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TANK CAR HEATING SYSTEM

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FIG. 3.

FIG. 4.

FIG. 5.
ABSTRACT OF THE DISCLOSURE

A heating system and method of melting partially solidified lading in a railway tank car or the like. System includes external heating complex on tank outer surface which melts lading crust at tank inner surface to form liquid film. Internal fin is also heated and melts through crust to place molten core and film in communication and greatly hasten complete liquification of lading.

This invention relates in general to tank cars. It deals more particularly with a system and method for melting partially solidified lading in a tank car to facilitate removal of the lading.

Railway tank cars are employed to transport various products having widely varying physical and chemical characteristics. Some of these products present few problems in handling, while others are more difficult. The present invention is concerned with the handling of products which are solid or semi-solid at normal ambient temperatures and must be melted for introduction to and removal from a tank car.

It is conventional to transport sulfur, for example, by tank car in its molten state. More precisely, it is conventional to introduce sulfur to a tank car in its molten state, after which the liquid sulfur solidifies to a greater or lesser extent against the cooler tank wall while being transported, depending upon time en route and ambient air temperature. When the sulfur reaches its destination, a relatively thick, solid crust has formed on the inner surface of the tank. A molten core remains inside the crust.

The solidified sulfur must be melted before it can be removed from the tank car. To this end, it is now a well known expedient to employ an outside heater system on the tank car to melt the solid sulfur. Steam is passed through a relatively dense conduit system secured to the outer surface of the tank and the heat released from the steam begins to melt the sulfur crust. A liquid sulfur film forms and gradually increases in thickness on the tank's inner surface. The solid sulfur crust acts as an excellent insulator, however, and transmission of heat to the liquid core is greatly impeded. The crust melts slowly.

As the heating process continues, the liquid film becomes thicker and the ring of solid sulfur loses some of its structural strength. The solid ring of sulfur, being supported primarily from its opposite ends at the tank heads, begins to sag at the center of the tank, generating liquid circulation from the bottom to the top of the tank. Finally, the solid sulfur ring breaks up and circulation is established between the liquid film and the liquid core. This accelerates the melting process.

The aforesaid system is eventually effective to completely melt the partially solidified sulfur. However, it may require up to 48 hours to melt the crust with normal steam pressure in the heater conduits. This considerable steaming time increases shipping costs as well as delaying delivery.

It is an object of the present invention to provide a greatly improved system and method for melting a partially solidified tank car lading such as liquid sulfur or the like. The invention contemplates a horizontally elongated cylindrical tank having substantially less dense external heating complex disposed on its outer surface. Inside the tank, longitudinally extending fin means are provided generally co-extensive with a heating conduit or conduits extending along the base of the tank. The conduit or conduits at the base of the tank are also preferably inside the tank.

When liquid sulfur is introduced to the tank, the liquid sulfur immediately begins to solidify at the inner surface of the tank, forming a crust. The crust thickens as additional sulfur solidifies while heat is dissipated during transport of the lading.

The internal fin means is constructed and arranged so that it extends upwardly from the base of the tank through this crust. When the tank reaches its destination, heat is applied to the tank through the aforementioned external heating complex by introducing steam to the complex, for example. At the same time, steam is passed through the internal conduit. The crust of solidified sulfur begins to melt at the inner surface of the tank and a film of liquid sulfur forms at the surface. At the same time, the heat dissipated through the fin or fins is effective to almost immediately melt through the ring of sulfur to its molten core, thus splitting the ring at the fin or fins. Circulation is established between the large liquid core at the center of the tank and the thin liquid film against the tank inner surface. This dynamic action promotes heat transmission by convection to the exposed inner surfaces of the solidified crust of sulfur lading.

As this process continues, the thickness of the liquid film against the tank inner surface and fin rapidly increases, and the structural strength of the solid sulfur, in a split ring configuration, decreases until it can no longer support itself. The solid sulfur begins to act as a beam generally supported at opposite tank heads with large deflections at the center of the tank. This movement induces an additional liquid circulation from the bottom to the top of the tank, which speeds up the melting process and shortly thereafter the "split-ring" of sulfur crust disintegrates. The melting now proceeds more rapidly as the chunks of sulfur sink to the bottom of the tank where the heat source is concentrated and the hot liquid sulfur rises to the top of the tank.

In another aspect of the invention, a fin or fins is provided along the roof of the tank, co-extensive with a longitudinally extending conduit which may be disposed on the inner surface of the tank or may be mounted on its outer surface. The fin or fins along the roof of the tank function in a manner identical to the fin or fins along the base of the tank, almost immediately melting through the crust of solidified sulfur to create another split in the ring. The ring of sulfur is thus virtually divided into two parts and melting and disintegration of the solidified crust takes place at an even faster rate.

