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(54) **Title**: METHOD AND SYSTEM FOR DISCHARGING FLEXITANK VISCOUS MATERIAL

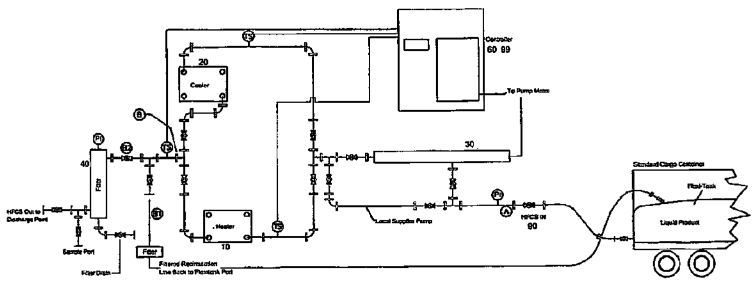

FIG 1

(57) **Abstract**: A discharge system that includes a flexitank having product stored therein and a discharge port. The discharge port is selectively fluidly connected to a first heat exchanger input port. The first heat exchanger has an outlet port that is in selective communication with the flexitank. The first heat exchanger is selectively connected to a source of heat or a coolant.

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METHOD AND SYSTEM FOR DISCHARGING FLEXITANK VISCOUS MATERIAL

Background

Viscous materials, such as syrups, vegetable oils, mineral oils, fruit mashes and juices, and pepper mash, are often transported via a large flexible bladder bag, commonly referred to as a flexitank. General descriptions of flexitanks are included in WO 2001070598, WO 1998013276 A1 and U.S. publication US 20100122981, all incorporated by reference. These filled bladders are often shipped via intermodal containers or shipping containers. The flexitank usually has a sealable input port and a sealable outlet port, but the input and outlet port may be combined. Some flexitanks include additional ports, for instance, aeration ports.

During the course of transport, portions of the contents in the flexitank may settle or precipitate out of solution, or develop crystals that are undesired in the finished product, or, due to ambient temperatures, increase in viscosity and become more difficult to handle and discharge upon arrival at the destination. On arrival at the destination, the contents are removed from the flexitank. This generally entails opening the intermodal container (a metal box surrounding the flexitank), attaching a discharge hose to the outlet port, and discharging the materials, either by gravity flow or with the assistance of a pump.

For materials that precipitate, crystalize, solidify or settle out, a non-flowable or slow flowable layer may be present near the discharge port, making removal of the materials difficult. Several processes have been developed to deal with this non-flowable or slow flowable layer. The techniques or processes involve either mixing the materials in the flexitank with a mixer (air injection) or heating the materials in the flexitank. One heating technique is to place a heating pad underneath the flexitank prior to loading. At the discharge facility, heated fluids are flowed through the heater pad, thereby transferring heat to the material via conduction. <u>See</u> U.S. patent number 5,884,814, hereby incorporated by reference. A second method is to insert a heat exchanging surface (a heated probe) into the interior of the container via injection ports positioned on the top of a flexitank, to directly heat the materials by contact with the heated probe. <u>See</u> U.S. patent number, 8,746,328 issued to the Applicant of this Patent Application, hereby incorporated by reference. A variation of use of a heating probe is disclosed in U.S. patent number 8,734,005, hereby incorporated by reference, where a heating probe (a heat exchanging surface) is positioned within the interior of the flexitank through the outlet of the flexitank prior to filling of the flexitank. At the discharge site, heated fluid is circulated through the heating probe, and the heated materials are discharged though an opening in the heating probe.

Each of the above solutions has limitations; heat transfer from the heating blanket into the contents of the flexitank is very slow and inherently inefficient, and while the use of heating probes in the interior raises the material temperature faster, putting probes in the interior of the flexitank is problematic. For viscous material that form crystals, but remain flowable, such as high fructose corn syrups, the above methods are inefficient.

A more efficient process and system is needed to transfer heat to the fluid materials in the flexitank.

Description of the Drawings

Figure 1 is a schematic showing one embodiment of the invention.

Figure 2 is the schematic of figure 1 showing flow paths for recirculation only.

Figure 3 is the schematic of figure 1 showing flow paths for heat and discharge.

Figure 4 is the schematic of figure 1 showing flow paths for heat, partial recirculation, partial discharge.

Figure 5 is the schematic of figure 1 showing flow paths for cooling and discharge.

Figure 6 is the schematic of figure 1 showing flow paths for heat, then cool, then discharge.

Figure 7 is a schematic showing one embodiment of a flexitank for use with the heating system.

Figure 8 is a schematic showing flow paths using a single heat exchanger to perform both heating and cooling functions.

Detailed Description of the Invention

The invention preferably is constructed or designed as a self-contained skid mounted discharge system for portability. External supplies for a self-contained discharge system can include external power, a source of heated fluid, and a source of chilled or cooled fluid. Alternatively, a portable steam generator can be included for use with the heat exchanger. One embodiment of the invention is shown in schematic form in figure 1, and includes a first heat exchanger 10, a second heat exchanger 20, a pump 30, a filter 40, and a control unit 60. Various valves and sensors are also indicated (TS=temperature sensor; PI=pressure sensor) preferably each communicating with the control unit 60. The valves may be operated via the control unit controller (if electrically controlled valves), or manually operated. Flow lines are also shown. Pump 30 may be skid mounted or supplied at the discharge facility. Multiple pumps may be used in the system, but this is not preferred as it adds to the complexity of the system. The skid is generally a portable platform, for instance, a platform that can be moved with a fork lift.

A first flow line A is connected to the discharge valve of the flexitank (not shown) to a pump 30. When the pump 30 is activated (preferred pumps may be sanitary pumps), the product exits the flexitank, flows through the pump and may be directed to first heat exchanger 10, or second heat exchanger 20, by operation of the appropriate valves. As shown, the pump 30 is located prior to the heat exchangers, but the pump could be located after the heat exchangers. Heat exchanger 10 is intended to raise the temperature of the input product (when operational), while heat exchanger 20 is intended to lower the temperature of the input product when operational (heat exchanger 20 is a cooler). For low heat transference exchangers, each exchanger could be a plurality of exchangers in series. The efficiency of heat transference of the system can be modified by changing the temperature of the heating fluids (heated water or steam, for instance) or the pressure (and hence, rate of flow) of the heating fluid through the heat exchanger, or the product flow rates though the exchangers (for instance, by modifying the pump rate).

