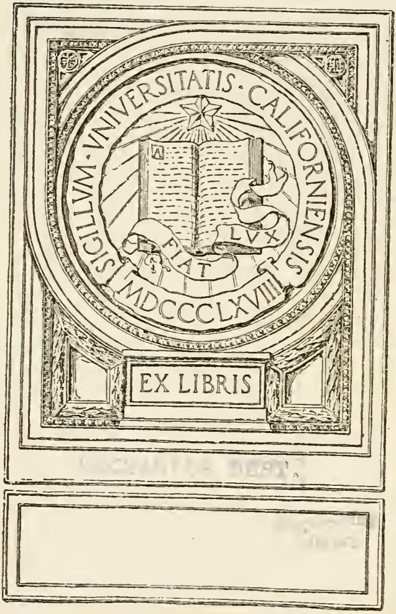
OIL TANK STEAMERS

Their Working and Pumping Arrangements thoroughly Explained

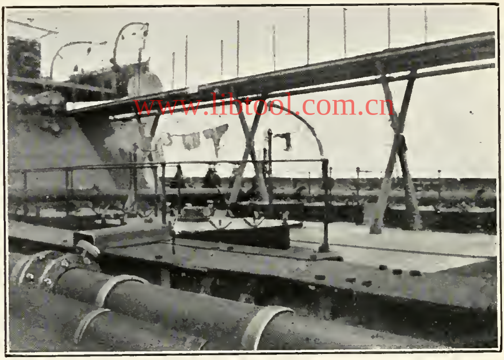
BY

Captain HERBERT JOHN WHITE

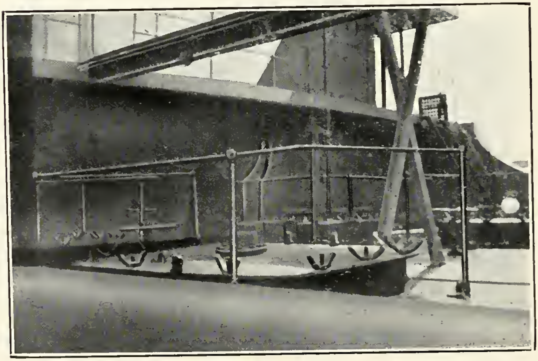
GLASGOW
JAMES BROWN & SON


SIGILLVM · VNIVERSITATIS · CALIFORNIENSIS
FIAT LVX
MDCCCLXVIII
EX LIBRIS

OIL TANK STEAMERS



Pipe Lines, Deck Steam-pipes, Tank-tops with Guard Rails, and Fore-and-aft Bridge on modern Tanker. Note davit for supporting oil hose.



Tank-tops showing Butterfly Screws and Plugs; Valve Wheels shown. Deck Pipe Line in foreground.

7s. 6d. NET

OIL TANK STEAMERS

Their Working and Pumping Arrangements thoroughly Explained

SECOND EDITION

30 CHAPTERS, WITH 13 DIAGRAMS, AND NEW TABLES FOR CALCULATING WEIGHTS OF OIL AND WATER

BY

CAPTAIN HERBERT JOHN WHITE

NAUTICAL PRESS

GLASGOW
JAMES BROWN & SON, PRINTERS AND PUBLISHERS
52 TO 58 DARNLEY STREET
1920

PREFACE.

THIS little book has been written by an officer on board an up-to-date oil tank steamer, in an endeavour to explain to those just starting—or who would like to start—in these ships, but who hesitate because they know that the work is entirely different, and there is no standard book or manual to give them the necessary guidance when first starting. I have been greatly assisted by Mr. J. D. Nesbitt, a brother officer, whose knowledge of oil tanks is from A to Z.

Any hints or criticisms for bringing up to date future editions will be gladly welcomed by the Author.

HERBERT JOHN WHITE.

PREFACE TO SECOND EDITION.

IN introducing the second edition of *Oil Tank Steamers* on to the market, I wish to thank my many correspondents who have helped to make the first edition such a complete success.

This edition fully describes eleven different types of tank steamers, and a diagram is given to illustrate each one.

The carriage of different kinds of oil is fully dealt with, and at the end is inserted a new table for calculating weights of oil or water. This table has been tested by experts in England and America, and is claimed to be the simplest and quickest method ever published.

Any descriptions of new improvements or useful information will be welcomed by the Author to improve future editions.

HERBERT J. WHITE.

Feb. 1919.

CONTENTS.

CHAPTER I.

ARRANGEMENT OF TANKS, COFFERDAMS AND PUMP ROOMS.

A TANK steamer is one which, as its name denotes, is divided into tanks. It is divided by a longitudinal bulkhead at the middle line through the whole length of the cargo part of the vessel, the bulkhead, extending from the tank bottom up to the deck. The vessel is also divided by athwartship bulkheads, which extend from one side of the ship to the other, thereby forming the tanks.

In large modern tankers, there are generally twelve double tanks, two pump rooms, and two cofferdams.

Starting right forward in the ship, there is first the fore peak with a watertight bulkhead at its after end. Next abaft this, is the fore hold, which is intended for any cargo the vessel is to carry besides oil.

At the after end of the fore hold is an oiltight bulkhead, extending from side to side, and from the bottom of the ship up to the deck above. This cuts off the fore hold from the oil tanks. Abaft this bulkhead, and 5 feet away, is another oiltight bulkhead similar in construction, these two bulkheads making an oiltight space which is called a cofferdam. When carrying dangerous oil this cofferdam is filled with water, thus making a solid body of water between the fore hold on the forward side of the cofferdam and the oil tank on the after side of the cofferdam.

There is a small pump room for this forward section of the ship, which is for this section of the ship alone. The small pump it contains deals with the fore peak, the fore deep tank (which is situated under the fore hold), and the cofferdam. Thus the forward section of the ship is entirely isolated from the oil cargo tanks.

The cargo tanks are conveniently numbered from aft and run from 1 to 12; so the forward tank is called No. 12 port and No. 12 starboard. This is the tank next abaft the cofferdam which has already been described.

Coming aft from No. 12 tank, we have tanks 11, 10, and 9. On the after side of No. 9 tank we usually have the forward pump room. It contains two big cargo pumps, one on the port side and another on the starboard side. The after bulkhead of No. 9 tank, which forms the pump room forward bulkhead, and the after bulkhead of the pump room, which forms the forward bulkhead of No. 8 tank, are oiltight, thus making an oiltight compartment between No. 9 and No. 8 tanks.

Proceeding aft, we have the tanks 8, 7, 6, and 5 and on the after side of No. 5 tank we have the after pump room. This is similar in construction to the forward pump room, and also has two big cargo pumps and an air pump which will be described later on, the after bulkhead of No. 5 tank forming the forward bulkhead of the after pump room, and the forward bulkhead of No. 4 tank, forming the after bulkhead of the after pump room.

Continuing aft, we have tanks Nos. 4, 3, 2, and 1. On the after side of No. 1 tank is an oiltight bulkhead, which is pierced by the pipe line on the port side only; this really finishes the oil cargo tanks.

The next tank abaft No. 1 is generally known as the cross bunker tank, which, if the vessel burns oil fuel, is used by the engineers as bunker space. If the vessel burns coal, then this tank is also used for cargo if required.

At the after end of this cross bunker tank is an oiltight bulkhead extending from side to side and from the tank bottom to the deck above, and at a distance of 5 feet further aft is a similar bulkhead. The space between these two bulkheads forms the after cofferdam, which, when a ship is carrying any dangerous oil in the cross bunker tank, is filled with water, thus making a 5-feet thick bulkhead of water between the tanks on the forward side and the stokehold on the aft side. Thus the stokehold and engine room (which is abaft it) are absolutely shut off from the tanks containing oil.

A careful study of diagram No. I. will show exactly how the tanks, pump rooms, and cofferdams are situated.

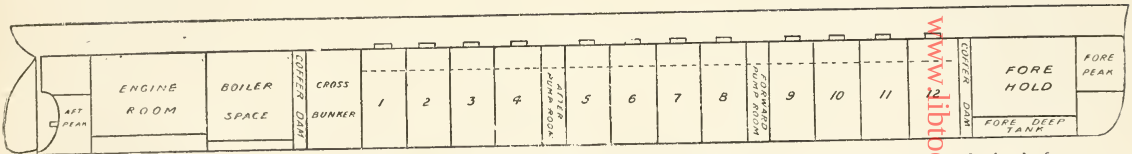


DIAGRAM No. I.—Side view of the arrangement of Tanks, Pump Rooms and Cofferdams. The dotted line shows the level of the Summer Tank bottom.

CHAPTER II.

SUMMER TANKS AND EXPANSION TRUNK.

THE question naturally arises, "How do you stop the oil from rolling, even though each tank has its longitudinal bulkhead at the middle line."

This is effected by filling the oil up into the expansion trunk of the tank. The expansion trunk could almost be correctly called "the contraction trunk," seeing that it is the smallest part of the tank.

It is formed by the summer tanks in the following way :—In each tank, and out in the side, is built another small tank close up under the deck, and extending about 15 feet from the ship's side towards the middle of the ship. It is about 8 feet in depth, and runs the whole length of each tank fore and aft. To describe it by name it could be correctly called "a wing tank," from its situation up in the "wings" of the main tanks.

It is entirely separate from the main tank in which it is situated, and has its own little hatches, opening up to the deck above, and also its own pipe line arrangements. Thus it will be seen that from the top of the main tanks to a depth of at least 8 feet down (which is the level of the summer tank bottom) each main tank is reduced in breadth by 15 feet owing to the presence of the summer tanks.

This, the smallest part of each main tank, is called "the expansion trunk." When the main tanks are loaded it is always the rule to fill them at least up into the expansion trunk some 4 or 5 feet. Thus below the expansion trunk is a solid body of oil, which therefore cannot roll. The only quantity which can roll is the small quantity in the expansion trunk. A glance at diagram No. I. will show the position of the summer tanks.

The expansion trunk of a tank is never filled right up to the top, but usually there is a vacant space between the top of the oil and the top of the tank. The measurement of this space is called the "ullage." When oil is at a higher temperature it expands, and when its temperature falls it contracts, so a vacant space is left at the top of the tank when loaded to give room for the oil to expand. Thus does the top part of the tank derive the name of "expansion trunk." Oil expands $\frac{1}{20}$ per cent. for every degree the temperature is raised, and will contract $\frac{1}{20}$ per cent. for every degree the temperature falls.

If a vessel uses coal as fuel, then most of the summer tank space would be used as bunker space. It is advisable to leave the description of the summer tank pipe lines and pumping arrangements till after the main tank pumping arrangements have been explained, in order that anyone can get a good knowledge of the main tanks; after this the summer tanks are quite simple.

Each summer tank has its own hatch, and sometimes more than one, and these hatches form the "expansion spaces of the summer tanks."

that in the forward end of No. 12 tank these two pipe lines are connected by a big pipe line running athwartships, which crosses over from one line, through the middle line bulkhead, to the other line. It is named the forward cross over.

Looking next at the forward pump room, we find there are two cross over lines running from one side to the other. One is at the forward end of the pump room, and one is at the after end of the pump room. These two pipes are called the forward pump room cross overs.

Looking at the after pump room, it is seen that there are also two cross over pipes there similar to those in the forward pump room which have just been described.

There is one more cross over line to be described, and this is situated in No. 1 tank. It is similar in construction to that in No. 12 tank.

Thus along the whole length of pipe line we have six different cross over lines, by which we can draw, or pump, from one line to the other.

Again examining the diagram, we see the pipe lines pass through each tank, and branching out from them we see short pipes which are called suction pipes, because by these pipes we draw the oil from the tanks into the pipe lines, and along them to the pumps.

Taking No. 10 tank first for an example, and starting with the port pipe line, we see that branching out from this line there is a short suction pipe which ends in the port side of the tank. This pipe is called "the port suction on the port line." Its name explains exactly what its work is; to draw from the port side into the port line.

Branching out from the port pipe line is a longer suction pipe which crosses the port side of the tank, and goes through the fore and aft middle line bulkhead into the starboard side of No. 10 tank. By this pipe we can draw from the starboard side of the tank into the port line. This one is called "the starboard suction on the port line."

Next, looking at the big starboard pipe line as it runs through No. 10 tank, we see that this line also has two suction pipes branching from it. The short one ends in the starboard side of the tank, and is called the "starboard suction on the starboard line," because it draws from the starboard side of the tank into the starboard pipe line. The other suction pipe crosses from the starboard side of the tank, goes through the middle bulkhead, and ends in the port side of the tank. This is called "the port suction on the starboard line," because it draws from the port side of the tank into the starboard line. After looking at the diagram the reader can grasp the system at once.

If this arrangement is learned for one tank it applies to every one of the main tanks. These are the four essential suctions in each tank which an officer must know; the port and starboard suctions on the port line, and the port and starboard suctions on the starboard line.

So far, only pipe lines and suction pipes have been dealt with; now it is necessary to describe the valves whereby the oil is either admitted into the pipe lines or, with the valves shut, is kept in the tanks.

Near the end of the suction pipes (described above), where they are open into the tanks, is fitted a valve which works up and down in a socket fitted in the suction pipes, according as they are turned from the deck above. These valves have attached to them a long spindle which goes up through the tank top, and is worked from the deck. If the valve is screwed upwards it opens the suction pipe into the tank, and if it is screwed down again it blocks the suction pipe from the tank. It acts exactly the same as a sluice valve on a bulkhead. By screwing up the sluice valve you uncover the hole and allow liquid to flow from one compartment to the next, and by screwing down the sluice valve you cover up the hole and stop the flow of the liquid, and this is exactly on the same principle. By opening a valve the oil is allowed to run from the tank into the suction pipe, and thence into the big pipe lines, and so to the pump. By screwing down a valve the hole in the suction pipe is blocked, so that the tank is shut off from the pipe line and pump. By looking at a valve open and shut the reader will grasp the meaning at once.

It must be mentioned that all suctions are situated near the after end of the tanks, so that it is essential, when draining the last oil from a tank, to trim the ship "by the stern," so that any oil left will drain towards the suction at the after end. The end of the suction pipes are fitted with rose boxes, which only allow liquids to pass through to the suction pipe, and keep out any dirt or floating refuse which may have got into the the tank, and so prevent the choking of the valves or pipes. To properly drain out tanks, the ship must be slightly listed away from the side you wish to drain. For instance, if draining tanks on the port side, list the ship two or three degrees to starboard, and any oil left in the port side will run towards the middle line where the suctions are situated.

Before finishing with the pipe lines, it must be stated that there are valves called master valves on the pipe line itself in different places which shut off one section of the pipe line from the next as may be required. The first two master valves are situated on the cross over lines. One is fitted exactly at the middle line in the No. 12 tank, thus dividing the forward cross over line, and the other is situated in the same relative position in No. 1 tank, on the after cross over line. By opening these two master valves it is possible to pump right round the ship.

For instance, with these valves open, if pumping be started with the starboard after pump along the starboard line, the oil will flow through the forward cross over into the port line. It will then go right aft to No. 1 tank, and through the cross over there, and then into the starboard line again, next arriving at the place it started from.

By keeping these two master valves shut, it completely isolates the port and starboard lines from each other at the forward and after ends.

There are other valves on the pipe lines, situated under the pump rooms. These will be dealt with in the chapter devoted to the pump rooms.