The invention, together with its construction and method of operation, taken with other objects and advantages thereof, is illustrated more or less diagrammatically in the drawings, in which:

FIGURE 1 is a diagrammatic side elevational view of a heating system embodying features of the present invention, mounted in place on the top of a conventional insulated railway tank car, with the tank illustrated in phantom lines;

FIGURE 2 is a sectional view taken along line 2--2 of FIGURE 1;

FIGURE 3 is a sectional view taken along line 3--3 of FIGURE 1;

FIGURE 4 is a view taken along line 4--4 of FIGURE 1; and

FIGURE 5 is a view similar to FIGURE 3 illustrating a modified form of the heating system shown in FIGURES 1-4.
Referring now to the drawings, and particularly to FIGURE 1, a broadly conventional structural inner tank for a railroad tank car is illustrated generally at 10. The tank 10 comprises a cylindrical body section 11 fabricated of steel plate or the like. A concave head section 12 is welded over each end of the body section 11. The tank 10 is adapted to receive a liquid lading through the manway 15 on the roof of the tank. An unloading fixture 16 on the base of the tank 10 is provided for draining liquid lading from the tank. A siphon and valve nozzle arrangement 17 also on top of the tank 10 can also be used.

Mounted on the tank 10 is a heating system 20 embodying features of the present invention. The heating system 20 includes an external conduit complex 22 and an internal conduit and fin assembly 24. The tank 10 and system 20 are normally encased in insulating material and covered with an outer skin, but for ease of illustration and description of the invention, the insulating material and skin are not shown. The tank 10 is supported from conventional railroad trucks (not shown) in a well known manner.

The heating system 20 is designed, according to the invention, to rapidly melt a liquid lading which has partially solidified in transit. For purposes of illustration the lading described is sulfur which has a melting point of 112.8 degrees centigrade. It should be understood, however, that numerous materials which might be transported in tank cars also solidify at normal ambient temperatures and, accordingly, require a heating system of one type or another to melt any portion which might have solidified before the lading has reached its destination. Such products include paraffins, naphthenale, phthalic anhydride, and many others.

In the present example, the sulfur lading is first melted for introduction to the tank 10 through its inlet facility 15. Immediately upon contact with the inner surface 26 of the tank 10, the sulfur begins forming a crust on the inner surface, since the ambient temperature is necessarily considerably less than 112.8 degrees C. As the crust thickens, however, it acts as more of an insulator and the rate of solidification decreases. As a result, an extensive core of molten sulfur normally remains at the center of the tank when it arrives at its destination. When the tank 10 reaches its destination, the solidified sulfur crust must be melted. The heating system 20 embodying features of the invention melts this crust at a substantially greater rate than heretofore possible with heating systems of a broadly similar nature.

The external conduit complex of the system 20 comprises a plurality of horizontal steam conduits 30 secured to the outer surface 31 of the tank 10. Each of the conduits 30 is a half-circular pipe, as best seen in FIGURES 3 and 4, with its free edges welded to the outer surface 31 of the tank.

The horizontal conduits 30 are spaced circumferentially on the surface 31 of the tank 10. Four of these conduits 30 are grouped on the base of the tank 10 on the opposite side of the center line CL. The remainder of the conduits 30 are more widely spaced around the side and top of the tank, with the conduit 30c disposed on the top center line CL. The significance of the positioning of these conduits 30 circumferentially of the tank 10 will hereinafter be discussed.

At opposite ends of the tank 10, where corresponding ends of the conduits 30 terminate, circumferentially extending headers 35 interconnect the conduits. The headers 35 (and all header sections hereinafter referred to) comprise channel members into which the corresponding ends of the conduits 30 extend. The free edges of the channel member headers 35 are welded to the outer surface 31 of the tank 10.

Intermediate the opposite ends of the tank 10 a short circumferential section 37 interconnects adjacent inner ends of one-half section of the conduit 30c and a half section of one of the bracketing conduits 30a alongside the conduit 30c. Also on the roof of the tank, adjacent its center line CL, a conventional valve housing 39 is mounted. The siphon and valve nozzle arrangement 17 in this housing 39, the inner end of the other half section of the conduit 30c and the inner end of a half section of the other bracketing conduit 30a are connected by pipes 40 into the valve housing 39 where suitable means are provided to passing the steam through the valve housing 39.

At the base of the tank 10, the inner ends of half sections of the lowermost conduit 30b are joined by short circumferential conduit sections 44 to inlet and drain pipes 46 and 47 on the center line CL of the tank 10. Similarly, short circumferential conduit sections 50 connect the inner ends of half sections of the lowermost conduit 30a to a pipe assembly 54 and an inlet pipe 55, and an outlet pipe 56. The pipe assembly 54 actually forms a collar around the outlet fitting 16 for the steaming of the lading in this critical area.