When the system is first started up, product will flow from the flexitank, through heat exchanger 10, to raise the temperature of the product. Exiting the heat exchanger 10, product can be directed to the second heat exchanger cooler 20, or to line B (or to both). Cooler 20 can be used with a cooling fluid, such as water or chilled water, for instance. Line B leads to two flow paths, line B1, which is a recirculation line, and line B2, which is connected to the discharge line C. Line B2, the recirculation line, is a flow line that connects back to the flexitank, such as through a flowline that attaches to a flexitank inlet port, or flexitank mixing port, or some other port on the flexitank. Preferably, the recirculation flowline attaches to the flexitank through a recirculation valve body located at a port on the top of the flexitank, at the end of the flexitank opposite the discharge valve. See figure 7. Preferably, the recirculation valve is positioned in the flexitank prior to the tank being filled. The purpose of the recirculation line is to allow heated product to be returned to the flexitank, to help raise the temperature of the product in the flexitank. One preferred flow path for recirculation is to pull from the discharge port (located near the bottom of the tank near the container doors) and send to the heat exchanger, and to recirculate heated fluids to the top end of flexitank near the closed end of the container. This recirculation path is preferred to more efficiently and evenly distribute heat throughout the product. The recirculation path could be reversed (e.g., pull from the top rear of the flexitank and recirculate to the front bottom). Other recirculation paths could be used depending on the particular flexitank construction and configuration. When the heating process is first started, recirculation may be the preferred first flow path, or alternatively partial recirculation and partial discharge. The flow path selected can depend, for instance, on the temperature of the product exiting the first heat exchanger 10, and the temperature of the product on exiting the flexitank (i.e., the flowable fluids temperature at the inlet of the heat exchanger) and the severity of crystallization or viscosity issues.

The recirculation line may be connected to the flexitank at the initial shipping point, and the filled flexitank shipped with a recirculation line in place for convenience. For instance, the terminal end of the recirculation line (the end remote from the recirculation port on the flexitank), may be positioned near the discharge point near the front of the flexitank (the "front" of the flexitank faces the doors of the shipping container) to allow ease of connection to the portable heat exchange system. In this instance, the recirculation valve may be placed in-line with the recirculation line and located near the front of the flexitank.

The goal is to preferably raise the temperature of the product to a desired first temperature reducing crystallization, viscosity, or both for discharge. For instance, one product often shipped in a flexitank is high fructose corn syrup (HFCS) such as HFCS 55 (approximately 55% fructose and 45% glucose), a material heavily used in the food and drink industries. Corn syrups, including HFCS 55, HFCS 42 (approximately 42% fructose and 58% glucose) and other variation, can form crystals within the fluid when the fluid cools and drops in temperature (during shipping, for instance). Crystals are not desired in the discharged HFCS product. One preferred temperature for discharge of HFCS 55 is about 98 degrees Fahrenheit. However, this temperature is not generally sufficiently high to melt or break corn syrup crystals. A temperature of about 120 degrees Fahrenheit is needed to quickly break large HFCS 55 crystals. However, raising the temperature of the HFCS to 120 degrees may adversely impact product coloration, for instance, causing yellowing of the HFCS product. While it is desirable to raise the temperature of the corn syrup to a temperature sufficient to melt the crystals, the temperature rise can be made to a less elevated temperature (for instance, to 105 degrees Fahrenheit) and maintained for a sufficiently long period to break or melt crystals over the extended period of time. That is, at a lower elevated temperature, it may take longer to fully melt entrained crystals. The desired temperature rise in the product will depend upon multiple factors, including the severity of crystallization, the type or size of crystals and the residence time (the length of time) the product will remain at an elevated temperature.

In the case of corn syrup, if the heat exchanger 10 has sufficient heat exchange efficiency, the product flowing out of the heater 10 may be at a temperature sufficient to melt entrained product crystals in a single pass. In this event, the heat exchanger 10 output product may be too hot for the preferred discharge temperature of 98 degrees Fahrenheit. Consequently, the product flow may be directed for recirculation, or to the cooling heat exchanger 20 for discharge, or a combination of recirculation and cooling/discharge. The selection to recirculate may be dependent on the product temperature entering the heat exchanger 10. For instance, if the inlet temperature is close to, or above the desired discharge temperature, then cooling only may be selected. If the inlet product temperature is far from the desired output temperature, then recirculation only may be desired. The selection will depend in part on the heat transference efficiency and product flow rates through the exchanger 10.

Other flow paths through the system are possible. For instance if the product needs to be maintained at a high temperature for a long residence time to break or dissolve crystals, then recirculation may be used until the product exiting the flexitank is at, or above the desired crystal breaking temperature. In this case, recirculation flows may be slowed or stopped, or continued with the heat exchanger 10 shut off. Flow could then be restarted after the needed residence time is achieved, with product then flowing through the cooler (with possible recirculation) if needed or desired, or directly to discharge. The combinations of heating, cooling and recirculation flows can be custom designed for the specific product. Several of many possible flow paths through the system embodiment of figure 1 are shown in figures 2-6. For instance, if the system is initially set to heat and recirculate the heated product, the system can be run in the heating/recirculation mode until the desired temperature (for instance, measured at the input to the heat exchanger) is achieved. The heating system can then be shut down and recirculation stopped, to let the product slowly cool to a lower temperature. This flow path allows the product to be maintained at an elevated temperature for an extended period of time. For instance, the HFCS product may be heated at a first location. When the desired temperature is reached, the heating system may be shut down and disconnected, and the intermodal container//flexitank, with heated product, may be transported to a second location for later discharge. That is, the product is not discharged through the system. Also shown in Figure 1, a filter is preferably positioned on the output line prior to product discharge, and an optional filter is placed in the recirculation line. For corn syrup product, a 50 micron sock filter has been utilized as this size filter will capture many HFCS product crystals. For the recirculation line recirculating heated product, crystals captured by a filter on the recirculation line will be exposed to additional heated product flowing over the captured crystals. This heated product provides additional opportunity to melt or break the filter captured crystals in an efficient manner. The surface area of the filter should be large enough to maintain flow through the system.