The next thing to consider is how to distinguish the different valves, because if the wrong one is opened it might be a serious thing, and different kinds of oil might get mixed. The standard rule for distinguishing valves is to paint them in different colours. So the valve spindles (on the deck above the tanks) are painted, the two suction valves belonging to the port line being painted red, and the two suction valves belonging to the starboard line are painted green. Thus, there is little possibility of a mistake if you remember which line you wish to use. For instance, it would be useless to open a green

2

valve if you were pumping on the port line, as the green valve would only open a valve on the starboard line.

Now, besides these four valves already described which are most important to know, there are also two steam valves, one for each side of the tank, and also two air valves, one for each side of the tank. The air valves are painted black and the steam valves are painted white. On looking at the valves which belong to a tank, the different colours will at once show what valves they are.

Air valves and steam valves have now to be explained. In the after pump room there is a big air fan driven by steam to help to clear the tanks of gas. The air is driven by the fan down into the main pipe line, and by opening the air valve of the tank you wish to free from gas, the air will rush in and drive the gas upward and out of the top of the tank. By opening the air valve which is fitted on the suction pipe, the air is allowed to blow freely into the tank. We could also open the suction valves for that tank and allow the air to come in, but seeing that the end of the suction pipe is covered by the rose box, the force of the air would be checked and not have a free outlet, so the air valve is opened and the draught comes right into the tank with its full force.

The next thing is the steam valve. On looking down into an empty tank, you will notice, right on the bottom, a coil of small pipes running all over the bottom of the tank and spreading in all directions. These are the steam heating pipes used for heating the cargo if required, and the white painted valves above mentioned turn on the steam into these coils in the tank whose valves are opened. Thus the cargo in the tank is heated and kept at the required temperature. Of course, it is never necessary to heat light oils, such as petroleum, naphtha or gasolene. You are always glad to see their temperature go down.

In considering this question of temperature, the writer has found by experience that the temperature of the oil in the tanks is regulated by the temperature of the sea water outside the ship. As the ship comes into colder water, so the temperature of the oil in the tanks decreases. Generally speaking, the tank temperature is about one degree above the sea temperature. Light oils quickly come down to the normal temperature when pumped from shore into a ship's tanks, but heavier oils take longer to cool down.

A few words why oil sometimes needs to be heated will not be out of place here. If proceeding to a colder climate where the sea temperature is low, the heavier oils will gradually lower in temperature and contract into a smaller space, thereby becoming thicker. This would make it much harder work for the pumps, which always show the best average and work much easier when the oil is thin; so the policy is to keep up the temperature of the oils by circulating steam through the steam coils in the bottom of the tanks.

Before finishing about valves, it is to be understood that the valve spindles come up through the deck (which forms the top of the tank) for a distance of 2 feet. The ends are square so as to enable a spanner to be fitted on to turn them. In some ships ratchets are used, and in others box spanners or wheels are used for opening and shutting these valves.

In up-to-date tankers, all tank valves are left handed; that is to say, they turn to the left to shut down and turn to the right to open. All valves are situated at the after end of the tank to which they belong.

Each main tank is provided with a hatch for access, which has a coaming extending about 18 inches above the top of the hatch, and which is sealed by means of a steel lid or cover. Round the edge of the cover, which slightly overlaps the coaming, there is a recess fitted with some suitable packing material. When closing the hatch the lid is forced down by means of bolts having butterfly nuts, which are fitted at intervals round the top of coaming until the packing is bearing on top of the coaming plate at all points. The hatch is then thoroughly oil tight.

When loading or discharging one should always be careful to see that the air plug which is fitted on each hatch lid is open ; that is, if the lid is not lifted up. In discharging a tank, if there is no place for the air to get in to the tank to fill the vacant space caused by the oil being pumped out, a big vacuum would be caused and it would be impossible to raise the lid or take the plug off.

In loading oil cargoes there must also be a place for the air to escape, as the oil comes into the tank from the pipe lines.

If an escape is not made for this air, it would become so compressed that it might force something to give way.

CHAPTER IV.

PUMPING ARRANGEMENTS OF THE SUMMER TANKS.

Having studied the pipe lines and valves in the main tanks, we will now mention the pumping arrangements of the summer tanks, or wing tanks, as they might be called.

The summer tanks run the full length of the main tanks below them, in their fore and aft direction, and project in from the ship's side about 15 feet. This summer tank space is, in the vessel under consideration, divided by transverse bulkheads into five summer tanks numbered 1, 2, 3, 4 and 5; being numbered from aft. Each tank is separated from the next, and the bulkhead is only pierced by the summer tank pipe lines and steam heating pipe.

First we will consider this little pipe line as it passes through the summer tank and leave its connection with the main pipe line till later.

Its forward end is in the after end of No. 5 summer tank, where it has a suction valve which, when open, allows the oil in this tank to enter the pipe line to be discharged, and when shut keeps the oil in the tank so that it will not run out through this pipe line. This pipe line passes through all the summer tanks, and at the after end of No. 1 summer tank connects on to the line which goes down to the main pipe line below. On this line, in every tank except No. 5, there is a master valve at the after end of the tank. This description applies to both sides alike. Situated at the after end of No. 4 and No. 2 summer tanks is a small pipe branching out from the pipe line. It goes towards the ship's side, and then turns downwards through the tank bottom and protrudes into the main tank situated below it. This is the drop pipe. On this short pipe there are two valves. The first one is the suction valve for this tank, and the other goes down through the tank bottom and works the valve on the end of the drop line. This valve is called the drop valve. By opening this drop valve and the suction valve the oil in these tanks (No. 4 and No. 2) will enter the pipe line and then run into the drop line and drop into the tank below. This is the quickest way and also the easiest to discharge the summer tanks. No. 5, also No. 3 and No. 1, can also be run down by means of these two drop valves in No. 2 and No. 4. All that is required is to open their suction valves for the oil to enter the pipe line, seeing that the master valves along the line are open. Then as the level of the oil falls in No. 2 and No. 4, so the oil from Nos. 5, 3 and 1 will run into them and drop down through the drop lines. These summer tank valves are all worked from the upper deck above the summer tanks; by using this method a lot of pumping is saved.

In loading a cargo of oil, we again use these drop lines to help to fill the summer tanks without pumping. First, we pump up the main tank below, and when the oil reaches the level of the summer tank bottom we open up the drop valves and the suction valves, and the oil then starts running into the summer tanks through this drop line, and as the level of the oil in the main tank gradually comes up, so the level in the summer tanks rises. When the oil in the main tank is up to its proper level in the expansion trunk, and we find no more oil will run into the summer tanks, the drop valves should be shut and the summer tanks should then be pumped up until the oil reaches the required height in the expansion spaces. Remember always to keep the suction valves and master valves open till you have finished your tanks, and remember also that the drop lines in Nos. 2 and 4 summer tanks lead into the main tanks Nos. 5 and 7.

We have traced the summer tank pipe line to the after end of No. 1 summer tank, now we will trace it from the main pipe line below.

On the port side the main pipe line comes through the after bulkhead of No. 1 main tank and into the cross bunker tank, where it is reduced in size to 4 inches. Near the after bulkhead of the cross bunker, a 4-inch pipe line leaves the line we have been tracing, and goes up in a vertical direction to the top of the cross bunker, where it runs into a horizontal line, thus forming a T. One line goes across in a horizontal direction to No. 1 starboard summer tank, the other line going into No. 1 port summer tank, and there it connects with the summer tank pipe line which we have already traced to No. 1.

Thus it will be seen that to pump up the summer tanks altogether by this line would be a very slow process. There is only a 4-inch line to press the oil through, and it would also have to be pressed upwards from the bottom line to the top of the cross bunker, before it reaches a level with the summer tank bottom.

Thus anyone can see what a big saving it is to fill up the main tanks Nos. 5 and 7, and fill the summer tanks through the drop lines from these two tanks.

The summer tanks have steam coils running through them to heat the oil if required, on the same principle as the main tanks. But there is only one valve for each side and that is on the after side of No. 1 summer tank. There are no air valves on any summer tanks.

CHAPTER V.

PUMP ROOMS AND THEIR VALVES.

Although the pumps and pump rooms are under the engine room department for repairs and maintenance the deck officer will find it absolutely essential to know all about them. It is necessary for him to know exactly what is being done with the pumps and valves and also as a matter of dignity.

When the loading or discharging of cargo is taking place, or the ship is being ballasted, the deck officer gives his orders to the pump man, or in some ships to the junior engineer who is looking after the pump rooms.

In case of a mistake being made, the deck officer is the responsible man, as he is the one who gives the orders and is expected to see them properly carried out. Hence it is essential that he should learn as much as he can of the pumping arrangements to enable him to see his orders properly executed.

In pump rooms, as in other things, every ship has its own little peculiarities, so it will be dealt with very broadly, but the main ideas in every tanker's pump room are the same. We have studied the pipe lines as they come from one end

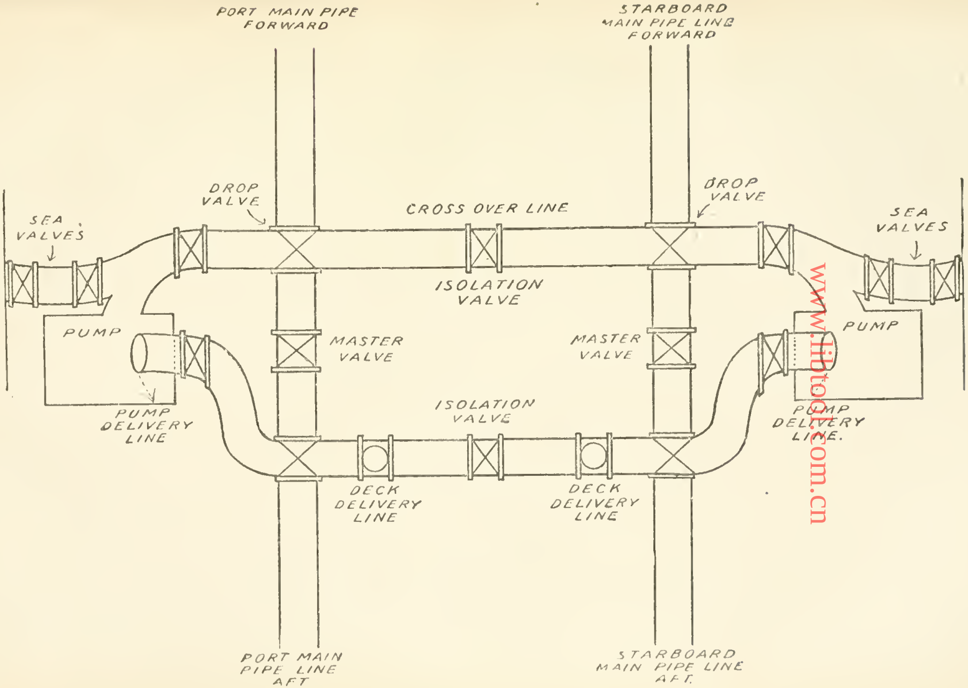


DIAGRAM No. III.—Arrangement of the Pump Room Pipe Lines and Valves. Plan.

of the ship to the other, passing through the different tanks, and now we will study them as they come through the pump rooms.

Taking the forward pump room first, the pipe line comes through the after bulkhead of No. 9 tank into the pump room, and when it leaves it goes through the forward bulkhead of No. 8 tank. But between these two bulkheads the pipe line has various lines branching out of it to the pumps, sea valves, and cross overs.

By looking at diagram No. III., it will be seen that the pump on either side is situated a little out towards the ship's side and is not directly over the pipe line.

From the main pipe line on each side is a pipe line branching out towards the pump just forward of it, which shows at once how the pump can draw from the pipe line at either side.

There is a similar pipe connecting the after part of the main pipe line to the pump on its after side. This shows that the pump can draw either from forward or aft in whichever direction is required..

On the main pipe line, between these two suction pipes just described, is a master valve by which the forward section of the pipe line is cut off from the after section. With this valve shut you can draw from the after section of the line into the pump through the after suction pipe, and deliver it along the forward section or *vice versa*. But in doing this the master valve must be shut, because it is not possible to draw and deliver on the same line if the line is not divided by the master valve. If this valve was left open, the contents of the pipe line, either oil or water, would simply run along the line till it found the lowest level, and the pump would just be circulating a quantity of oil or water and would be unable to press it along the line in any direction.

In fact, by working the valves which are shown on the diagram, it is possible to draw from any part of the ship, and by working the cross over valves to pass oil or water from one side to another in any direction. But the most simple way, and also the way to learn, is to go down in to the pump room and trace the pipes, when it is seen quickly which valves to shut and which to open.

From the top of each pump you will see a large pipe going upwards in a vertical direction till it reaches the level of the deck; it then turns aft and comes out on deck through the upper part of the pump room where it connects to the pipe lines on deck. This is called the deck delivery line, because it is the line by which the pump delivers the oil up to the deck to be discharged by the deck pipe lines. In loading through the deck lines the oil would go down through this delivery line. There is another pipe branching from it, just above the pump, and by this line the oil can be diverted into the main pipe lines without going through the pump at all. It is just a question of tracing these pipes and manipulating the valves.

A very important line to know in the bottom of the pump room is the sea delivery line, and the two sea valves on it. To trace this line, start on the main pipe line close to the pump suction pipe, and here we see a pipe branching out towards the ship's side. There are two valves on this line, one close to the side of the ship; this is the outer sea valve. and there is another close to the place where this pipe branches out from the line. This is the inner sea valve. By this line we obtain the sea water for ballasting purposes, and sometimes by this line we discharge ballast into the sea. A study of the plan will show that by opening the two sea valves, the sea water is allowed to come in through this sea delivery line and into the main pipe line. Or by shutting certain valves on the main pipe lines, we can lead it to the pump to be pumped in any direction we require. You can hardly make a mistake which is the outer sea valve, because it is the one valve which is out close to the ship's side, and by tracing the line from the ship's side inwards the inner sea valve is at once found.

Always be sure that the sea valves are both shut as soon as they are finished with, and on no account have them open while any cargo is being loaded.

In the pump room, and connected with the deck delivery line, is a pipe running vertically and parallel to the deck delivery pipe. It goes upwards till the level of the deck is reached. Here it is stopped at the end by a flange, and has no connection with the deck at its upper end. This pipe is the same diameter as the deck delivery line and is called a balancing column. The idea is that when the pump forces the oil up towards the deck by the deck delivery line it also forces the oil up into the balancing column. But the end of this column being stopped, the oil presses downwards again and up into the deck delivery pipe. Thus it helps the pump by balancing the column of oil in the deck delivery line by a similar column of oil in the balancing column.

The pump room also has two small bilge suction pipes to drain the pump room bilges. These are the only bilges there are in the oil cargo section of the vessel, because the bottom of the ship forms the tank bottom, therefore there can be no bilges.

The after pump room is similar to the forward one just described in every way. It has one addition, and that is the large air fan for circulating air along the pipe lines and into the tanks where gas has to be driven out. Situated near the top of the pump room is a branch pipe running out to the ship's side which is called the "barge delivery pipe," and by this line barges alongside can be loaded without the oil going on deck at all.

CHAPTER VI.

WATER BALLAST AND SHIFTING BALLAST.

The question of ballast is a most important one for an officer to know, as most tank steamers go outwards in ballast every voyage. The few exceptions seem to be those which are loaded with creosote.

Having obtained a good knowledge of what has been said about the tanks and their valves, and the pipe lines and their valves, also the pump rooms and their valves, it is quite a simple matter to take in sea water for ballast and pump it anywhere you require it.

Having two main pipe lines, it is the best rule to keep one solely for oil and the other solely for water ballast. The starboard line should be used for ballast, because the port line is the only one by which we can pump oil up into the summer tanks, as has already been explained.

