communicating with said chamber and the header.

10. Heat exchange apparatus comprising a fluid receptacle having an opening in a wall thereof; a heating unit located in the receptacle with its outer end secured in said wall opening so as to close and seal the opening, said heating unit comprising an elongated shell communicating at its inner end with the receptacle, an outlet header mounted in said shell at its inner end, and a drum element which includes a drum having spaced tube sheets and a plurality of open-ended tubes mounted in and between said tube sheets, said drum element being mounted in said shell with its outer end spaced from the outer end of the unit to form a chamber and its inner end supported in the header, the header and the drum being spaced from the shell to form a fluid passage communicating with the inner end of the shell and said chamber, and the tubes communicating with said chamber and the header; a heated fluid connection extending from the header to the outside of the receptacle; and inlet and outlet heating fluid connections extending from the drum to the outside of the receptacle.

11. Heat exchange apparatus comprising a fluid receptacle having a wall; an elongated shell mounted in the receptacle, said shell being closed at its outer end by said receptacle wall and open at its inner end to receive fluid from the receptacle; an outlet header mounted in the inner end of the shell and having a heated fluid connection extending to the exterior of the receptacle; and a drum having spaced tube sheets, a plurality of tubes mounted in said sheets and heating fluid inlet and outlet connections extending to the exterior of the receptacle, said drum being mounted in the shell with its outer end spaced from said wall to form a chamber and its inner end supported in the header, the header and the drum being spaced from the shell to form a fluid passage communicating with the inner end of the shell and said chamber, and the tubes communicating with said chamber and the header.

12. Heat exchange apparatus comprising a receptacle; a stationary outlet header mounted in the receptacle, said header having a discharge port and a fluid delivery line extending to the exterior of the receptacle; and a drum in the receptacle having spaced and fixed tube sheets, a plurality of tubes mounted in said sheets and heating fluid inlet and outlet connections extending to the exterior of the receptacle, said drum being mounted in the receptacle with one end of the drum supported in the header, the tubes opening into the header at said end of the drum and communicating with the receptacle at the opposite end of the drum.

13. Heat exchange apparatus as claimed in claim 12 wherein a valve is provided for said header discharge port, and actuating means, controlled externally of the receptacle, are provided for opening and closing said valve.

14. Heat exchange apparatus as claimed in claim 12 wherein a quick-acting reciprocatory valve is provided for said discharge port; and wherein actuating means, controlled externally of the receptacle, are provided for opening and closing said valve, said actuating means comprising a valve stem mounted for reciprocation in a wall of the receptacle and adapted for manual operation to open the valve; spring means constantly urging the valve towards closed position; and readily releasable means for holding the valve in open position against the action of the spring means, whereby said spring means operate immediately upon release of the holding means to tightly close the valve.

15. Heat exchange apparatus comprising a tank adapted to receive a fluid; an outlet header mounted in said tank, said header having a discharge port and a fluid delivery line extending to the exterior of the tank; a drum in the tank having spaced tube sheets, a plurality of tubes mounted in said sheets and heating fluid inlet and outlet connections extending to the exterior of the tank, said drum being mounted in the tank with one end thereof supported in the header, the tubes communicating with the tank to receive fluid therefrom and opening into the header to discharge heated fluid therein; and fluid expansion and vent means providing continuous communication between the interior of the header and the space in the tank above the normal maximum fluid level therein.

16. Heat exchange apparatus as claimed in claim 15 wherein the tank has an opening in its top wall, a detachable cover closes and seals said opening, and said expansion and vent means comprise an upright riser tube connected to the upper portion of the header; and wherein a valve is provided for said header discharge port, and

actuating means mounted on said cover and controlled externally of the tank are provided for opening and closing the valve, said actuating means extending into the header through the riser tube and being removable with the valve and the cover when the cover is detached from the tank.

17. The combination in heat exchange apparatus of a fluid receptacle having an inspection opening in a wall thereof; a removable cover for said opening; a stationary outlet header mounted in the recetacle and having a drum-receiving opening; a heated fluid outlet connection extending from the header to the outside of the receptacle; a horizontal drum having spaced tube sheets and a plurality of open-ended tubes mounted in said tube sheets, said drum being removably mounted at one end in said drum-receiving opening in the header, the tubes communicating with the receptacle at the outer end of the drum to receive therefrom a fluid to be heated and opening into the header at the opposite end of the drum; stationary means mounted in the receptacle for supporting the outer portion of the drum; releasable means for securing the drum to said supporting means; and releasable heating fluid inlet and outlet connections extending from the drum to the outside of the receptacle, whereby to render the drum free for removal through said inspection opening upon removal of said cover and release of said securing means and said inlet and outlet connections to the drum.

18. Heat exchange apparatus as claimed in claim 17 wherein said stationary supporting means comprise a transverse saddle supporting the outer end of the drum and to which the drum is anchored by said securing means, and a pair of spaced elongated members extending between and supported by the saddle and the header, said members having drum supporting and guiding surfaces alined with the drum-receiving opening in the header, whereby said members support the drum during removal thereof and guide the drum into said opening in the header when the drum is replaced.

19. Heat exchange apparatus comprising a tank adapted to receive a fluid to be heated and having an opening in an upright wall thereof; a horizontally-elongated heating unit located in the tank with its outer end secured in said opening so as to close and seal the opening, said heating unit resting on the tank bottom and comprising an elongated shell communicating at its inner end with the tank, a strainer covering the inner end of the shell, an upright end plate with an inspection opening therein mounted on the shell and attached to said wall to secure and seal the outer end of the unit in said tank opening, a removable cover for said inspection opening, an outlet header mounted in said shell at its inner end, drum supporting means in the outer end of the shell, and a heat-exchanger drum having spaced tube sheets and a plurality of open-ended tubes mounted in said tube sheets, said drum being mounted in the shell with its inner and supported in the header and its outer end anchored to said supporting means and spaced from the outer end of the unit to form a chamber, the header and the drum being spaced from the shell to form a fluid passage communicating with the inner end of the shell and said chamber, and the tubes communicating with said chamber and the header; a heated fluid connection extending from the header to the outside of the tank; and inlet and outlet heating fluid connections extending from the drum to the outside of the tank.

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