Also shown in figure 1 is a control system 99 that is in communication with various sensors, and contains an optional variable frequency drive to control the throughput of the pump. Control system may include a processor or PLC, and be in communication with various valves used in the system, and be able to automatically control valve position. For known product, the sequence desired (e.g., heat/recirculate/cool/discharge; or heat/recirculate/discharge, or heat/recirculate or other combination) can be determined in advance and coded into the controller. Decisions on when the controller should act to change the state of the system can be made based on sensor readings input to the controller (temperature, pressure, or pump rate) and/or prior stored recorded sensor readings (e.g., the history of the process for the particular flexitank). This allows the discharge process to be automated, using the known viscosity/temp characteristics of the product, and with sensors values input to the controller (e.g., temperatures and pressures), and can include modification of the pumping rate, the heating and cooling transference parameters based on a prior programmed sequence. For instance, when the heated product reached the desired temperature, the controller can be configured to shut down or deactivate the first heat exchanger 10. Alternatively, the controller could be configured to deactivate the heat exchanger, and operate valves to allow product to be discharged, or to shut down both the heat exchanger 10 and system pump, or other variations.

The system as described, can be used for a variety of products such as inks, oils, paints, and flowable foodstuffs (e.g., mashes, syrups, sweeteners, oils, fruit extracts, juices and wines). The system, as shown in figure 1, includes an alternate flow path to a separate pump, such as a pump located at the discharge facility. The system can also include a skid mounted steam generator for the heat exchanger 10, to create a more complete system.

The system as described can be modified to eliminate the recirculation line if the outputs of the heat exchangers meet the desired temperature criteria (heat exchanger raises the product to the first desired temperature) and/or cooler (heat exchanger 2) lowers the temperature of product exiting the first heat exchanger to a desired discharge temperature, if cooling is desired. The second heat exchanger (the cooler) may be eliminated if cooling is not needed or desired, or may be combined with the first heat exchanger, as later described. Additionally, the recirculation line may or may not be desired.

The system also employs a flexitank, which are well known in the industry. However, for recirculation, the desired flexitank may have a port on the top rear of the tank, where the port terminates in a valve for a recirculation line. Alternatively, the recirculation port may be located elsewhere on the flexitank,

The prior art heating methods, such as the heating pad methods, can require 24 hours or longer to raise the temperature of, for example, HFCS 55 in a 16,000 liter flexitank, from about 96 degrees to about 105 degrees Fahrenheit. The present system, pumping HFCS 55 at about 80 gal/min through a heat exchanger, (a plate exchanger with inlet design temperatures of 230 degrees Fahrenheit designed to handle 50 GPM of heated fluid) showed the following temperature profile for a filled 16,000 liter flexitank, using continuous recirculation of heated product:

time	inlet temp	outlet temp
11:20	96.0	104.0
11:35	98.0	106.0
11:50	98.0	108.0
12:05	100.0	110.0
12:20	100.0	112.0
12:35	100.0	116.0
12:50	102.0	118.0
13:05	103.0	120.0
13:20	104.0	122.0.

As can be seen, the system raised the inlet temperature (product entering the heat exchanger, e.g., the material leaving the flexitank) from 96 degrees to 104 degrees Fahrenheit in about two hours versus 24 hours for the prior art heating method. These results were obtained using portable steam generating equipment of limited capacity as the heat source for the heat exchanger. Even more efficient heating times could be obtained if a larger capacity steam source was used as the heat source for the heat exchanger, or a larger capacity heat exchanger.

Another embodiment is shown in figure 8. In this embodiment, a single heat exchanger is used for both heating and cooling functions. The heat exchanger will be connected to both a heat source (such as a steam generator) and a coolant source, such as water or chilled water using valves. In some embodiments, the heat exchanger may in essence, be two heat exchangers to allow cooling and heating simultaneously. A more cost efficient system uses a single heat exchanger that either cools or heats, but not both, at a single time.

In this embodiment, the function invoked (heating, cooling or otherwise) will generally depend on the product temperature, the product desired output temperature, the desired product elevated temperature and desired residence time at the elevated temperature (e.g. the heating history of the product through the system). For instance, the user will input the desired output product temperature, the desired elevated temperature, and the desired residence time at the elevated temperature into the controller. The user may specify where the temperatures are to be measured for comparison to the predetermined elevated temperatures and desired output temperature. Generally, the product temperature will be measured after the discharge valve but before the exchanger 10, 20. The product temperature, after exiting the exchanger 10, 20 can be used to compare to the desired elevated temperature and desired output temperature, but the product temperature measured prior to the heat exchanger can also be used for this purpose.

The controller monitors the temperature of the product (where ever measured). Note, the controller may also monitor the temperature of the heat exchanger fluid entering or leaving (or both) the heat exchanger. Generally, at system start up, it will be desired to heat the product to the desired elevated temperature. In this instance, the controller (or the operator) can open the valve connecting the heat source to the heat exchanger, and maintain the value to the coolant source closed. The pump 30 will pump product through the system, and at start up, the entire product volume exiting the heat exchanger can be recycled back to the flexitank through the recycle line. Once the product temperature reaches the desired elevated temperature, the heat source may be shut down, and product simply recycled until the desired residence time is achieved. Alternatively, the heat source may say connected intermittently during the residence time, or the volume of heated fluid passing through the heat exchanger may be reduced (such as by partially closing the valve to the heated fluid source.

Alternatively, once the desired product elevated temperature is reached, the heat source may be closed, and the pump turned off until the desired residence time is achieved (the pump may rung for several minutes after the heat source is shut off to allow the heat exchanger to cool in anticipation of a cooling cycle). The controller (such as a PLC, or several PLCs) may provide a visual or audible indicator that the desired elevated temperature has been achieved. The controller may record the time spent at after achieving the desired temperature, or the user may manually monitor the elapsed time. Once the desired residence time is achieved, a cooling cycle can be implemented if desired. If a desired discharge temperature has not been provided to the controller 10, 20, the user will input the desired discharge temperature to the controller. The controller will open the automatic control valve to the coolant source, to allow the coolant to pass though the heat exchanger. The coolant may separately run for several minutes before the pump 30 is activated. On activation of the pump 30, product is pumped through the system through the heat exchanger to extract heat from the product. The controller will monitor the temperature of the product (generally after the heat exchanger) and will usually be set to recycle product through the system until the desired output temperature is achieved. At this point, the coolant supply can be removed (for instance, closing a valve), and a visual/audible indicator may be given to notify the user that the proper discharge temperature has been reached. At this point, the user has several options: cease pumping for later discharge of product from the flexitank; continue to recirculate (or intermittently recirculate (such as by intermittent pumping) until product discharge is desired, or discharge product by operation of the discharge valve. In some instances, the discharge location may be remote from the heating/coolant location, in which event, the pump would be shut down, the discharge valve on the flexitank closed, and the recirculation line removed, to allow the heating/cooling system to be disconnected and the flexitank moved to the discharge location or a storage location prior to discharge.