Thus, in starting to load ballast, open the two sea valves you are going to use on the starboard side of the pump room. The water will then come in through the sea delivery line into the starboard main pipe line.

See that all the cross-over valves are shut, to prevent the water going across to the port pipe line. In ballasting a tanker for a Western Ocean passage in winter time, it is the general rule to fill tanks 2, 4, 6, 8, 10 and 12. With six tanks full, she is half loaded and in splendid trim to face any weather she is likely to meet.

Now to continue the ballast. We have allowed the water to come into the starboard pipe line, and, by opening the two green valves of the tank we wish to fill, we allow the water to run in both sides of the tank, because we have both suction pipes open from the starboard line by opening the two green valves. Take care that the two red valves are shut to stop the water entering the port line.

It is not necessary to start pumping in ballast (unless you are in a hurry), because the water will run in until the level of the tanks equals the sea level, when it will no longer run in by gravitation. Then by leading the water to the pump by the valves in the pump room, start pressing up the tanks with the ballast till it is well up in the expansion trunk.

What has been said about oil being pressed up into the tank expansion trunk equally applies to ballast. It would be very bad policy to have "slack tanks," with a great body of water rolling from the ship's side to the middle line bulkhead every time the ship rolled.

In discharging ballast, it is not necessary to start pumping till the water in the tanks has run down to sea level by gravitation. To discharge the ballast, open the two green valves of the tank to be emptied. This allows the water to enter the starboard pipe line; it will then be necessary to adjust some valves in the pump room, and open the two sea valves on the sea delivery line, and the extra head of the water in the tank will press the water out till sea level is reached by the water in the tank. Then by adjusting the valves in the pump room, lead the water to the pump, and either pump it up through the deck delivery line to be discharged over the side, or by setting the valves on one cross over, pump it through this cross over to the sea delivery line on the opposite side, and out into the sea under water. In this case, shut the starboard sea valves and open the port sea valve you are going to discharge through. Take care that the valves on the port side, on the port pipe line, are shut, so that when pumping through the cross over the water will not enter the line but go right out through the open sea delivery line on the port side. This is very handy to know, as it saves a lot of mess on deck when discharging dirty ballast from any tank.

A fine thing about these tank steamers is that it is possible to put them into any trim you require by shifting the ballast from tank to tank. As an example, we will shift the ballast from No. 12 to No. 1. Open the two green valves on No. 12, and the two green valves on No. 1. See that the master valves on the pipe line are open. The water will run out from No. 12 into the starboard pipe line, and run right aft till it comes to the open suction pipes at No. 1 tank. It will continue to run from No. 12 to No. 1 till they become level. Then lead the water to the pump by the valves in the pump room, shutting the master valve on the pipe line abreast of the pump. The pump will then draw from No. 12 along the forward section of the pipe line and press it along the after section of the line to No. 1. And in this way any tank can be shifted to another. It is only advisable to shift ballast from tank to tank at sea in fine weather.

CHAPTER VII.

CLEANING TANKS FOR CARGO.

The cleaning and preparing of tanks to receive cargoes of oil is an important subject with which all officers should be well acquainted.

The officer who has the tanks cleaned and ready to receive cargo in the quickest time after the ship's arrival at a loading port is the one who is most highly thought of by his owners.

Any delay on the ship's part to receive cargo causes endless questions and inquiries, and if there is any unnecessary delay caused by an officer he might as well send in his resignation. If the ship is on charter, then the charterers may claim this time from the owners.

So the main thing is that every tank must be cleaned and ready for inspection by the representative of the loading firm in the quickest possible time after arrival.

For loading different oils different standards of cleanliness are required. For light or refined oils the tanks must be absolutely clean and dry. This also applies to lubricating oils, because the finding of any water or dirt or oil of another kind decreases is value at once.

The standard of cleanliness for fuel oil is not so high as light oil, but the tanks must be dry before being passed by the inspector.

For creosote the standard is lowest of all. Taking creosote as the lowest and refined oils, such as kerosene, as the highest standard, I will explain the quickest way a "dirty tank" can be brought up to the standard of a "clean tank." The tank is supposed to be dirty with creosote. Shut down the tank lids and screw in the plugs, and close all valves belonging to the tank. Then steam it for six hours. By steaming a tank we mean the injecting into the tank of a good pressure of steam, which is continued for six hours. In modern tankers there is a steam pipe fitted into the top of the tank, and by opening the steam valve the tank is filled with steam without any trouble. This is entirely different from the steam coils for heating cargo. But in ships which have not any fixed steaming apparatus it is done by means of a steam hose. This is a small hose about 2 inches in diameter which connects on to the main steam pipe, which runs from the boilers to the forward pump room and windlass. The other end is then put down through the plug hole in the tank lid and lowered down to as near the tank bottom as it will reach.

The hose where it enters the plug hole must be well parcelled with old canvas or other material to prevent the steam from escaping out of the tank. As may be expected, the sides of the tank and the deck which form the top will get very hot, which is just what you require, because the hotter the tank sides become the more the oil which is sticking on the sides will run down to the bottom where it can be pumped out.

After steaming for six hours, lift up the tank lids and put down a windsail to blow the steam out. Next proceed to wash the tank sides down, all round, with the water hose, which should have a good pressure. After giving a good wash down, pump out the water, using brooms to sweep the sediment towards the suction. Any refuse must be taken up in buckets to prevent the rose box from becoming choked. After the tank is pumped out as dry as possible, shut down the tank lids again, and steam them for another two hours. Then open up the lids once more, and wash down again with the hose. Pump out the tank as dry as possible. The tank is now ready to be washed out with a light oil. Gas oil is the best, or it may be substituted by the loading firm for any other light oil which can be spared.

Fill the tank right up to the top with the "gas oil," and then pump it from one tank to another till every tank has been put through this process. Then inform the loading firm that you have finished with the gas oil, and await their instructions to pump it ashore, where it is refined again and all impurities taken out of it. The tanks have now to be washed right down with sponge cloths and gas oil (or the oil that has been given you). Wipe down each tank with great care.

To finish up, and before all the oil has gone ashore, open all the master valves on the main pipe lines and thoroughly wash out the pumps by pumping oil in every direction. When you have finished pumping the dirty gas oil ashore, drain all the pipe lines fore and aft into No. 1 tank. As the vessel will be in trim "by the stern," it will all drain aft into No. 1 tank without any trouble. Then send your men down into No. 1 tank with buckets and sponge cloths to dry the tank right up. All tanks have to be treated in the same way, and it will take several days to thoroughly clean a big ship for refined oils. The tanks are now ready for inspection by a representative of the loading firm.

Always remember when draining pipe lines below, that water or oil may be lodging in the suction pipes, between the pipe line and suction valve. If the inspector of the tanks demanded all tank valves to be opened, this quantity would run out into the tank bottom and be seen at once, although it was hidden before.

At some ports, the inspector will order all tank valves to be shut, and he will then put an air pressure on the pipe lines till his gauge shows about forty pounds pressure. He will then order the suction valves of the two after tanks to be opened, and if there is any water lying in the pipe line, this compressed air will force it into the tanks, where it is at once detected.

It may be mentioned that light oils would not hurt heavy oils, except by lowering their flash point, but heavy oil will damage a light oil by discolouring it.

There is one exception. On no account must any light oil be mixed with lubricating oils. In fact, the tanks must be just as clean for lubricating oil, and the greatest care taken that no oil or water of any description should be allowed to mix with it.

It has already been stated how necessary it is to have the tanks clean and dry for all kinds of lubricating oils, but a little more information is necessary.

This oil can be damaged in three ways. First, by water. Secondly, by mixing it with an oil of a low flash point; and thirdly, by discoloration.

The first needs no explanation. The second is explained in Chapter IX. In dealing with "discoloration," it is to be understood that different kinds of lubricating oils have different colours and shades, and an analyst examining a sample will put it into a clean sample bottle and hold it up to the light to examine the colour or shade. Water gives it a cloudy appearance, and is detected directly, because the oil should be perfectly clear. An instance is given here to show how easily it can be discoloured.

In a certain ship's cargo was a tank of lubricating oil called 999. This oil has a pure claret colour when in good condition. On arrival at the discharging port a sample was taken, and being found "cloudy" in appearance and "creamy" in colour, it was condemned as damaged by the ship.

The Master, not being satisfied with this verdict, took a sample of this "cloudy" oil and placed it on a steam heater and gradually warmed it. As the temperature gradually rose the oil resumed the right colour. It was proved upon inquiry that during the passage the weather had been exceptionally cold, and the oil in the tanks being warmer had caused the tank to "sweat," and this mixing of a small amount of water with the oil had been sufficient to discolour it. Needless to say, the ship was absolved from blame.

Another way in which discoloration might occur is the mixing of another kind of oil which is darker in colour. For instance, if Dorada lubricating oil or Ruby oil was mixed with Spindle oil it would spoil it directly, because they are both of a much darker colour.

Generally speaking, the term "heavy oil" is given to all grades of fuel oil and also to creosote. Therefore, if a ship has been loaded with a light oil, her tanks are quite clean enough to load any heavy oil without further work.

To clean a tank for light refined oil after having in fuel oil, we proceed the same as before, with the exception that the second steaming and the second wash down are not required before washing the tank out with gas oil as before. To prepare a tank for fuel oil, after fuel oil has been in it before, it is only necessary to wash it down with the hose and dry it thoroughly; also see that rose boxes are all clear of refuse.

When a tanker is going into dry dock to have repairs in any tanks, it is necessary to have them "gas free." There are three ways in which the gas can be cleared. First, by steaming them out, and then putting a windsail into them. The best way to rig windsails for tank ventilation is to fit a fore-and-aft wire stay from mast to mast, which will pass over the tanks. On this stay fit one double block for each double tank by means of a shackle, to enable the block to be shifted along if required. The two sheaves of this block will be used for the two sets of windsail halyards. The second is to start the big air fan in the after pump room, and force the gas upwards by this pressure of air. The third way is to fill the tank with clean sea-water and overflow it, so that any oil that may be floating on top of the water will be pushed over the tank top on deck. This should never be done when a vessel is lying in a dock or enclosed harbour. An instance occurred lately in which a ship, after discharging benzine, overflowed the tanks into a dock. The benzine, which had been lying on top of the water in the tank, ran overboard and floated on the surface. A spark from a tug ignited the floating oil and the ship was immediately surrounded by flames.

This shows that overflowing tanks after an oil of a low flash point has been in them must only be done in open water, with no other ships in the vicinity.

Before the use of naked lights or red-hot rivets are permitted in a tank, the air in the tank must be tested by a chemist who comes aboard for that purpose. He issues a certificate, if he finds the different tanks are "gas free," which has to be posted up in a conspicuous place.

A few words about the "water test" for tanks in dry dock is wanted. Each tank in a ship has four sides, one top, and one bottom, and the only way in which we can find the leaks and mark them for repair is by filling a tank right up with water and having the next tanks on all sides of it perfectly dry. For an example, we will assume that No. 11 starboard tank is to be tested. Fill it right up to the top with water. Now we must have No. 12 starboard tank dry, to enable the forward bulkhead of No. 11 to be examined. We must also have No. 10 starboard dry to enable us to examine the after bulkhead of No. 11. We must also have No. 11 port tank dry for examination of the amidships bulkhead of No. 11. We can see under bottom if the tank bottom is leaking or not, and we can see from the outside if the ship's side of the tank is leaking, and by looking round the tank top on deck we shall soon discover if any water is coming from there, as the tank has been pressed right up to the top.

Every tank has to go through this process, and after one tank has been examined, and the leaks marked with chalk or paint, the water ballast is pumped to another tank for testing purposes.

It seems to be the general rule to have two double tanks full of clean sea-water ready for this tank-testing process. It is a good plan to send a man down to sweep a tank clean after the workmen have finished. He will generally find plenty of refuse, pieces of waste, etc., which would cause a lot of trouble when water is put in this tank again. While loading or discharging at night, it is not necessary to have any lights near a tank. The practice of shining a light down into a tank of oil should not be allowed, as the slightest spark may cause an explosion. The practice I always follow is to "sound" the depth of the oil with a small flat piece of wood attached to a line. The following hints may be useful. First find the correct depths of all the tanks from the plug hole to the bottom. This is easily done by the steel tape with the weight attached, or the carpenter's sounding rod can be used. Make a small wooden float about six inches in diameter. Into this put a small screweye and fit a small line (signal halyards will do) long enough to reach the tank bottom. Measure this line and mark it—a sail-twine mark at every foot, and a small strand let in at every five and ten feet.

When a sounding is required, lower the wooden float till it touches the surface of the oil. This can be felt immediately. Note the ullage by the marks on the line, and by subtracting this from the depth of the tank it shows how many feet of oil there is. I always use this method, whether by day or night, and find it much easier than any other system.

CHAPTER VIII.

DIFFERENT KINDS OF OIL.

A FEW words about the different kinds of oil to be dealt with in a tank steamer may be very useful. But I shall not say much on a subject which is best left to experts.

The kinds of oil generally carried are creosote, fuel oil, crude petroleum, lubricating oils, petroleum, gasolene, benzine, naphtha, and gas oil.

Each kind of oil has its own peculiarities. Some are much heavier than others, and some are much more dangerous than others by reason of the gas which arises from them.

When loading light oils which emit gas, always have the tank lids down. Leave the plug hole uncovered to allow the air to escape, as the oil comes in at the bottom from the pipe line; air and gas will come up through the plug hole, so great care is necessary.

Those oils which are gassey are generally carried in the forward tanks. Thus they are as far as possible from the stokehold, engine room and galley.

While loading naphtha, or any oil of a low flash point, all smoking and the use of naked lights should be forbidden on board. The gas emerges from the plug hole of the tank being loaded, and only a spark is necessary to cause an explosion. As soon as the tanks containing oil of this nature are finished, put on the plugs and screw down the tank lids securely. Each tank has an air pipe from the tank top through which gas can be released or kept in.

The plug should only be removed while the ullage* and temperature are being taken each day, and then screwed on again. With regard to smoking on a tanker, it seems to be the general rule that it is permitted in the cabins and forecastle and abaft the funnel on deck, but it is absolutely forbidden on deck or near the tanks.

Oil is always lighter than water, therefore if there is water in a tank it will always find its way to the bottom and the oil will remain on top. If loading light oils such as naphtha, kerosene, benzine, or gasolene, and the tanks are not properly filled up into the expansion trunk, then you would proceed to press it up with clean sea water, thus making the tank "secure" from rolling. It is quite a simple matter to do. With your pump draw from the sea delivery pipe and press the water along the pipe line to the tank you are pressing up. When the oil is high enough in the expansion of the tank stop the pump and close all valves. When discharging this tank,

*See page 51 for the definition of this term.

the water, being at the bottom, and thus nearest the suction, will be pumped out first, either overboard or into a settling tank ashore, whichever is ordered.

Water will not hurt light oils of this description. But there is no way of pressing up a tank of heavy oil. It is also impossible to press up a tank of lubricating oil, because any water or other liquid that mixes with it will spoil it at once. It is quickly detected in this case by the analyst who examines the samples taken from the ship's tanks, and the value of the oil drops accordingly.

With fuel oil the water takes much longer to reach the bottom of the tank, but it arrives there eventually. This water must be taken out first either by pumping it overboard or pumping it into a settling tank ashore, where the water can be drained off after it has properly settled at the bottom.

To have water in fuel oil in a vessel's bunkers will cause endless trouble, and probably result in putting the fires out till the water is got rid of and pure oil obtained.