Referring now also to FIGURE 2, inside the tank 10 are provided two conduit sections 64 and 65. Each conduit section 64 and 65 extends slightly less than one-half the length of the tank 10. The conduit sections 64 and 65 are in alignment with each other longitudinally of the tank 10 on the center line CL of the base of the tank. Once again, each conduit 64 and 65 comprises a half oval having its free edges welded to the inner surface 26 of the tank.

The outer free ends of each of these internal conduits 64 and 65 have short, circumferentially extending conduit sections 69 connected thereto. The conduit sections 69 are connected in a suitable manner through the tank 10 to the adjacent headers 35 on the outer surface 31 of the tank 10.

Adjacent to its inner end, the internal conduit 65 is connected through the tank 10 to the external conduit section 44 and, consequently, to the inlet pipe 46. At the same time, the inner end of the internal conduit 64 is connected through the tank 10 to the conduit section 50, and, accordingly, to the pipe assembly 54 and the inlet pipe 55.

Mounted on top of each inverted, half-oval conduit 64 and 65, and co-extensive longitudinally with it, is a vertical heat transfer fin 70. As seen in FIGURE 4, each of the fins 70 extends over and is welded to the upper surface of a corresponding circumferential internal short conduit section 64 or 65.

Each fin 70 is fabricated of a highly conductive alloy and extends approximately seven inches up from a corresponding conduit 64, 65 in the present illustration. Since the height of the conduits 64 and 65 is approximately two inches, the overall height of the fin 70 from the inner surface 26 at the bottom center line of the tank 10 is approximately nine inches. For reasons hereinafter discussed, the overall height of the fin 70 may vary in various applications of the invention.

The heating system 20 embodying features of the invention has now been described in detail as to its construction. The operation of the system 20 is best understood by considering the hypothetical situation wherein the tank 10 is being used to transport sulfur.

To transport sulfur in a tank car 10 in a well-known manner, the sulfur is first liquified and introduced into the tank, as has been pointed out. As soon as the liquid sulfur contacts the relatively cooler inner surface 26 of the tank, a crust of solidified sulfur begins to form at this surface. As the tank 10 proceeds to its destination, additional liquid sulfur continues to solidify and the crust thickens. Since the crust itself acts as an insulator, the rate at which the solidification of the sulfur decreases rapidly with time, however, and a substantially extensive core of molten sulfur remains for a considerable period of time.

It has been found from experience that the crust of solidified sulfur normally does not become more than six or seven inches thick in average to average-cold climates;
taking normal maximum trip times into consideration. Accordingly, the fin 70 virtually always extends upwardly into the molten core of sulfur when the tank has reached its destination. Where extreme cold is normally encountered, the height of the fins 70 can be appropriately extended to accommodate thicker crusts. When the fins 70 are extended upwardly, however, heat transfer is limited substantially. Accordingly, it is within the purview of the invention to actually segment the fin in a horizontal plane and introduce a steam conduit pipe between upper and lower fin segments. Steam passed through this conduit pipe greatly enhances a tall fin's melting capability.

When the tank car gets to its destination, steam is introduced through the pipes 46 and 55 and courses up through the conduit sections 44 and 50, then into the internal conduits 64 and 65 and also into the lowermost half oval conduits 30a and 30b. The steam then courses through these conduits toward the heads 12 of the tank 10 and the headers 35, where it then passes upwardly and divides itself, supplying steam to all the remaining conduits 30, the three upper conduits 30a and 30b, and conduit 30c. Steam, and condensate as it forms, flows through respective conduits towards the opposite end of the tank, down through the headers 35 and back towards the center of the tank through the lowermost half oval conduits 30a and 30b to the conduit sections 44 and 50 and then to the outlet pipes 47 and 56. It is interesting to note at this point that each of the conduits is a split complex. The complex 22 on opposite sides of the tank 10 is actually fed with steam and drained of condensate through separate pipes so that a leak on one side will not incapacitate the entire complex.

The steam passing through the external conduits 30 and 35 immediately melts the solidified sulfur at the inner surface 26 of the tank 10, except on the heads 12, and forms a thin film of molten sulfur at this surface. At the same time, the heat transfer fin 70, being supplied with heat from the corresponding conduits 64 and 65 inside tank 10 melts through the "ring" of solidified sulfur crust to form what is, in fact, a "split-ring." The molten core of sulfur is thus placed in communication with the thickening film of molten sulfur at the surface 26 of the tank. A circulation path is established between the large liquid core at the center of the tank and the thin liquid film surface 26. This dynamic circulation action promotes heat transmission by convection to the exposed solidified surfaces of the lading.