By using a single heat exchanger for both heating/cooling functions, a smaller skid footprint can be achieved. Also, by mounting the heat exchanger above or below the pump, additional space efficiency can be achieved on the skid platform. As shown in the figures, the pump appears between the flexitank and the heat exchanger. The pump could also be located after the heat exchanger. Other variations of the system are within the scope of the invention.

CLAIMS

1. A discharge system comprising a flexitank for storing flowable product therein, said flexitank comprising a flexible bladder having a valved discharge port, and a first heat exchanger located remotely from the flexitank, said discharge port selectively fluidly connected to an input port on the first heat exchanger, said first heat exchanger having an outlet port in selective fluid communication with a system discharge port or a recycle port; said heat exchanger in select communication with a source of heat to transfer heat to a product flowing through said heat exchanger, and a coolant source to remove heat from product flowing through said heat exchanger; and a pump, said pump operatively connected to said system to pump product in the flexitank to the first heat exchanger.

2. The discharge system of claim 1 further having a recirculation line, one end of said recirculation line in fluid communication with said flexitank, the other end of said recirculation line in selective fluid communication with said outlet port of said first heat exchanger.

3. The discharge system of claim 2 having a first temperature sensor; said first temperature sensor positioned to measure the temperature of product in said system near said discharge port.

4. The discharge system of claim 3 having a second temperature sensor, said second temperature sensor positioned to measure the temperature of product in said system near said outlet port of said first heat exchanger.

5. A discharge system comprising a flexitank for storing flowable product therein, said flexitank comprising a flexible bladder having a valved discharge port, and a first heat exchanger located remotely from the flexitank, said discharge port selectively fluidly connected to an input port on the first heat exchanger, said first heat exchanger having an outlet port in selective fluid communication with a system recycle port; said heat exchanger in select communication with a source of heat to transfer heat to a product flowing through said heat exchanger, and a coolant source to remove heat from product flowing through said heat exchanger; and a pump, said pump operatively connected to said system to pump product in the flexitank to the first heat exchanger.

6. A method of discharging a flowable product from a system comprising:

a flexitank, having a valved discharge port and a recirculation port, a first heat exchanger located remotely from the flexitank but in fluid communication with the discharge port and the recirculation port of the flexitank; and a pump operatively connected to said system to pump flowable product in the flexitank to the first heat exchanger; the flexitank having flowable product located therein;

the method comprising the steps of:

(a) pumping flowable product from the valved flexitank discharge port to an input port on the remotely located first heat exchanger, said first heat exchanger operating to raise the temperature of said flowable product passing there through;

(b) returning, after heating, a portion of said flowable product, from an outlet port on the first heat exchanger to the flexitank;

(c) continuing steps (a) and (b) until said flowable product reaches a desired first temperature;;

(d) after step (c), pumping said flowable product from the valved flexitank discharge port to said input port on the remotely located first heat exchanger, said first heat exchanger operating to lower the temperature of said flowable product passing there through to produce a cooled flowable product.

7. The method of claim 6 further including the step of (e) returning a portion of said cooled flowable product from the outlet port on the first heat exchanger to the flexitank.

8. The method of claim 7 further comprising the steps of measuring the temperature of said cooled flowable product and discontinue pumping when said flowable product reaches a second desired temperature.

9. The method of claim 7 further comprising the steps of measuring the temperature of said flowable product occurs either (i) after or near the flexitank discharge valve but before the first heat exchanger outlet port, or (ii) after the outlet port of said first heat exchanger.

10. The method of claim 6 wherein said flowable material comprises high fructose corn syrup.

11. The method of claim 8 wherein the desired first temperature in in the range of 98 degrees Fahrenheit to about 120 degrees Fahrenheit.

12. The method of claim 6 wherein the system further comprises a filter in communication with the outlet port of the first heat exchanger.

13. The discharge system of claim 1 wherein system further includes a filter in fluid communication with said outlet port of said first heat exchanger.

14. The discharge system of claim 13 wherein said pump, said filter and said first heat exchanger are located on a skid.

15. The system of claim 15 wherein said skid is portable.

16. The system of claim 15 further including a steam generator located on said skid.

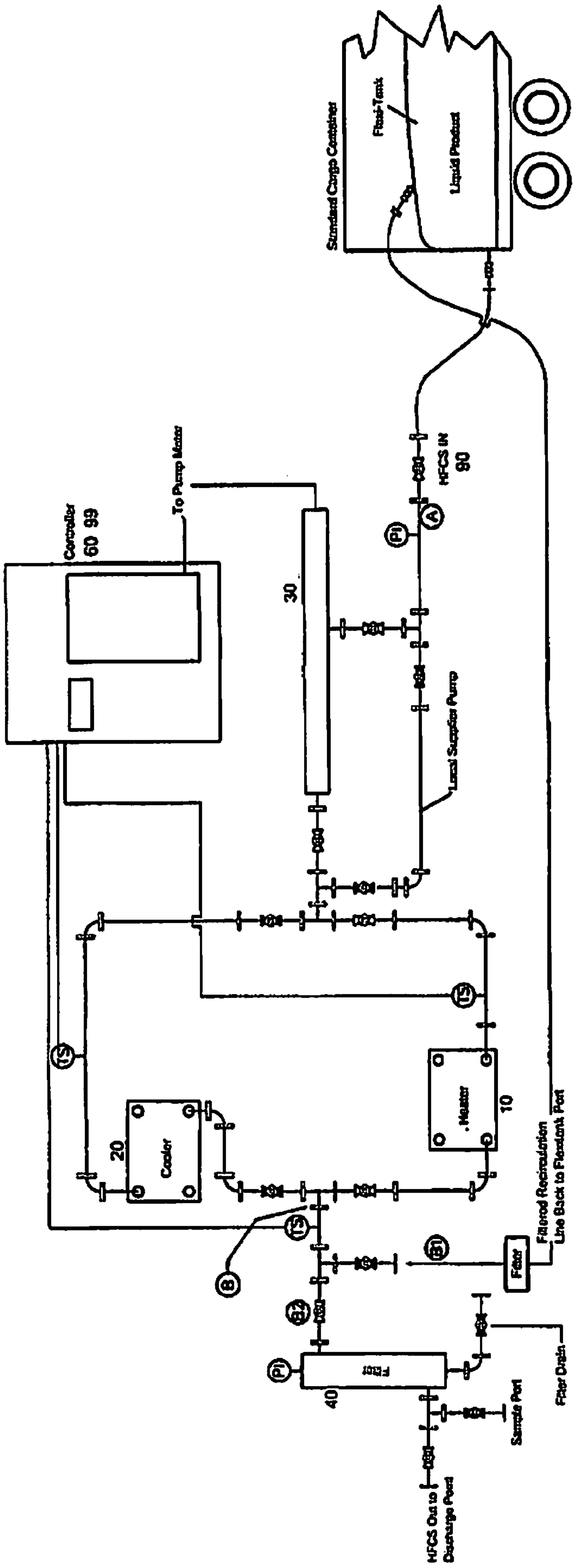
Standard Cargo Container
Flexi-Tank
Liquid Product
Controller
60 99
To Pump Motor
30
HFCS IN
90
Local Supplier Pump
Cooler
20
Heater
10
Filter
40
Filtered Recirculation Line Back to Flexitank Port
Filter Drain
Sample Port
HFCS Out to Discharge Port