A few words are required about testing tanks containing oil for water in the tank bottom. The procedure is that, on arrival at a discharging port, a representative of the consignees comes aboard, and with an officer, he goes round every tank, taking the ullage, temperature, specific gravity, and samples. He will also test the tanks for water in the following way :—A small line is used, long enough to reach the bottom of the tank, and attached to it is a small brass instrument about 2 feet long called a water finder. This instrument is marked in inches. A strip of litmus paper is fastened to this brass gauge by a sliding ring. It secures the litmus paper up and down the gauge.

It is then lowered to the bottom of the tank, and on being drawn up the litmus paper is examined, and if it is discoloured for any length it shows there is water in the bottom of the tank, and the gauge shows how many inches there is.

In water finding with a tank of light oil, a chalked sounding rod can be used. By chalking the rod well up its length and then lowering it to the bottom of the tank, it will be found on examination that the chalk marking is the same all the way down if there is no water there. But if the rod has been in water, it will be found that the chalk is much plainer, to the same height that it has been in the water.

This method only applies to light oils, and could not be relied on for heavy oils.

In searching for water in a tank of creosote, it will always be found at the top if there is any, because creosote being of a specific gravity of about 1·400 is much heavier than water. Consequently, when the tank has settled after loading, the creosote will be at the bottom and the water on top.

The standard temperature from which expansions and contractions of oil are measured is 60° Fahrenheit.

After discharging a cargo of refined oil into shore tanks, it is generally the custom to pump water through the shore lines till all the oil has been pressed into the tanks. Thus no oil is lost, and the shore pipe lines, from the tanks to the wharf, will remain full of water till they are used again. This is a very necessary precaution, because it would not be advisable to have oil of a low flash point lying in these lines. Also when disconnecting the shore hose, the only liquid that will run out will be water if this system is used. If there is water in the shore lines before loading, it will be found by testing the first tank which is filled on board the ship.

In some ports, it is the custom for an officer to go ashore and take the "dip" of the shore tanks before loading or discharging commences, and again after the completion. Always remember that shore tanks are measured by the "dip" or depth of oil, and not by the ullage. In "dipping" shore tanks, three dips are necessary to form an average, because often the bottom of a tank is "concave" and not flat. In taking these three dips, take them in a straight line across the tank, naming them, for instance, "East," "Centre," and "West."

CHAPTER IX.

FLASH POINTS, SPECIFIC GRAVITY, VISCOSITY, AND ITS EFFECTS.

As these are rather delicate subjects for an amateur to write about, I will describe them very broadly. First, we will deal with the flash points of the various oils dealt with in tankers. I think the explanation will be clearly understood in these words. The flash point of an oil is the temperature of the oil at which it gives off a gas which will explode immediately it comes in contact with a spark.

Thus different kinds of oil have different flash points. Taking fuel oil for the first instance, its flash point varies between 175° and 185°. In plain language, it means that the fuel oil has to be at a temperature of over 185° before it will give off gas which will explode or cause fire. If a ship has fuel oil in her bunkers at a temperature of 60°, it will have to be heated up to a temperature equal to its flash point before it gives a gas which will ignite. The lower the flash point the more dangerous the oil, because it will form gas to explode at a lower temperature.

Lubricating oils have a very high flash point, because their work is to lubricate machinery, and it would be dangerous to use oil which had a low flash point, because the constant friction of the machinery would heat it up till it took fire. Therefore it is essential, when carrying mixed cargoes, *i.e.*, different kinds of oil in different tanks, that no oil of a lower flash point, such as petroleum or gasolene, should ever get into a tank of lubricating oil. If it does get mixed, and the flash point of the lubricating oil is found to be below a certain standard, its value falls at once and it would quite probably have to be refined, thus causing great expense. This is determined by the analyst who examines the samples taken from the ship's tanks. Great care must be taken to see that the wrong valves are not opened by mistake, or that the pipe lines have any other oil in them before discharging this oil. Some ships have another precaution. Blank flanges are put in the pipe lines down below to ensure that no other oil can possibly get into the line close to the lubricating oil.

For light oils, such as naphtha, benzine, gasolene, or petroleum, the flash point will be much lower and therefore much quicker to take fire or explode. To give an instance of the difference. the flash point of naphtha is about 62 to 75. Therefore great caution is needed.

Now we come to the specific gravity of oil. This is really the ratio of weight of a cubic foot of oil to that of a similar quantity of fresh water. It is found by an oil hydrometer. A tanker carries hydrometers to measure all the different kinds of oil it is likely to carry. Generally speaking, the oil varies from ·650, which is very light oil indeed, to ·950, which is heavy oil. With the hydrometers usually supplied any liquid can be measured for specific gravity, from light oils up to sea water, which is the heaviest liquid we have to deal with. In an oil hydrometer, the small bowl at the bottom is filled with a certain quantity of mercury to float it at the required depth.

In all measurements for specific gravity, or S.P.G. as it is commonly called, fresh water is taken as the standard. Fresh water weighs 1000 ounces to the cubic foot, and fuel oil weighs from 900 to 925 ozs. per cubic foot, and coming to lighter oil we have lubricating oil which weighs about 860, and benzine which weighs about 780.

This immediately shows that oil is lighter than water. In calculating the S.P.G. it is the custom to name fresh water as 1·0, and the S.P.G.'s of the different oils as decimals. Therefore, fuel oil would be called from ·900 to ·925, and lubricating oil would be marked about ·860, and benzine ·780. These figures are only approximate, as the S.P.G. always varies in different grades of the same oil.

The S.P.G. of all oil varies at different temperatures. Thus, if the temperature is high, the oil will expand and become thinner, and so lighter per cubic foot, and if the temperature falls the oil will contract and become more solid and the S.P.G. will be higher. It may appear sometimes, when the temperature is high, that there is more oil in a tank, or it may appear when the temperature is low, that there is less oil in a tank. But the fact remains that there is the same weight of oil, and it is the specific gravity of the oil which is varying according to the temperature.

It is seldom that an officer is asked for the viscosity of oil, but it is handy to know. It can be called the fluidity of the oil. It is the speed at which the oil would run or drip through a small hole of very small size in the viscometer. It is generally tested for viscosity by Redwood's No. 1 viscosity finder. But this is a subject for analysts and experts.

CHAPTER X.

MEASUREMENT OF TANKS, TAKING ULLAGES AND FINDING QUANTITIES.

When a ship is built, all spaces are measured for their cubic capacity and when an oil tank steamer is built all the tanks are measured for their cubic capacity. A set of calibration tables are then made out, which show exactly how much each tank holds at any depth to which it is filled. In the measurement of a tank, everything contained in it which takes up any space has to be deducted, to arrive at the correct cubic space that is contained.

Thus, there are deductions for the pipe lines, and the cubic capacity of their interiors, which is considerable, seeing that they are 14 inches in diameter. There are also deductions for suction pipes, steam coils, valve spindles, gusset stays, and channel irons; in fact, everything which takes up any room has to be allowed for. When this calculation has been made, it is possible to make out the correct calibration table for each tank. This table is made out to inches, and by its use can be found exactly how many cubic feet of space is filled in each tank.

In measuring the cargo in any tank, the

measurement is taken by a steel tape line graduated to eighths of an inch, and it is measured from the centre of the plug hole in the tank lid to the surface of the oil in the tank. This measurement is called the ullage. It is the measurement of the vacant space between the surface of the oil and the centre of the plug hole. To be absolutely correct, the ship should be upright and on an even keel. On obtaining the ullage, and looking at the scale of the tank we are measuring, we take the cubic feet corresponding to the ullage, and this is the number of cubic feet which is actually filled with cargo.

To calculate the weight of cargo a tank contains is very simple. Having found the ullage and the corresponding cubic feet of space that is filled (from the tables), take a sample of the oil, and with the hydrometer find its specific gravity and temperature. These are all the elements needed. Multiply the number of cubic feet by 997 and by the specific gravity and the result is ounces.* Bring the result to tons, and the calculation is complete. There are several methods in use for doing this calculation. One way is shown in the petroleum tables. Another way is by logarithms, which is given as an example.

Find the mean ullage of both sides of a tank. Take the number of cubic feet from the calibration tables corresponding to this ullage. Take out the logarithm of this number of cubic feet. Add this log.

* 997·136 ounces in a cubic foot of pure fresh water.

to the logarithm of 62·321 (which is the weight in pounds of a cubic foot of distilled water). Add this to the log. of the specific gravity, and subtract the log. of 2240; the result is the logarithm of the number of tons required.

Practical Example.—Let the capacity of the oil in the tank be 16,000 cubic feet, and the oil benzine with a S.P.G. of ·780, then,

Log. of number of tons of oil in tank

$$= \log. 16000 + \log. 62{\cdot}321 + \log. {\cdot}780 - \log. 2240$$
$$= 4{\cdot}2041200 + 1{\cdot}794634 + \bar{1}{\cdot}8920946 - 3{\cdot}3502480$$
$$= \quad 2{\cdot}540601$$

From a book of logarithms this log. will be found to correspond to the number 347·2, which is the number of tons of oil in the tank.

Here is another way, much shorter, and very accurate. Take the specific gravity (which in this case is ·780) and multiply it by 997. Divide this by 35,840, which is the number of ounces in a ton.

```
            ·780
             997
            5460
           7020
          7020
35840)777660(·021698 constant
      71680
       60860
       35840
       250200
       215040
        351600
        322560
         290400
         286720
```

Thus ·021698 is the constant, or ·0217 if worked to four decimal places, and this remains the "constant" while calculating oil of ·780 specific gravity.

Next, multiply the number of cubic feet (which the ullage has given from the calibration tables) by this constant, and the result is the number of tons of oil in that tank.

Here is the formula, and a worked example :—

$$\text{Cubic feet} \times \frac{\text{S.P.G.} \times 997}{35{,}840 \text{ ozs.}} = \text{tons of oil in tank.}$$

Here is the previous example worked by this method :—

$$16{,}000 \text{ cubic feet} \times \frac{\cdot780 \times 997}{35{,}840} = \text{tons of oil in tank.}$$

16,000 cubic feet
·0217 constant
———
112000
16000
32000
———
347·2~~000~~ tons of oil in tank.

Thus while calculating the weight of the oil of the same S.P.G., the constant will remain the same, viz. ·0217. If the oil is of a different specific gravity, find the right constant first, by the procedure given above, and multiply the cubic feet in the tank by the new constant, which will give the tons of oil contained in the tank to the fourth decimal place.

I think this is the shortest (and equally as accurate) method of any on the market.

There is nothing to go wrong and nothing to be puzzled about. A set of tables calculated from this formula is inserted at the end of this book, from a specific gravity of ·500 to 1·025. It will thus serve to calculate the weights of all oils, and also fresh and salt water.

When samples of oil are taken from a tank, it is the general rule to take it from the top, middle, and bottom of the tank. These are then mixed, and the mean specific gravity taken. To a beginner, it is rather puzzling how a sample can be taken from the middle or bottom of a full tank of oil, so I will briefly describe the procedure.

A small can, holding about a pint, is used. This can is weighted in the bottom with lead to make it sink. A small line is made fast to the handle, long enough to reach the tank bottom. A special cork is fitted into the can, the cork having an eye screwed into it, to make the cork lanyard fast to. This lanyard is about a foot long. The other end of this cork lanyard is made fast on the line, about 2 feet from the handle of the can. The cork is then fitted tightly into the can. Thus the line is slack between the place where the cork lanyard joins it and the can handle, and when lowering into the tank the cork lanyard has the weight of the can. The cork being in tight no oil can enter the can until it reaches the required depth, and then a sharp jerk on the line pulls the cork out, and the can fills with oil at this depth. The same procedure is used to get a sample from the bottom of the tank.

CHAPTER XI.

FLEXIBLE HOSES AND THEIR CONNECTIONS.

A FEW words must be said about the hoses and their connections with which the ship is connected to the shore pipe lines for discharging or loading.

There are three different kinds of hoses in general use. First, there is the copper-bound flexible hose. This is formed by strips of copper or similar material joggled together very tightly to make it perfectly oil tight. It will bend in any direction, but great care must be used to see that no kinks get into it or that the turns should not be made too sharp.

Otherwise the pressure of the oil, being forced through by the pump, would burst the hose if there was too sharp a turn or a kink in the hose; this applies to all oil hoses.

The second kind of hose is the flexible steel hose, which is formed by strips of malleable steel joggled tightly together, and is oil tight.

The third hose in general use is the wire spring hose, which is formed by turns of steel wire tightly bound together and covered with many turns of canvas.

On each length of hose, at both ends, they are fitted with flanges, to enable them to be connected to the flanges of the next hose, or to be connected with the ship's deck delivery line, or to the shore pipe line. These flanges have $\frac{5}{8}$-inch holes in them, to enable them to be connected to the flanges of the next hose with bolts and nuts.

Sometimes to connect a hose to a pipe line clamps are used, which clamp the flanges of the hose to the flange of the pipe line, and packing is inserted between the two flanges to make the joint quite tight.

It is best to have a derrick swung out to plumb the hose, and a tackle from the derrick head to a strop round the hose, to keep the weight of the hose which is outside the ship from dragging down and chafing on the sharp edge of the covering iron. The hose should be kept as nearly level as possible, with the rigid pipe line it is connected to, so that the oil may enter the hose in a perfectly straight direction.

Sometimes it happens that the hose and pipe line are of different sizes. In this case a reducing piece is necessary to join the two together.

The sizes of the reducing pieces in general use are 9 inches to 6 inches, 8 to 6, 8 to 5, 6 to 3, and 5 to 3. The name explains their use, viz. to reduce the size to fit a smaller hose. These are all fitted with flanges and are secured by bolts or clamps.

Another fixing of a similar description is the adaptor pieces. These are used for exactly the same purpose as reducing pieces, but instead of having flanges at the ends they are fitted with a screw and a collar, and are tightened up by means of a spanner or key, which is supplied with them.

These are generally used by tankers in Government service. The ends of these adaptors are generally named Male or Female.

CHAPTER XII.

BLANK FLANGES IN PIPE LINES.

Blank flanges are circular plates of brass or iron which are fitted between the flanges of a pipe line to entirely block it up.

The pipe lines are composed of many lengths of pipe, of the same diameter, and at both ends of each length are flanges, with holes drilled in them, to fit the bolts, which connect each length with the next.

To fit a blank flange into a pipe line, it is necessary to take out the bolts which connect the two flanges together, and force the two lengths apart far enough to allow the blank flange to be inserted between the two pipe flanges. The pipes are then forced back into their proper position, and bolted together again, the blank flange having holes drilled around its edge for the bolts to pass through when the two pipes are being connected together.

The idea of a blank flange is to divide a pipe line so that there is no possibility of oil which is in one section of the line leaking through into the next section.

A careful study of diagram No. 4 will show the actual positions of blank flanges which are in a certain ship at the present time.

It will be noticed she is a ten-tank ship (the tanks being numbered (from aft), and is about five years old, and carries 9500 tons. She has three pumps, one forward and two aft. The space on the port side of the forward pump-room being used as a cofferdam, and no cargo carried in it.

This ship was engaged carrying mixed cargoes of refined oil. Nos. 1, 2, and 3 were used for kerosene, Nos. 4, 5, 6, and 7 being reserved for lubricating oils, and Nos. 8, 9, and 10 being used for either naphtha, benzine, or kerosene.