As this process continues, the thickness of the liquid film against the tank surface 26 rapidly increases. The structural strength of the split ring sulfur crust decreases until it can no longer support itself. The solid sulfur begins to act as a beam supported at the opposite heads 12 of the tank, and a large deflection of the beam occurs at the center of the tank. This deflection induces additional liquid sulfur circulation from the bottom of the tank to the top thereof, thus speeding up the melting process. Soon the entire split ring shell or crust of sulfur disintegrates and chunks of sulfur sink to the bottom of the tank where the heat source is concentrated and they are quickly melted.

Referring now to FIGURE 5, a modified form of the heating system embodying features of the present invention is illustrated generally at 120. The heating system 120 is identical in the system 20 hereinbefore discussed in all respects except for the additional provision of a roof fin 170 or fins (only one shown) mounted on the inner surface 26 of the tank 10.

The roof fins 170 comprise a pair of longitudinally continuous fins welded to the inner surface 26 of the roof of the tank 10 in the centerplane 20 hereinbefore discussed. The fins 170 are disposed directly under the roof centerline conduits 30c so that heat from the steam in the conduits 30c dissipates to the lading crust through the fins 170 as well as through the tank wall to its inner surface 26. The fin or fins 170 function in a manner identical to the fins 70, as has been pointed out. They immediately melt through the crust of solidified sulfur to cause another split in the crust ring. Additional liquid circulation is effected and melting of the crust takes place at an even faster rate.

The constructions of the heating systems 20 and 120 have now been described in detail. Similarly, their operation and method of the invention have been thoroughly discussed. It should now be recognized that a partially solidified lading such as sulfur or the like can be melted and dispensed faster than heretofore considered possible with heating equipment of comparable complexity. On the other hand, it is possible to eliminate a substantial segment of an external heating complex, for example, and obtain comparable melting times.

It is the positioning of the conduits 30, 64 and 65, and the fins 70 (and 170) which contribute to this high rate of melting. The arrangement of the conduits 30a and 30b at the bottom of the tank 10 assures rapid melting of lading chunks which fall to the bottom. The arrangements of the fins 70 and 170 assure that the lading crust breaks up rapidly into chunks.

The invention has been described in terms of a steam heated fin or fins internally of the tank 10. It is, however, also contemplated that electrically heated fins might be employed, or even some other heating medium. It is important only that heat be dissipated through the fins 70 and 170 at a sufficient rate to melt through a lading crust quickly.

While several embodiments described herein are at present considered to be preferred, it is understood that various modifications and improvements may be made therein, and it is intended to cover in the appended claims all such modifications and improvements as fall within the true spirit and scope of the invention.

What is desired to be claimed and secured by Letters Patent of the United States is:

1. A method of rapidly melting a lading such as sulfur or the like in the container of a tank car wherein the lading has partially solidified so as to define a solid outer crust with a molten inner core, comprising the steps of: (a) generally applying heat around the outer surface of the container to melt the lading within the container at the inner surface of the container and form a film of melted lading at this inner surface, and (b) applying concentrated heat to the still solid crust, which is separated from the inner surface of the container by the film, along a longitudinally extending line at the base of the container for substantially the length of the container to melt through the crust at this line and place the inner core of molten sulfur and outer film in communication.

2. The method of claim 1 further characterized by including the step of: (a) applying concentrated heat to the still solid crust, which is separated from the inner surface of the container by the film of melt, along a longitudinally extending line at the roof of the container for substantially the length of the container to also melt through the crust and place said molten inner core in additional communication with said film.

3. In a tank car including an elongated cylindrical tank, the improvement in a heating system for rapidly melting a partially solidified lading such as sulfur or the like, comprising: (a) means secured to the outer surface of said tank and adapted to carry a heating medium to apply heat generally completely around said outer surface for melting the solidified lading within the tank and form a film of melted lading around said inner surface, (b) conduct means inside said tank extending longitudinally along the base of the tank for substantially
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7. the length of the tank, said conduit means being adapted to carry a heating medium,
(c) longitudinally extending fin means on said conduit means along the base of the tank for substantially the length of the tank and extending radially inwardly of said tank inner surface,
(d) said fin means adapted to apply concentrated heat to the solid lading along a longitudinally extending line at the base of the tank for substantially the length of the tank to melt through the lading along this line.

4. The improvement in heating system of claim 3 further characterized in that:
(a) said conduit means is secured directly to the inner surface of said tank,
(b) said fin means being mounted on said conduit means and extending radially inwardly therefrom.

5. The improvement in heating system of claim 4 further characterized by and including:

8. (a) other conduit means inside said tank extending longitudinally along the roof of said tank for substantially the length of the tank, said other conduit means being adapted to carry a heating medium, and
(b) fin means on said other conduit means extending radially inwardly of said tank inner surface.

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