FIG 1

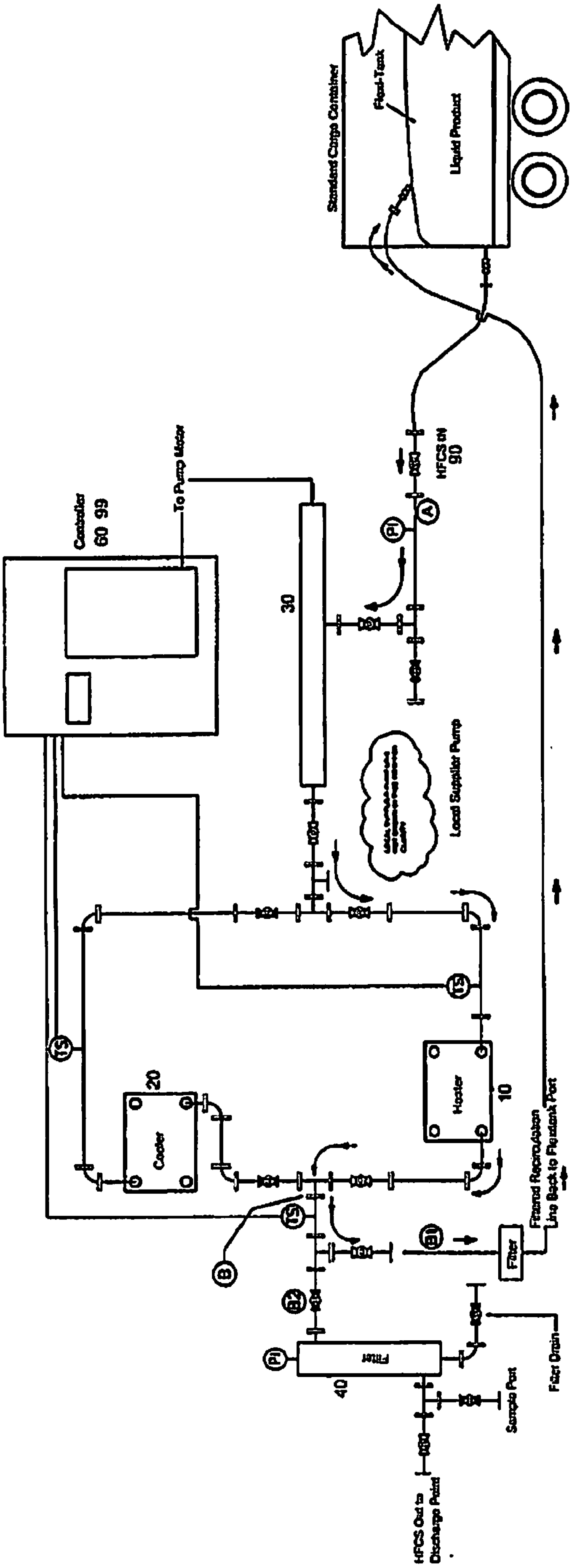

FIG 2

RECIRCULATION ONLY - FLOW DIAGRAM

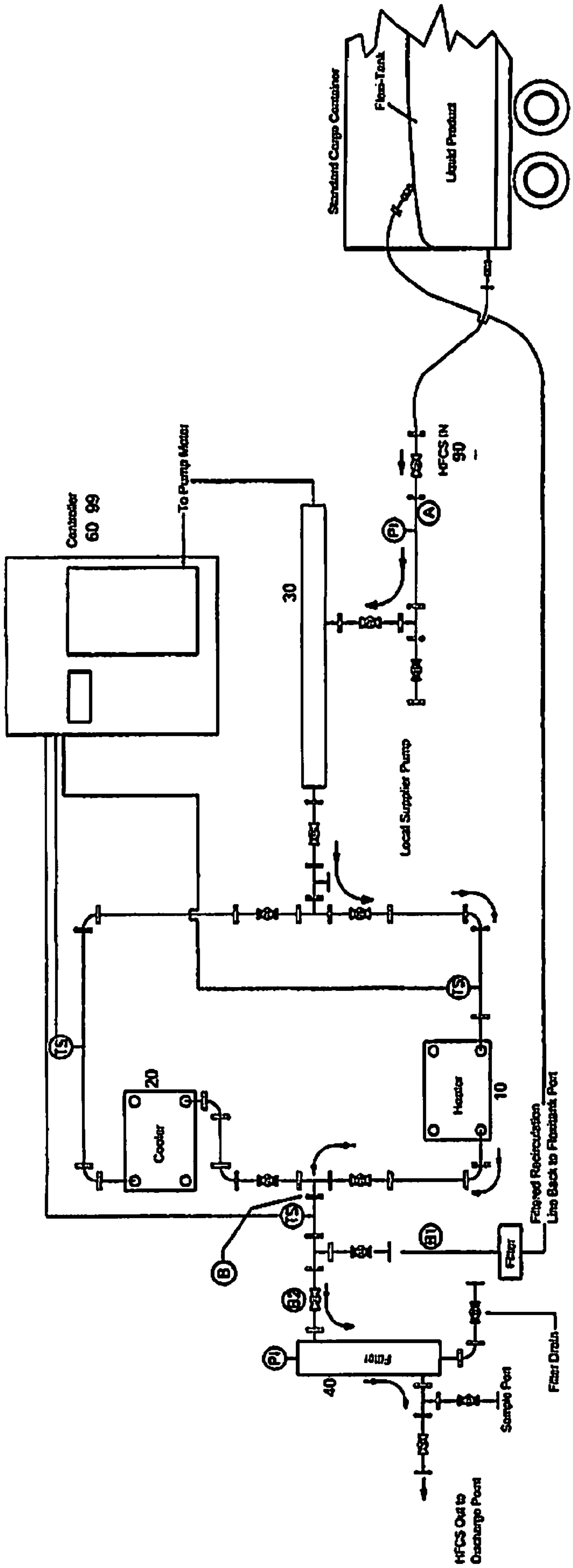

FIG 3

HEAT & DISCHARGE - FLOW DIAGRAM

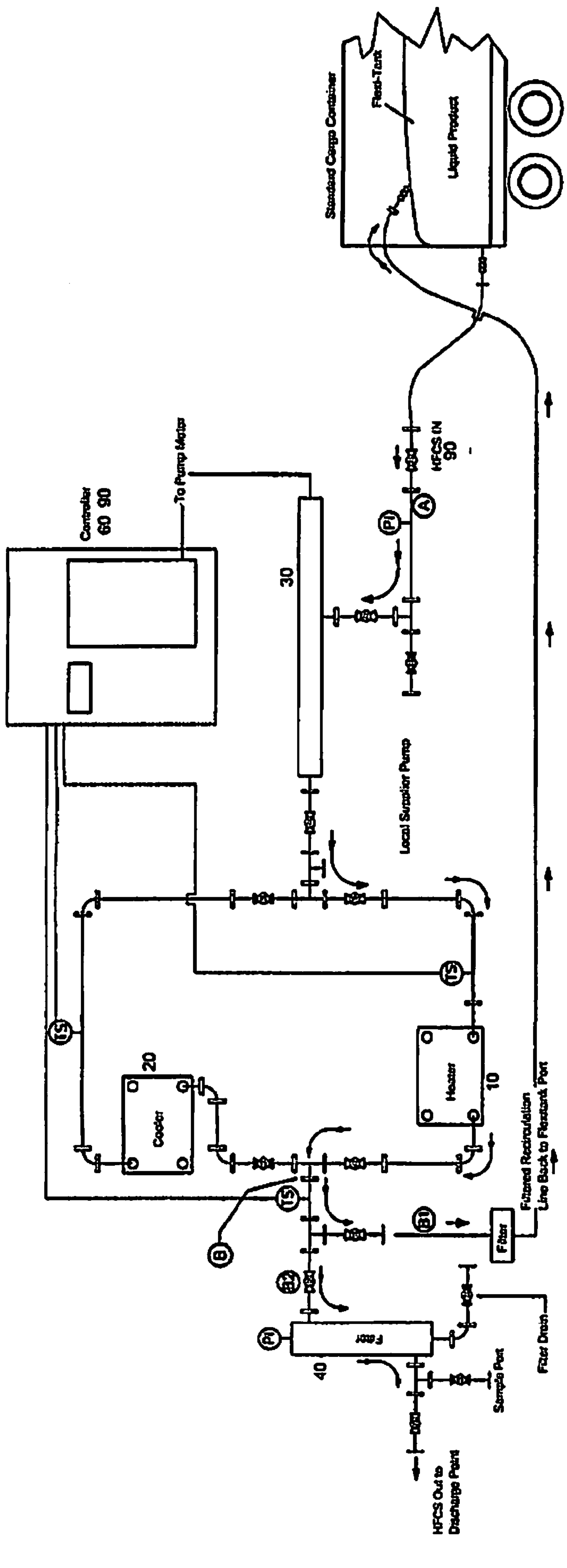