It will at once be seen how necessary it is to prevent the light oils contained in the three forward tanks, from leaking into the next four tanks, or their pipe lines, which pass through them; and it is equally important to keep the light oils in the three after tanks from leaking into Nos. 4, 5, 6, or 7. The blank flanges in the diagram are marked "BF" to make them conspicuous. Some ships are fitted with a master valve in the pipe line, at the after end of each tank, and these are fitted for the same reason, *i.e.* to prevent any oil leaking into another section of the pipe line, which contains different oil. These master valves are much handier than blank flanges, and can be opened or shut without trouble by their valve spindles on

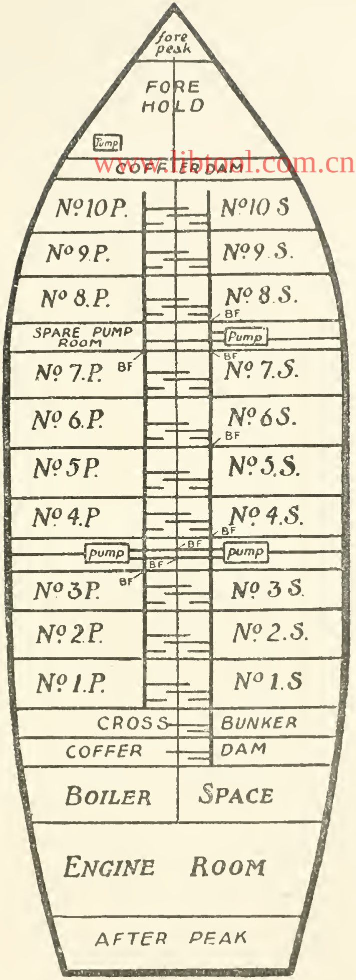


DIAGRAM No. IV.—Ten-tank Ship, with eight Blank Flanges in the Pipe Lines. Blank Flanges marked "BF".

deck, but if they should not be perfectly tight, either through wear and tear, or through the labouring of the ship, then the blank flange is safest.

In the diagram before us every possible precaution is taken to prevent any mixing of light oils with the lubricating oil in Nos. 4, 5, 6, and 7 tanks. There is an empty compartment on the forward side of them, formed by the forward pump-room and cofferdam, and a similar empty space on the after end made by the pump-room.

The first thing to note is that the four middle tanks, Nos. 4, 5, 6, and 7, can only be pumped out by the port after pump, and using the port pipe line and port suctions.

It would be useless to attempt to draw from these tanks by the starboard line, because there is a blank flange in the starboard lines at the after end of No. 4 tank. The two blank flanges at the forward end of No. 7 tank on both lines prevent any oil being drawn from the three forward tanks by the after pumps. And again, the port after pump cannot draw from the three after tanks, Nos. 1, 2, and 3, because the blank flange at the forward end of No. 3 tank, on the port line, entirely blocks that line from the pump; and the two blank flanges in the crossover line, in the after pump-room, make any accidental mixing an impossibility.

To explain the reason for the blank flange at the after end of No. 6 tank on the starboard line, it is necessary to explain that this ship carried different kinds of lubricating oil, and these must be kept apart from each other. In Nos. 4 and 5 tanks, "Spindle" oil was carried. This is a very light and expensive oil, used for lubricating light and delicate machinery, and its colour is light yellow. In the next two tanks, Nos. 6 and 7, Dorada or Ruby oil was carried. These are much heavier oils, and of a dark purple colour. So in the event of these oils being mixed, the Spindle oil would be discoloured and made heavier, which would ruin its utility for lubricating very delicate machinery.

In loading these two different kinds of oil, the pipe lines at the bottom of the ship were not used. Two hoses from the shore were put aboard, and the one for Spindle oil was put in the top of No. 4 tank, starboard side, whose lid was raised. The green valves on Nos. 4 and 5 tanks were then opened, but no red valves.

Thus No. 5 starboard tank would be filled through the starboard suctions on the starboard line. The oil running from No. 4, which was being filled over all by the hose, into the starboard line, and thus through the suctions in Nos. 4 and 5 port tanks. Thus the starboard line and suctions only were used, the port line being kept "clean" ready for discharging.

The hose for the Dorada oil was put in the top of No. 6 tank, whose lid was raised on the starboard side By opening the green valves on Nos. 6 and 7 tanks, the oil, which was being loaded through the hose over all into No. 6 starboard tank, ran into the starboard line through the open suctions in No 6 starboard, and thus filled Nos. 6 and 7 port through the port suctions on the starboard line, and No. 7 starboard through the starboard suction in that tank. In this case also the port line and red valves were not touched, thus ensuring the port line being "clean" for later use. So it will be seen how handy and necessary it was to have the blank flange at the after end of No. 6 tank, because it completely stopped the Dorada oil in Nos. 6 and 7 tanks, and also in the starboard pipe line in these two tanks, from penetrating along the starboard line and entering Nos. 4 and 5 tanks.

In discharging these oils, the "Spindle" oil would be pumped out first, if possible, while the line was "clean"; and to guard against the possibility of the line being "dirty," the first few barrels to come up through the deck delivery line would be carefully kept by itself, till inspection showed that the pure Spindle oil was coming out, and no discoloration showing.

If discharging lubricating oil into lighters, it is very necessary for an officer to go into the barge's tanks and inspect them, to make sure there is no dirt or drainings of other oils left in there. If this happened, when the analyst's sample from the barge was examined he would soon detect that other oil was mixed with the lubricating oil, and it would immediately drop in value. Next, looking at tanks 1, 2, and 3, it will be seen that only the starboard after pump can work them, and only by the starboard line and starboard suctions. The port after pump could not touch them because of the blank flange at the forward end of No. 3 tank, on the port line, and the blank flanges on the cross-over line in the after pump-room prevent any drawing from the starboard line by the port pump. The after cofferdam is pumped out by the starboard pump and starboard line only. This ship had no crossover lines in the forward and aftermost tanks, like the newer ships. We have now only tanks 8, 9, and 10 left to explain, and these can only be worked by the forward pump, which is situated on he starboard side. The port line and port suctions will be used, and then the oil or water will be drawn through the crossover line to the pump. From the pump it goes upwards through the pump delivery line into the deck lines. In this ship the shore delivery lines were abreast of the after pump-room, both sides. The deck line from the forward pump-room came along the main deck, and connected to the shore delivery line outside the after pump-room, and by means of the different lines, crossover lines, and valves, oil or water could be pumped either ashore or down through the after pump-room into the after tanks if required.

A study of this diagram, and a comparison with that of the more modern ship of twelve tanks, will show that as experience is gained and embodied in the new ships, so they become handier and more simple to understand.

I was with this ship in dry dock, and having two double tanks of water aboard for tank-testing purposes, I will describe how the ballast was shifted from tank to tank. I will give the most complicated examples it was possible to find. The water in No. 10 starboard had to be shifted to No. 9 port. Having only the port line to work with forward, red valves only were used. Open No. 10 starboard suction on the port line, and open No. 9 port suction on the port line. The water will now run into the port line from No. 10 starboard, and will run into No. 9 port, whose valve is open. When the two tanks have run level it will stop. Next shut the open valve on No. 9 tank, to keep that water in there while we draw from No. 10 starboard. The water has now to be drawn from No. 10 starboard till it is empty, but as it is impossible to draw and deliver on the same line, in the same direction, at the same time, we must find an empty tank to put this water in, that is clear of the line we are drawing on. So we select No. 2 starboard tank, which is empty, to put this water in temporarily. Draw from No. 10 starboard through the port line and crossover line to the forward pump, set the valves in the pump-room to send the water up through the pump delivery line and into the deck line, then bring it along this line till abreast of the after pump-room, and by setting the valves there, divert it down into the after pump-room, starboard side, from there into the starboard line, and by opening the starboard suction of No. 2 tank on the starboard line, the water will go into No. 2 starboard tank. When No. 10 starboard tank is empty, shut the valve to prevent water going in there again. Next proceed to draw the water from No. 2 starboard with the starboard after pump, send it up on deck through the pump delivery line, then forward through the deck line, and down into the forward pump-room through the pump delivery line, through the crossover line, into the port line, and by opening No. 9 port suction on the port line the water will fill the required tank. It may seem a roundabout way to some, but it is the best possible way in which it could be done in a dry dock, and where the same water is required to test other tanks. If the ship was afloat, the water from No. 10

starboard could be pumped overboard till the tank was empty, and then shutting No. 10 starboard valve and opening No. 9 port, and drawing water through the sea delivery and sea valve from outside, and pumping it through the crossover line and along the port line, the same result would be attained. Another complicated instance is the shifting of ballast from No. 8 starboard to No. 7 port. The following procedure is necessary. Open the No. 8 starboard suction on the port line and draw the water down the port line and through the cross-over line to the forward pump, send it up on deck through the pump delivery line into the deck line, bring it along the deck till abreast of the after pump-room, and by means of the crossover line on deck send it down into the port after pump-room by the pump delivery line into the port line, and by opening the No. 7 port suction on the port line the water will fill the required tank.

These two instances are about the hardest and most complicated examples that can be found on this diagram, and by a careful perusal the reader should have no difficulty in understanding these movements. Of course the right valves must be opened, and it should always be a rule when first joining a ship to inquire whether the valves are right-handed or left-handed, and also inquire whether the tanks are numbered from forward or from aft, because both systems are in force in different ships.

Notice the small pump situated forward on the port side, which is used for pumping out the fore-peak, fore deep tank (under the fore hold), and the forward cofferdam. In both the given examples of shifting ballast an alternative method could be used, by connecting on a hose to the deck delivery line outside the forward pump-room and putting down the other end into the tank it was required to fill; but this vessel had no hoses of sufficient length to do this.

CHAPTER XIII.

SHIP WITH SMALL PUMP-ROOM.

In this chapter an eight-tank ship is described, carrying about 7000 tons, nine years old, and engaged principally in the carriage of petroleum and benzine. As there are a good many tankers built on this system, a full description is necessary to satisfy those who are sailing in this class of ship. Diagram 5 (overleaf) has been drawn to show the side view, as only by a side view can the peculiarities be seen.

The outstanding feature, which is at once noticed on studying diagram 5, is that the pump-room does not extend to the bottom of the ship, but only extends about half-way down, and it is situated in No. 4 tank. Also, it is noticed that the pump-room has no sea delivery line and sea valves situated in it, and the pipe line is not continuous along the bottom of No. 4 tank.

A description of the sea delivery line and sea valves are given first. The sea suction and valves are situated in the side of the after cofferdam, nearly at the bottom. The sea delivery line starts from here and goes upward in a vertical direction till it reaches the level of the summer tanks, and then turns forward and along the bottom of the summer tanks till it reaches the forward side of No. 5 tank; it then turns downwards into the pump-room, where it is connected to the pumps. I have heard two reasons for this arrangement. First, that the risk of water from the sea line getting into the cargo tanks is eliminated. Secondly, these ships carry fuel oil in both the forward and after coffer-dams. Therefore the bulkhead at the forward end of No. 8 tank (the after one in this ship) is not pierced at all, and the risk of getting fuel oil into the "clean" tanks is nearly nil.

It will be noticed on studying the diagram that there is a master valve at the after end of each tank except No. 8. Thus each tank and its section of pipe line can be completely shut off from the next.

The ship has two pipe lines and two pumps, and two sea delivery lines, just one-half of her complement being shown to facilitate explanation. Supposing we are looking at the ship from the starboard side, the master valves which face forward would appear as a straight line, as on the diagram.

The tank valves, marked "TV," would not be seen, being closer to amidships than the starboard pipe line, but, to give their approximate position with the master valves and pipe line, they are

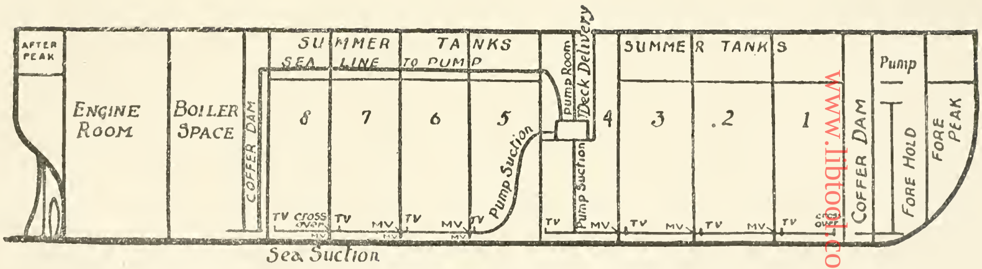


DIAGRAM No. V.—Tanker with Small Pump-room. Position of Summer Tanks shown; also position of Tank Valves and Crossover Lines.

inserted. There are crossover lines in the forward tank No. 1 and the after tank No. 8. Note that in this ship the tanks are numbered from forward to aft, and all the valves are right-handed. Hence it is always necessary to inquire about these details when first joining a fresh ship. There are also two crossover lines in the pump-room, by which oil or water can be diverted from one line to the other. The pump delivery line will also be noted, to understand how the oil or water reaches the deck from the pump-room. The pipe lines pass through the different tanks exactly the same as in the twelve-tank ship, with the exception of No. 4 tank. Here, it will be seen, the pipe lines branch upwards and enter the pump-room through the floor. With this arrangement it is not easy to shift oil or water from tank to tank without pumping, and therein is the drawback to this system. It is quite easy to run tanks 1, 2, 3, and 4 into each other, or 5, 6, 7, and 8 tanks into each other, till they become level, but then the pump would be necessary. For instance, shift the water in No. 1 tank to No. 2, and use the starboard line to draw with. Open No. 1 and No. 2 green valves—that is, the port and starboard suctions on the starboard line. The water from No. 1 will enter the starboard line through the open suctions, and running along this line will enter No. 2 through the open suctions there, and it will continue to run like this till the two tanks are level. Now shut the green valves in No. 2 to keep that water in there, and start to draw from No. 1 by the starboard line to the starboard pump. Set the crossover valves in the pump-room, so that the water from the pump delivery goes into the port forward line, and by opening the red valves on No. 2 this tank will be filled by the port line. It would be quite easy to shift water from the forward tanks to the after tanks or *vice versa* by either line, because the pump comes in between the line we are drawing on and the line we are delivering on. The procedure for shifting water from one after tank to another after tank will be same as is used forward. Shift No. 8 to No. 6, and use the port line to draw with. Open the red valves on No. 8 and No. 6, and the water from No. 8 will run along the port line till it comes to the open suctions on No. 6, and it will continue running like this till the two tanks are level. Now shut the red valves on No. 6 tank, and draw the water along the port line by the port pump. Set the crossover valves in the pump-room to divert the water into the starboard after line, and by opening the green valves on No. 6 tank the water will be pressed in there by the pump. A simple hint to remember when working ballast like this, is to use opposite colour valves for delivering to what are being used for drawing. In this diagram the position of the summer tanks are plainly shown, and these have their own little pipe line and suctions, similar to the twelve-tank ship. These summer tanks are filled from the deck lines, and not pressed up from the pipe lines in the bottom of the ship. In the big ships also it is possible to load the summer tanks from the deck line by manipulating certain valves. But in the case of summer tanks, every ship seems to have a peculiarity of its own regarding the filling and discharging of these tanks. At the side of the pump-room there is a discharge pipe through which ballast is pumped overboard.

There is a small pump situated at the side of the forehold, which is used to pump out the forepeak, fore deep tank or bilges (under the forehold), and the forward cofferdam. The after bulkhead of this cofferdam is not pierced by any pipe, the fuel oil which is carried here is pumped up on deck through a small fuel pipe which runs right along the deck, and then down into the side bunkers aft. The fuel oil in the after cofferdam is taken out by a small pipe which pierces the after bulkhead and leads through to a small pump situated near the boilers. The forward bulkhead of this cofferdam is oil-tight.