FIG 4

PARTIAL RECIRCULATION & DISCHARGE - FLOW DIAGRAM

BOTH VALVES OPENED OR PARTIALLY OPENED

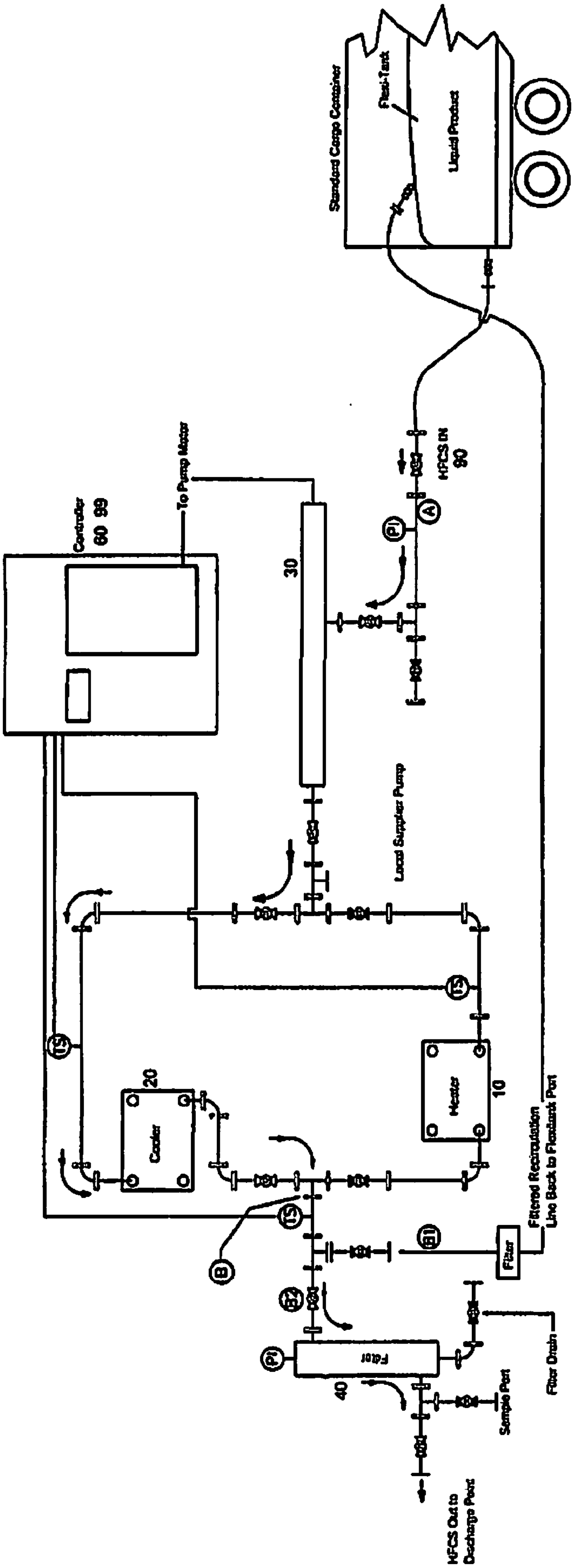

FIG 5

COOL & DISCHARGE - FLOW DIAGRAM

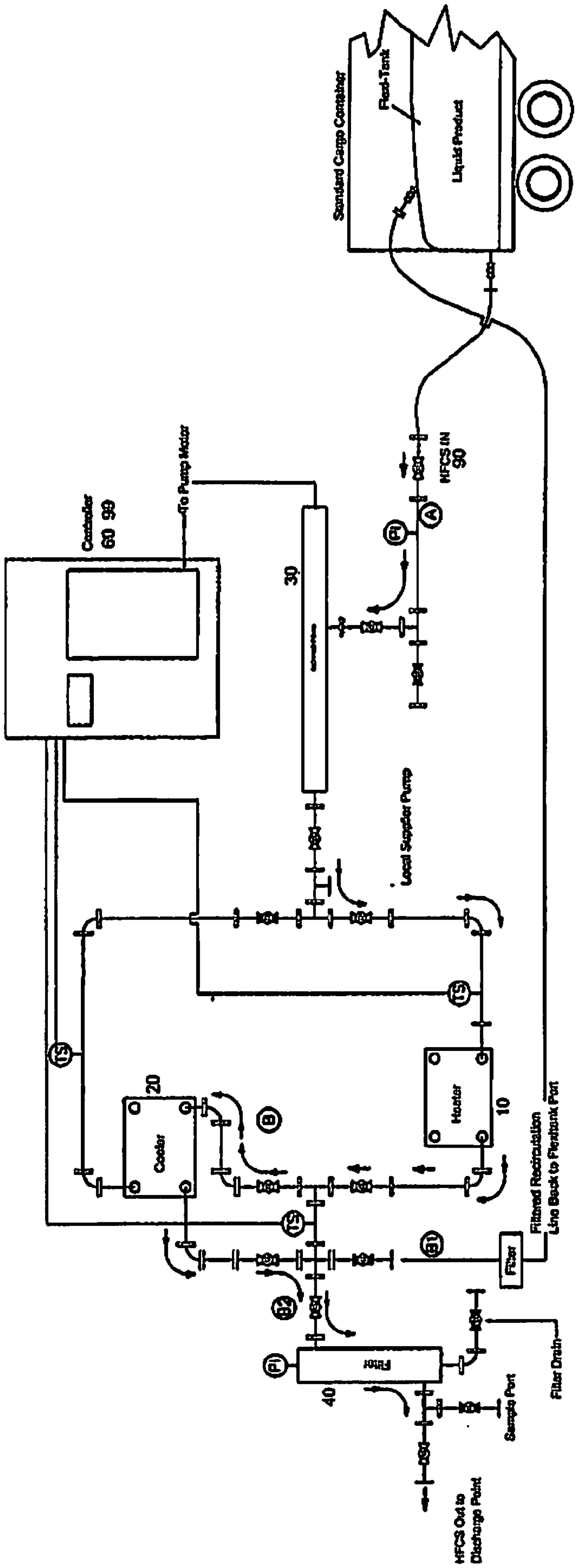

FIG 6

HEAT, THEN COOL & DISCHARGE - FLOW DIAGRAM

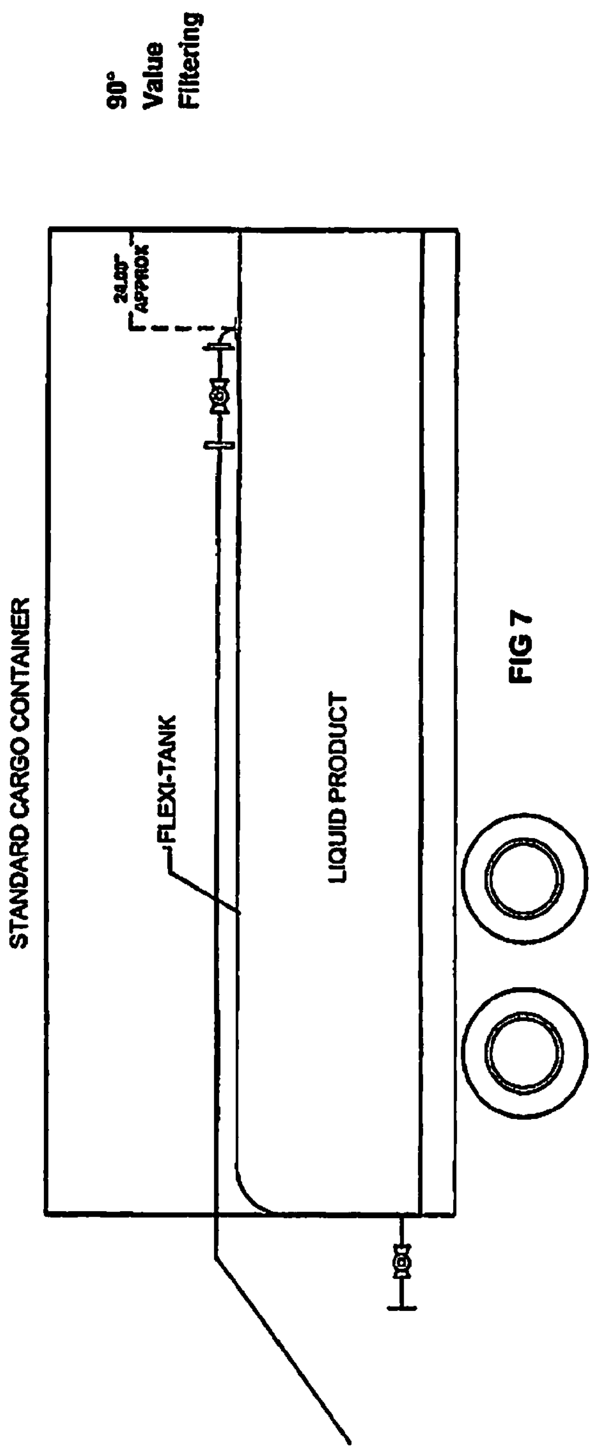
90°
Value
Filtering
24.00"
APPROX
STANDARD CARGO CONTAINER
FLEXI-TANK
LIQUID PRODUCT