The position of the pump-room in this ship is very favourable when carrying oils which give off a lot of gas. Being high up, it escapes from a lot of the gas which would penetrate into it if it were situated at the bottom of the ship. In all respects the pipe lines are arranged the same as a twelve-tank ship, with the exceptions which have been fully explained.

CHAPTER XIV.

OIL TANKERS WITH ONLY ONE PIPE LINE.

As there are a good many old tankers still in service, ranging from fifteen to thirty years old, it is necessary to include a chapter on them to supply the information for those who are serving in these ships. The description and diagram No. 6 are the correct details of a tanker, thirty years old, and one which has done much useful work during the war, acting as a fuel-oil depot ship for supplying big ships and destroyers. She had six tanks, each holding about 600 tons, and the pump-room was situated between tanks Nos. 3 and 4. In this ship the tanks are numbered from forward to aft and all her valves are right-handed, which is just the reverse to the latest modern ships. There is no sea suction or sea delivery line in the main pump-room, but there was a little ballast pump-room, situated at the after side of No. 6 tank, with the sea delivery line and sea valve on the starboard side. The main pump delivery lines came up on deck at the after side of the main pump-room, and hoses were fitted on to it to discharge either side. For the big ships two five-inch hoses were connected on, but when oiling destroyers two three-inch hoses were connected on by reducing pieces, having a five-inch connection at one end and a three-inch at the other. The valve spindles on deck were painted the same colour as in a modern ship, viz. red for port and green for starboard, but having only one pipe line in the bottom of the ship; there were only two valves to each double tank.

When loading, we connected the hose on to the pump delivery line, just outside the pump-room, and by means of the valves in the pump-room and tank valves, we could guide the oil along either the forward or after section of the pipe line, and into whichever tanks we required to fill, by means of the tank valves. With ballasting, everything was simple work. By opening the sea valve on the sea delivery line, the water came to the ballast pump, which sent it along the pipe line and into the tank, whose valves were opened. The shifting of oil or water from tanks Nos. 1, 2, or 3 to 4, 5, or 6 is quite simple, because the pump is in between the lines you are drawing on and delivering. For example, shift water from No. 1 starboard tank to No. 6 port tank. Open the green valve on No. 1, and draw the water along the line to the pump (either one will do) and deliver it along the after pipe line; and by opening No. 6 red valve the water will enter this tank through the open suction.

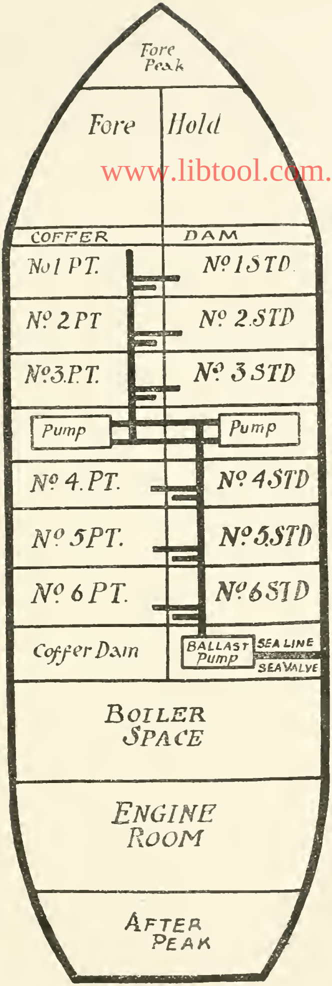


DIAGRAM No. VI.—Old Tanker, thirty years old. Only one Pipe Line; no Sea Line or Valves in Pump-room.

It is an entirely different matter to shift water or oil from No. 3 to No. 1, or from No. 4 to No. 6. For example, shift water from No. 3 to No. 1. If any of the after tanks are empty, it will be an easy matter. Open the valves on No. 3 and No. 1. The water from No. 3 will now enter the pipe line and fill into No. 1 through the open suctions. This will continue till the tanks are level. Shut the valves on No. 1 to keep that water in there till we have drawn all the water from No. 3. Draw from No. 3 to the pump, and deliver the water along the after line into the empty tank we are using temporarily. When No. 3 is empty shut the valves to prevent water going in there again. Draw the water from the after tank we are using to the pump, and deliver along the forward line and it will be pumped into No. 1, because these are the only valves which are opened. The same method is applicable when shifting oil or water from No. 4 to No. 6, or *vice versa*. In this case open the No. 4 and No. 6 valves, and let the water run level, then shut the valves on No. 6, and draw the water from No. 4 to the pump. Deliver it along the forward line, and by opening the valves of an empty tank along this line the water will be pumped in there, till the No. 4 tank is dry. Shut the No. 4 valves, and then start drawing along the forward line to the pump from the tank you have been using. Deliver along the after line, and by opening the valves on No. 6 it will go in there through the open valves. A study of these movements on the diagram will show how simple it is once the right method is learned.

Now, another problem presents itself. We will suppose there is no empty tank on the other side of the pump to put the water or oil into. A different procedure is necessary. For an example we will suppose you require to shift the oil in No. 1 tank to No. 3 tank, and all the after tanks are full. Open the valves on No. 1 and No. 3, and the oil will run along the pipe line and into No. 3 till the two tanks are level. Next shut the No. 3 valves to keep the oil in there. Draw the oil from No. 1 tank to the pump, and set the valves to deliver up into the deck delivery line. Have the oil hose connected on to the deck delivery line, and put the other end of the hose into the top of No. 3 tank. Then pump away, drawing it out of No. 1 by the pipe line and putting it into No. 3 through the hose on deck. This is the only way it can be done, because, as has been stated before, it is impossible to draw and deliver on the same line, in the same direction, at the same time. These are the hardest examples it is possible to find in a ship with only one pipe line, and for that reason I have fully explained them.

In the older class of tankers there are hardly two whose pipe lines and pumping arrangements are the same, every one of them differing in some respect, but the position of the pump-room is the principal thing to be studied in cases like I have mentioned. If the main pump-room was situated at the after end of No. 6 tank, then it would not be possible to shift oil or water from No. 1 to No. 3, as has been described in this chapter; also the procedure of shifting from No. 4 to No. 6 would have to be altered. The solution of this problem of shifting from No. 3 to No. 1 is as follows:—

Open No. 3 and No. 1 valves and let the two tanks run level. Then shut the valves on No. 1 and put the hose (which is connected on to the deck delivery line) into the top of No. 1 tank. Start to draw from No. 3 with the pump, and set the valves in the pump-room to send it up through the pump delivery into the deck line. It will then pass along the hose and fill No. 1 from the top. This is the only way it could be done when the pump-room is situated at the after end of all the tanks. I hope I have now made the working of a one pipe-line ship perfectly plain.

CHAPTER XV.

EIGHT-TANK SHIP. ONE SUCTION ONLY IN EACH TANK.

As there are many vessels of this type, or very similar, in the oil-carrying trade, this book would not be complete without a chapter devoted to them.

In the first place, it is noticed that the pipe lines are exactly the same as in diagram 2, but there is only one suction from the pipe line in each tank.

There are four crossover lines, viz.: one in No. 1 tank, two in the pump-room, and one in No. 8 tank. It will be noticed that the longitudinal bulkhead is only pierced by the crossover lines, and not by any suctions, as shown in diagrams Nos. 2, 4, and 5.

The pump-room is situated between No. 4 and No. 5 tanks, and is practically in the middle of the cargo tanks. There is also a cofferdam at the forward and after ends of the cargo tanks to prevent any leakage of gas or oil through to the forehold or stokehold.

In this class of ship the crossover lines are used very frequently, and a study of the diagram will

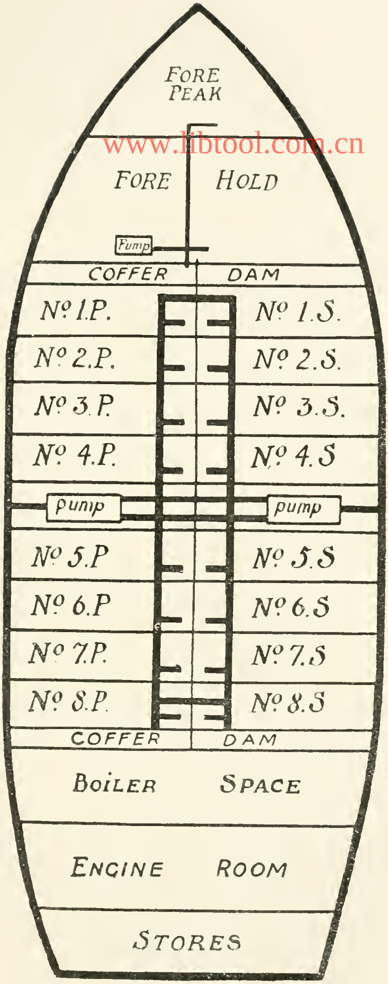


DIAGRAM No. VII.—Eight-tank Steamer, with one Suction only in each Tank

show how necessary this is. It would be quite simple if each pump pumped out the side it is situated on, and also worked at exactly the same speed and output. But there are many occasions when it becomes necessary to use one of the pumps to discharge or load a tank on the opposite side, and then it becomes necessary to use the crossover lines. There are master valves situated on all the crossover lines, exactly in the middle of the ship, and also at the after end of No. 4 tank, both sides, and at the forward end of No. 5 tank on both sides. By shutting these four master valves the pump-room can be entirely isolated from the tanks.

One system of working this type of vessel would be to use either the port or starboard pump for the forward section of tanks, and the other pump to be used for the after section of tanks.

For the first example, suppose No. 1 tank, both sides, is to be discharged with the starboard pump. See all tank valves are closed except No. 1 valves, both sides. Open the master valve on the crossover line in No. 1 tank. Shut the master valve at the after end of No. 4 tank, port side. Open the master valve at the after end of No. 4 starboard tank, and shut the master valve at the forward end of No. 5 starboard tank. The forward section of the starboard line is now all clear for the pump to draw from No. 1 tank, both sides, and by shutting the master valves we have stopped the oil or water from entering the port pump or any part of the after section of pipe line.

The oil in No. 1 port tank will now enter the suction and thence into the pipe line, being then drawn through the crossover line into the starboard pipe line and then to the starboard pump.

In discharging any of the port tanks in this forward section the crossover lines in the pump-room could be used. Taking the same example as before—*i.e.* to discharge No. 1 tank, both sides, by the starboard pump and using the pump-room crossover line—we should proceed as follows :—

Shut the master valve at the after end of No. 4 starboard tank. Open the master valve on the crossover line in No. 1 tank. Open the master valve at the after end of No. 4 port tank. Shut the master valves in No. 5 tank, both port and starboard. Open the master valve on the forward crossover line in the pump-room. Also close the valve on the line leading to the port pump.

This procedure would be a more complicated way, but it would apply to any of the tanks Nos. 1, 2, 3, and 4 when using the starboard pump only.

Either section of tanks, both forward and aft, could be discharged or loaded by either pump, and it is just a question of opening or shutting the right valves.

By setting the valves properly it is possible to pump right around the whole of the ship. For instance, we could draw from No. 4 port tank, using the starboard pump as before, along the forward section of the port line, then through the forward crossover line and down the starboard line to the starboard pump, which could then send it along the starboard line, after section, till it came to the after crossover line in No. 8 tank. Passing through this it would come into the after section of the port line and thence into the port pump-room, where it could be sent on deck by the pump delivery line.

By studying the diagram the reader can trace every movement thus described, and can at once understand which valves should be shut and which should be opened.

In loading this type of ship the procedure would be similar to those already described. The oil would enter the deck lines from the shore, and by means of the deck valves bring it to the pump delivery line, and down into either pump-room as desired. Divert it into whichever pipe line is being used, and then into the tanks by their respective suctions.

When ballasting open the sea valve in the pump-room, on the same side as the line which is to be used. Let the water enter the pipe line, and by means of the valves direct it to the tank to be filled. When it has run up to sea-level it will stop, so lead it to the pump, and press the water up to the required level in the tank.

The pipe lines, crossovers, and sea line in the pump-room of these ships are very similar to those shown on diagram No. 3. There may be a little difference, but the principle will be the same.

A small pump is installed at the port side of the forehold to pump out the forepeak, fore deep tank (situated under the forehold), and forward cofferdam.

CHAPTER XVI.

TANK STEAMERS WITH ENGINES AMIDSHIPS.

THE majority of vessels carrying oil in bulk as cargo have their boiler space and engine-room situated at the after end of the vessel. This certainly seems to be the safest arrangement, because when carrying dangerous cargoes, such as benzine or other oils of a low flash point, the danger of any gas coming into contact with the fires either in the stokehold or galley is confined to one end of the ship.

In the tankers with the engines and boilers situated at the after end of the vessel the cargo in the nearest tank is always separated from the stokehold by a cofferdam, and in some ships an oil-fuel bunker as well.

At sea the speed of the vessel through the water will tend to draw the smoke and sparks from the funnel towards the stern, where there is the least danger of ignition of gas by sparks. The galley fire, being the only open fire on deck, is situated abaft the funnel as far as possible, thereby reducing the risk of explosion from this source. Therefore it is safest for these reasons to have the engines, boilers, and galley at the after end of the ship.

Some tankers have been constructed with their engines and boilers amidships, and as the forward section of tanks is entirely isolated from the after section, it is necessary to explain their working and show the pumping arrangement by diagram.

Looking at diagram No. 8, it is seen that there are four cargo tanks situated at the forward side of the forward pump-room, and also four cargo tanks on the after side of the after pump-room. These two pump-rooms act as cofferdams or vacant spaces between the stokehold and tanks on the forward side and the engine-room and tanks on the after side.

Some of this class of vessels also have a cofferdam situated between the pump-rooms and stokehold and engine-room. They also have two other cofferdams, one situated at the forward side of No. 1 tank and the other at the after end of No. 8 tank.

Some of these vessels have two pumps for the forward section of tanks, and two pumps to work the after section. Others have only one pump at each end of the ship. It will be seen by the diagram that the pipe lines, suctions, and crossover lines are similar to those described in Chapter III.

The only awkward point in these ships is when cargo or ballast has to be shifted from either of the forward tanks Nos. 1, 2, 3, or 4 to one of the after tanks Nos. 5, 6, 7, or 8, or *vice versa*. For

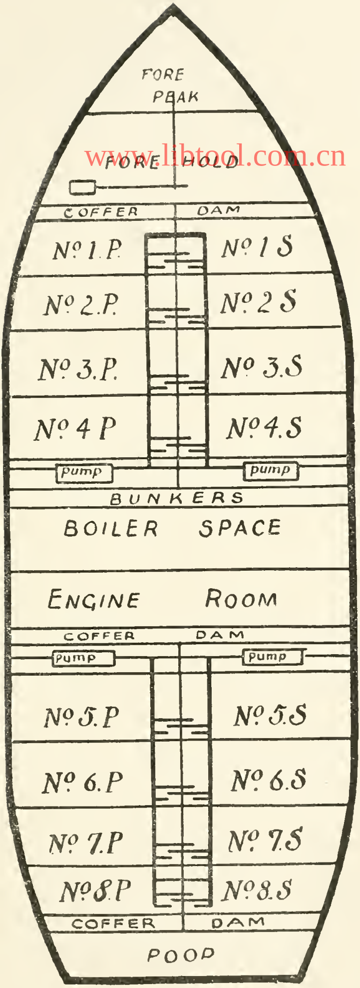


DIAGRAM No. VIII.—Tank Steamer with Engines Amidships.

this purpose it is necessary to use a deck pipe line, which will connect the two pump-rooms. This deck line is sometimes fixed, and in some ships a temporary line is fixed for use in harbour.

This deck line, being connected to the deck delivery line from the forward pump-room, then passes upwards to the bridge deck. Passing along the bridge deck to the after end, it descends and connects on to the deck delivery line outside the after pump-room. This is the only means of connection between the forward and after sections of tanks. This deck line, whether permanent or temporary, passes along the bridge deck.

As an example of the working of this arrangement, we will shift the ballast from No. 1 to No. 8, using the port lines.

Open the two suctions on the port line in No. 1 tank. This allows the ballast to pass into the port pipe line. The port pump will now draw this aft into the pump-room, and by setting the valves we press it up on deck through the deck delivery line, where it enters the deck line. Set the valves on deck to pass it aft to the after pump-room, where it will enter the deck delivery line, and down into the pump-room. Set the valves in this pump-room and pass it along the port pipe line, and by opening the two suctions on the port line at No. 8 tank the ballast will enter the required tank.

Just the reverse procedure would be carried out in shifting ballast from one of the after tanks to a tank in the forward section. In this case the after pump would be used to draw the ballast from the tank and press it along the deck line to the forward pump-room.

In these ships great care is necessary to prevent sparks from the funnel dropping on to the after tank tops which might cause an explosion if there was a leakage of gas from these tanks.

In all tankers, whenever carrying oil of a low flash point, chipping decks or any work liable to make sparks should be strictly forbidden.

In this class of ship the after pump-room does not extend to the bottom of the ship, but only as far as the top of the tunnel.

CHAPTER XVII.

NEW TANKER WITH SINGLE PIPE LINE.

In Chapter XIV. an old type of tanker with a single pipe line was described, and in this chapter a new tanker with a single pipe line is dealt with. In this ship there are three pumps, one in the forward pump-room and two in the after pump-room. Another difference is, that in this case the sea lines and sea valves are situated in the main pump-room, whereas in the other vessel they were in a small pump-room at the after end of the tanks.

In this ship there is only one pipe line at the bottom of the tanks, and this is situated on the starboard side. A great saving of material is the given reason, for a pipe line the whole length of the tanks is saved, and also the two suction pipes in each tank which this line would be fitted with. This vessel being new contains all the latest ideas in oil tank construction. She is built on the Isherwood system, and there are eighteen bulkheads altogether, without the longitudinal bulkhead which runs through every tank. The tanks are numbered from forward to aft, and all the tank valves are left-handed. A few of the valves in the pump-rooms are right-handed, and this must always be looked for to prevent mistakes.

There are two crossover lines in the after pump-room, but there are no others in this vessel. There is one suction pipe only in each tank, and these are connected to the pipe line on the starboard side. There are three sea lines. One in the forward pump-room and two in the after pump-room. These are all controlled by double sea valves, situated on the sea lines close to the side of the pump-room. The vessel is divided into three sections by master valves on the pipe line. One is situated at the after end of the forward pump-room, and the others are situated one on the forward side of the after pump-room and the other on the after side of the same pump-room. The ship is thus divided into three tanks in the forward section, four tanks in the middle section, and three tanks in the after section.

There are seven summer tanks on each side, and each one is an oil-tight compartment. There are no pipe lines in these summer tanks, but situated at the after end is a drop valve, which is worked from the deck by a valve spindle. When filling the main tanks below them, the drop valves are opened, and the oil will enter the summer tanks till it reaches the same level as the main tanks. The drop valve is then closed, and if it is considered necessary to

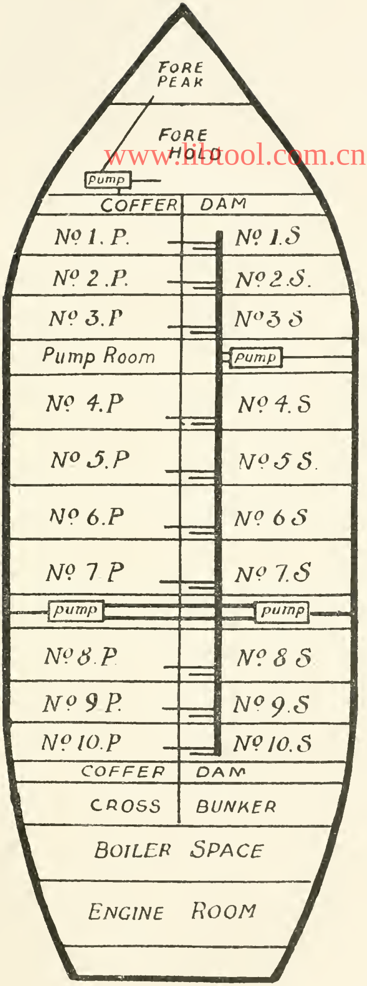


DIAGRAM No. IX.—New Tanker with Single Pipe Line.

increase the height of the oil in these summer tanks, a hose can be connected on to the deck line, and the other end put down the expansion trunk of the summer tank, and the oil coming from the shore is thus diverted into these tanks "over all."

In this vessel a portion of the oil-fuel bunkers are carried in the cross bunker and side bunkers aft, and the remainder in the fore deep tank (under the forehold).

A small pump-room is situated in the forehold, just forward of the cofferdam, and this is used to pump the bunkers from the deep tank into the small six-inch deck line, which carries it aft to the cross bunker ready for use.

This pump also has connections for pumping out the forepeak and cofferdam.

The arrangement of the after pump-room is similar to that on diagram 3, with the exception of the port pipe line shown there, and this is the only difference.

The cross bunker has its own pipe line into the stokehold, but it is always filled from the bunker line on deck.

The procedure for discharging the summer tanks would be that as soon as the level of the oil in the main tank below had gone down, open the drop valve and the oil in the summer tank would run into the main tank and be pumped out by the main pumps below.

Having only one pipe line in the bottom of the ship, the procedure for discharging the main tanks would be very similar to that described in Chapter XIV. It is perfectly simple to load these ships by running the oil from the deck line down into the pump-room and then into the pipe line, and by opening the valves of the tank to be filled the oil will enter into the required compartment.

The only problem which arises is when oil or ballast has to be shifted from two tanks on one side of a pump-room into each other, such as No. 1 to No. 2, or No. 9 to No. 10, or *vice versa*. We will take one example of this :—Shift ballast from No. 2 tank to No. 1. Open the two valves in No. 2 tank, the ballast will now enter the pipe line; open the two valves in No. 1 tank, and the ballast will enter this tank from the pipe line, through the open suctions, till No. 1 and No. 2 tanks are level; shut the two valves on No. 1 tank to prevent the ballast running out again; connect up a hose from the pump delivery line on deck, and put the other end into the top of No. 1 tank; set the valves in the pump-room and draw from No. 2 tank, and send it up on deck through the deck delivery line, and it will then enter the hose, and so into No. 1 tank.

A similar procedure would be used in changing ballast from No. 9 to No. 10, or *vice versa*.

In this vessel there are no gas pipes for taking away the gas, but a new system is installed. The system is described best by explaining that a small pipe about 2 inches in diameter is fixed vertically in the pump-rooms and cofferdams. The bottom end is open. At the top, where it comes on deck, it is crossed by a horizontal steam pipe, the end of which projects just outside the bulwarks. A pressure of steam is sent through this pipe, which causes a vacuum in the vertical pipe, and gas and water can be drawn up from the bottom of the ship by this method.

Some of the latest tankers are fitted with double pipe lines, and an additional valve on each tank suction, but this is not necessary.

Expansion joints (or sleeve joints) are fitted in the pipe lines on deck, and at the bottom of the tanks, to give them a certain amount of elasticity when the ship is straining in a rough sea. The large steam pipes on the deck also have expansion joints. A watertight bulkhead divides the engine-room and stokehold, and access between the two compartments can only be obtained by way of the deck.

CHAPTER XVIII.

CONVERTED SHIPS WITH CIRCULAR TANKS.

A FEW words about the ships which were originally laid down as cargo steamers and were altered on the stocks, or have been altered since launching, will be of interest and instruction.

I am indebted to a friend, who drafted the plans of this vessel, for this information.

This subject must be treated on very broad lines, as no two ships seem to be alike in all details, but vary in accordance with the ideas of different designers and builders.

Diagram No. 10 gives a bird's-eye view of one of these vessels with all hatches and decks removed, and shows at a glance the whole tank arrangement. It is first noticed that all the cargo tanks are circular in shape, and vary in size, getting smaller as they go farther from amidships. The dimensions of the tanks in this ship were :—No. 1 and No. 6, 21 feet in diameter; No. 2 and No. 5, 34 feet in diameter; and No. 3 and No. 4, were 42 feet in diameter.

A pump-room was fitted at the forward end of No. 1 tank to pump out tanks Nos. 1, 2, and 3.

A similar pump-room was fitted at the after end of No. 6 tank, and this dealt with tanks Nos. 4, 5, and 6. Another small pump was installed at the after end of No. 3 tank on the port side. This being used to work the oil-fuel bunkers, which were carried in the vacant space, between the boiler-room bulkhead and the No. 3 tank bulkhead.

A bulkhead is built across the whole breadth of the vessel at the after end of No. 3 tank, and a similar bulkhead at the forward end of No. 4 tank. These bulkheads keep the engine-room and stokehold completely isolated from the cargo tanks. Bulkheads are also built from the outside of the tanks to the ship's side, and also fore and aft.

The top of the circular tanks are fastened to the deck. The hatches were increased in height, and so formed the expansion trunk of the tank below them. These hatches also had a longitudinal bulkhead fitted in them to prevent the oil in the expansion trunk from rolling with the motion of the vessel.

It will be noticed what a large amount of waste space there is outside every tank, and ships fitted in this way do not carry the dead-weight which they were originally built for. These ships can be reckoned as a war measure, and no company would consent to a 12,000-ton ship only carrying 9000 tons in her cargo tanks. It was caused by the increased demand for tank tonnage, and these emergency ships were so fitted up to help make up the deficiency.

In some of these ships which were converted on the stocks, the bottom plating and ballast tanks of cargo steamers had already been constructed. Therefore the circular tanks were built on the ballast tank tops because that was the most solid foundation for them. After the circular tanks were constructed, large manholes were made in the top of the ballast tanks, inside the circular tanks, to enable these tanks to be used in conjunction with the circular tanks for cargo.

There are no longitudinal bulkheads in the circular tanks, but there are six web plates in each tank, built to the side, and extend from the ballast tank top to the deck above, and extending about 6 feet into the tank. In some ships there are eight of these web plates in the large tanks, and six in the smaller ones. In the middle of these tanks there are built centre pillars, two in the large tanks and one in the smaller tanks. These are formed by four six-inch angles riveted together. The web plates all assist in strengthening the tanks, and also prevent the oil in the tank gaining too much motion.

The ballast tanks are fitted with wash plates to prevent the oil in these tanks from rolling, and also to strengthen the top of the ballast tanks.

Running aft from the engine-room bulkhead to the stern is a circular tunnel about 6 feet 6 inches

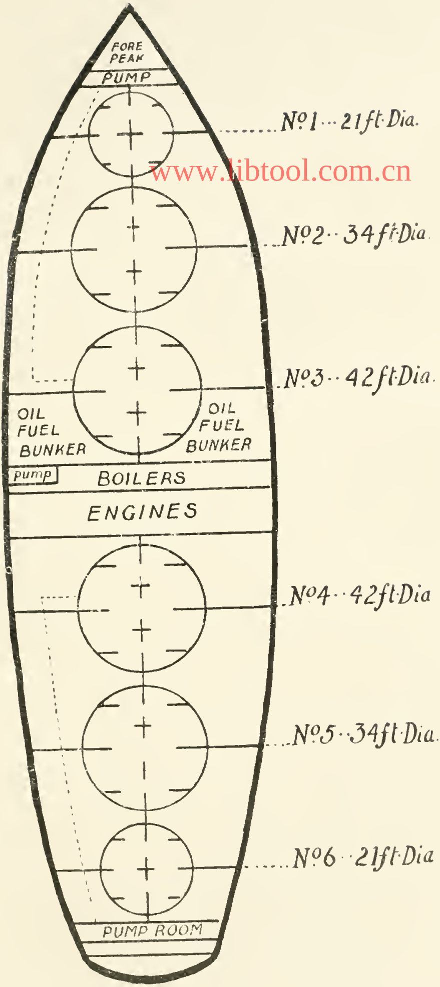


DIAGRAM No. X.—Converted Ship fitted with Circular Tanks.

in diameter. This tunnel passes through Nos. 4, 5, and 6 tanks, and inside is the propeller shaft. This tunnel has no passage right through to the stern, except a small passage for the shaft to pass through. Access to the after sections is obtained from the deck.

Some of these ships have the circular tanks only for cargo, the ballast tanks being used to carry the oil-fuel bunkers. In these cases all manhole plates would be fastened on to prevent the cargo from being mixed with the bunkers.

The pumping arrangements also vary according to the ship. Some have their pipe lines passing through the manholes in the floor plates of the ballast tanks, with a suction pipe passing through the tank top into the bottom of the circular tanks.

Other ships have their pipe lines laid along the limbers, with a suction pipe going into each tank and controlled by valves. As mentioned before, the details of these ships can only be treated very broadly, and there is no standard rule either for their construction, pumping arrangements, or working. The dotted lines show the direction of the pipe lines in some vessels where the pipe lines are fitted along the limbers. In some of these ships the pump-rooms are situated amidships — the forward one on the forward side of the stokehold, and the after one at the after side of the engine-room.

CHAPTER XIX.

STANDARD TYPE TANK STEAMERS.

As there are now many tankers afloat, and also being built, of the standard type, it is very necessary to include a chapter on these ships.

They vary in size, the usual types carrying either 5000, 6500, or 8000 tons. They are built on a standard pattern, so that once the details of one is known it will apply to them all, with slight modifications in different ships which have been built in different yards.

I am indebted to a friend who supervised the construction of an 8000-ton ship of this type for the details in this chapter.

It will be noticed by studying the diagram that the cargo space is divided into five tanks, three of these are forward of the engine-room and boiler space and two are situated abaft. These tanks are much bigger in proportion to the vessel's size than in an ordinary tank steamer.

The reason for this is that much material has been saved in their construction by making the tanks bigger, and thus having a less number of athwartship bulkheads.

The pipe line and pumping arrangements are of the simplest nature. One long continuous pipe line of ten inches in diameter is installed, and extends from No. 1 tank through Nos. 2 and 3 tanks, and then passes through the oil-fuel bunker, pump-room, coal bunker, boiler space, and engine-room, at the after end of which it enters No. 4 tank, and passing through this tank it enters No. 5 tank, where it terminates at the after end.

The pipe line, it will be noticed, passes right through the boiler space and engine-room, so that it is very unlikely that these ships will ever be used to carry oil of a gassy nature, as the risk of a leakage of oil or gas while passing though the boiler space and engine-room would make it too dangerous.

In each tank there is one suction pipe of eight inches diameter through which the oil is drawn from the tanks into the pipe line. The valves on these suction pipes are fitted with spindles which go up through the top of the tank and are worked by wheels or rackets, similar to those in use on an ordinary tanker.

There is a longitudinal bulkhead in every tank, and fitted on this bulkhead in every tank is an equalising valve of fourteen inches diameter. This valve, as its name indicates, is used to equalise the level of the oil or water in the two sides of a tank. It is a valve fitted on the bulkhead with the slide working vertically. It is fitted with a spindle, and is worked from the deck above.