FIG 7

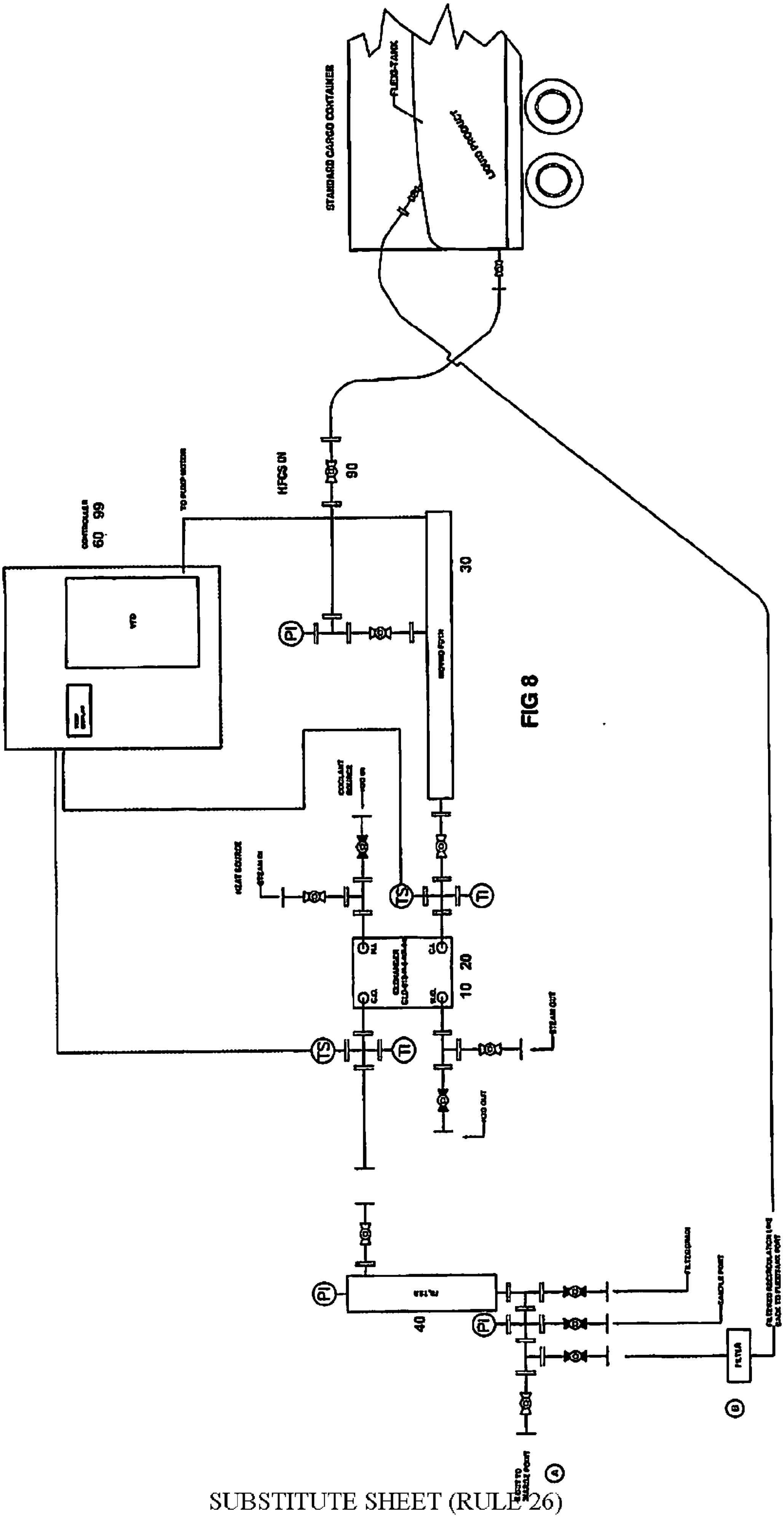
STANDARD CARGO CONTAINER
FLEXI-TANK
LIQUID PRODUCT
HFCS IN
90
30
CONTROLLER
60 99
TO PUMP MOTOR
VFD
HEAT SOURCE
COOLANT SOURCE
10 20
40
PI
TS
TI
A
B

FIG 8

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2016/019036

A. CLASSIFICATION OF SUBJECT MATTER

IPC(8) - B67D 7/80 (2016.01)
CPC - B67D 7/80 (2016.02)
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC(8) - B65D 90/04; B67D 7/80, 7/82 (2016.01)
CPC - B65D 90/046, 2590/046; B67D 7/80, 7/82 (2016.02)

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
USPC - 137/334, 339, 340, 599.14; 222/146.1, 146.2, 146.6 (keyword delimited)

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
Orbit, Google Patents, Google
Search terms used: flexitank, flexible tank, bladder tank, conex tank, heat exchanger, cooling, skid, recirculate, filter, viscous fluid, viscous liquid, dispense

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 2,506,412 A (CHAUSSE) 02 May 1950 (02.05.1950) entire document	1-5
Y	US 2011/0083768 A1 (SIMS et al) 14 April 2011 (14.04.2011) entire document	1-5
Y	US 2008/0264601 A1 (HANSEN) 30 October 2008 (30.10.2008) entire document	3, 4
A	US 2006/0093717 A1 (AKKERMAN et al) 04 May 2006 (04.05.2006) entire document	1-16
A	US 6,002,838 A (NIR) 14 December 1999 (14.12.1999) entire document	1-16
A	US 3,583,415 A (SMITH) 08 June 1971 (08.06.1971) entire document	1-16

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier application or patent but published on or after the international filing date
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"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
07 April 2016	03 JUN 2016

Name and mailing address of the ISA/	Authorized officer
Mail Stop PCT, Attn: ISA/US, Commissioner for Patents P.O. Box 1450, Alexandria, VA 22313-1450 Facsimile No. 571-273-8300	Blaine R. Copenheaver PCT Helpdesk: 571-272-4300 PCT OSP: 571-272-7774