On the forward side of the boiler space is the coal bunker, which extends from side to side.

The pump-room is situated on the forward side of the coal bunker, and extends the whole breadth of the vessel. One large horizontal oil pump is installed to work the cargo or ballast in the main tanks.

The oil-fuel bunker is situated on the forward side of the pump-room. This also extends from side to side and has a longitudinal bulkhead in the middle. This bunker has two suction pipes connected to the main pipe line, which enable this space to be filled or pumped out by the main cargo pump. When using oil fuel for the furnaces it is drawn from the bunker by the oil-fuel pump, which is situated in a recess at the forward end of the stokehold in amidships. This pump has a small pipe line to the bunker, and is used for this purpose only. Abreast of the engine-room and boiler space are 'tweendecks, which are used for coal bunkers when required, but these 'tweendecks only extend ten feet from the deck downwards.

In these vessels there are no summer tanks. There is a hatch fitted on each tank, and the coamings of these hatches, which are about three feet high form the expansion trunk. In case of emer-

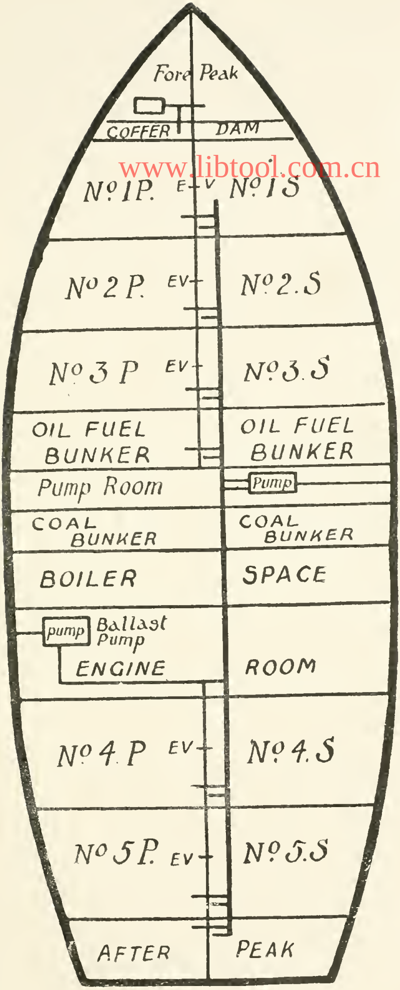


Diagram No. XI.—Standard Type Tank Steamer. "EV" marks position of Equalising Valve in each Tank.

gency or other causes the ballast pump in the port side of the engine-room can be used to discharge the cargo from the tanks. It will be seen from the diagram that there is a pipe line connecting the ballast pump to the main pipe line. In the latest type of these ships the cargo pump is being installed in the starboard side of the engine-room, and the space now used for the pump-room will be used for bunkers.

There is one sea line and sea valve in the pump-room, and through this line the water will be obtained to ballast the main tanks.

The ballast pump in the engine-room also has a sea line and sea valves, thus providing an alternative way to ballast the ship if necessary. There is a small pump in the forepeak for pumping out the forepeak and cofferdam. There is a dry well situated at the after end of the engine-room which acts as a small cofferdam, but it is only built to a level of the engine-room double-bottom. It saves any oil which leaks from No. 4 tank from entering the engine-room bilges.

A circular tunnel is fitted from the engine-room to the stern, and this tunnel, which is perfectly oil-tight, passes through Nos. 4 and 5 tanks. The bottom of this tunnel is about four feet from the bottom of the tanks. The suction pipes in these two tanks pass under the tunnel. Access to the tunnel bearings is provided by means of a round ventilator which passes down through No. 4 tank. Access to the after end is obtained through the afterpeak.

If the ballast pump is used for discharging cargo, a flexible hose must be connected on to the ballast pump delivery line on the engine-room casing.

There are no barge suction or discharge pipes. There are also no fore and aft pipe lines on deck. A small pipe exends from each side of the pump-room on deck for delivery, and on to this line the flexible hose would be connected to deliver the cargo or to load.

All sleeve expansion joints on the main pipe line in the tanks are packed with one turn of soft packing and then lead threading caulked in to make it "oil-tight."

The term "oil-tight" is best understood by the explanation that often oil will penetrate through a seam or bulkhead which is "water-tight." Therefore wherever the word "water-tight" is mentioned in this book it will be assumed that "oil-tight" is meant.

CHAPTER XX.

TANKER WITH TWO VALVES ON EACH SUCTION.

This chapter is based on a small tanker of the "Trunk" design, carrying about 3000 tons and built within the last five years. It will be seen from the diagram that this vessel has two main pipe lines in the tanks, which are of twelve inches in diameter. There are five double tanks, and the expansions are formed by a trunk running fore and aft. There are no summer tanks, the vessel being of the trunk design, and the main deck does not extend to the full beam of the vessel.

There is a harbour deck about four feet in width from the outside beam of the vessel in as far as the sides of the trunk, and this deck extends fore and aft the whole length of the cargo tanks.

This vessel is of a very handy design and size, the great difference between this one and those previously described being that on each suction pipe, which extends from the main pipe lines through the longitudinal bulkhead, there are two valves. One valve is situated on each side of the bulkhead.

By this arrangement it will be seen that it is possible to draw from both sides of a tank by opening the two valves on any suction pipe.

Thus, if the two pumps and both pipe lines were used, it would be possible to pump just as quickly and easily as the tanker described in Chapter III., which is fitted with two suction pipes in each tank.

It will be noticed that the port suction pipes are situated at the after end of the tank, so it is essential that the port line should be used for draining the tanks on completion of discharging cargo or ballast. The starboard suctions are situated one bay farther forward.

The valve spindles extend up through the deck at the after end of the tank they belong to, the two after valves being the port and starboard suctions on the port line, and the forward pair are the port and starboard suctions on the starboard line.

By means of the crossover lines it is possible to pump right round the ship in any direction, with either pump. As an example of what is possible in this vessel, we will discharge No. 1 tank both sides, using the port pump and the starboard line. First, open the two starboard line suction valves in No. 1 tank. The oil and water will now enter the starboard line and run towards aft till it comes to the crossover line in the pump-room. By shutting the valve on the starboard pump suction line, and opening the master valve on the crossover line, it

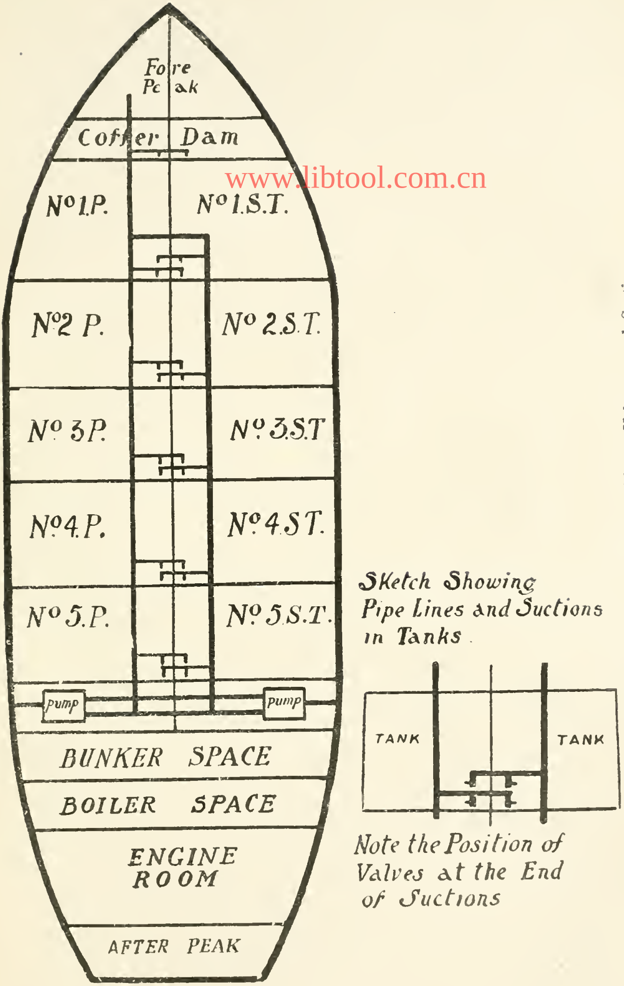


DIAGRAM No. XII.—Tanker with two Valves on each Suction.

will pass over to the port pump. In using the port pump and the port line or the starboard pump and starboard line the procedure will be more simple.

This vessel has two large horizontal oil pumps of large capacity. The deck delivery line from the pump-room proceeds upwards till on a level with the harbour deck, and then proceeds through the side of the trunk and has the end projecting just above the harbour deck, and on to this the discharging or loading hose will be connected. At the bottom of diagram No. 12 there is a sketch to plainly illustrate the suction pipes and valves in this ship. There are two sea lines and two sea valves situated in the pump-room, through which the water would be obtained to ballast the ship.

In the pump-room this vessel is especially handy, the different valves being situated close together all in a row.

By the manipulation of certain of these valves the deck delivery line can be made into a suction line to draw from the deck, and then the pump would discharge into the tanks as required.

This vessel has many times been ordered alongside other ships to take the oil bunkers from them when they required lightening for dry-docking purposes.

The procedure was as follows :—

The end of a flexible hose was taken aboard the ship to be lightened and put down to the bottom of the oil bunker to be emptied. The other end of this hose was connected to the deck delivery line on the harbour deck which has been previously mentioned. Then by opening and shutting certain valves in the pump-room the deck delivery line was connected to the pump suction line (instead of the pump delivery line).

The pump was then started, and the oil was drawn through the flexible hose, then through deck delivery line to the suction side of the pump, which discharged it into her own tanks through the pipe lines and tank suction pipes.

CHAPTER XXI.

TANKER WITH THREE PIPE LINES ON EACH SIDE.

In this chapter a tanker is described which has several unique and interesting features. The thing which the observer will first note is the number and position of the pipe lines as shown on diagram 13. There are three separate pipe lines on each side of the longitudinal bulkhead in amidships, and each pipe line is absolutely independent of the others. There are four pumps installed in the pump-room, which is situated on the forward side of the forward cofferdam. One pump only is used for each section of tanks, and the remaining pump is used exclusively for ballasting purposes.

This class of tanker was built in 1908, and were designed to carry mixed cargoes, *i.e.* different kinds of oil in different tanks. The tanks are divided into three sections. Nos. 1 and 2 being the forward section, Nos. 3, 4, and 5 being the middle section, and Nos. 6 and 7 being the after section.

The marking on the ship's plan indicates that the forward section, Nos. 1 and 2, was intended for the carriage of refined oil, such as kerosene. The middle section, Nos. 3, 4, and 5, was intended to hold crude petroleum; and the after section, Nos. 6 and 7, was intended to hold benzine.

With this explanation, it is at once seen why the three sections of tanks should be fitted with separate pipe lines and pumps, the object being that no mixing of the different kinds of oil should be possible in the ship. To distinguish the different tanks and their respective pipe lines and pumps from those of another section, the sections have been named with different colours. This description is identical with that used in this ship at the present time. The forward section, Nos. 1 and 2 tanks, is named "Red"; and the pump for these two tanks, which is situated at the starboard forward end of the pump-room, is also "red"; and, to carry it still further, the deck delivery line from this pump and the deck line itself are painted "red," so that there may be no confusion.

The middle section, Nos. 3, 4, and 5 tanks, is named "Blue," and this section is loaded and discharged by its own blue pipe line and blue pump, which is situated at the port after end of the pump-room. The deck delivery line, and also the deck line itself, are painted "blue" to distinguish them.

The after section, Nos. 6 and 7 tanks, is distinguished by the name of "Yellow," and are loaded and discharged by the "yellow" pump, which is situated at the starboard after end of the pump-room.

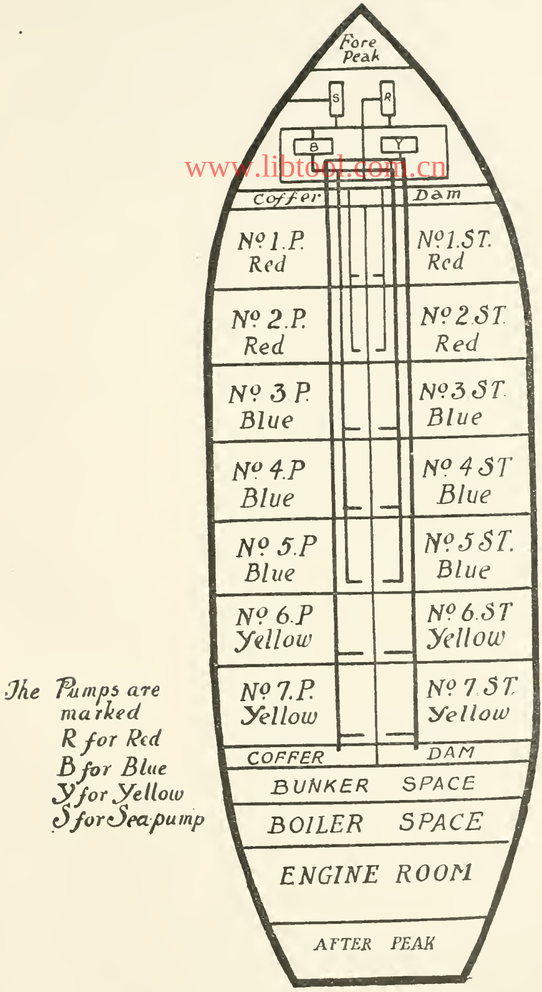


Diagram No. XIII.—Tanker with Three Pipe Lines on each Side.

The deck delivery line and deck line are painted "yellow."

Thus there are three deck delivery lines emerging from the after side of the pump-room, and these are extended to a position about amidships, where they are fitted with valves and flanged ends, in readiness to be connected to the shore pipe lines. It certainly does look peculiar to see three separate discharge lines on deck side by side, but the separation of tanks and pipe lines are carried right to the rail.

There is one suction pipe only in each tank, but in each tank there is fitted on the longitudinal bulkhead an equalising valve, by means of which oil or water can be levelled into another tank of the same section and colour. This is very handy in case of an accident or stoppage in a pipe line, because the oil or water could then be run through the equalising valve and then pumped out through the suction and pipe line on the other side.

The system of naming the different sections of tanks, pipe lines, pumps, and deck lines in colours is also carried out on the gauges in the pump-room. This is quite necessary to distinguish them and show which pump they belong to.

The ballast pump is situated at the forward end of the pump-room on the port side, and by means of the crossover lines it can pump water into any pipe line, and thence into the tanks. A close study of the pipe lines in the diagram is necessary to trace the different movements which can be performed. For instance, it would only be possible to shift oil or water from Nos. 6 and 7 tanks to any other tanks by taking it right forward to the yellow pump, and then through the crossover lines, till a connection was obtained by means of the valves with the pipe line of another colour.

The same system would apply if it was required to shift oil from Nos. 3, 4, or 5 tanks to Nos. 1 and 2, or to Nos. 6 or 7.

Therefore the pump-room is the most important part of the ship to understand. This vessel has summer tanks on each side of the main tanks, which are filled or discharged into the main tanks below them by means of drop valves.

It will be noticed that the after cofferdam can only be pumped out by the yellow pump and through the yellow pipe line.

All pipe lines from the tanks pass through the forward cofferdam on their way to the pump-room.

CHAPTER XXII.

THE CARRIAGE OF KEROSENE.

THERE are four distinct "kinds" of oil often carried in tankers, namely: "Spirit," which is used for all kinds of motor work; "Burning Oils," which include all grades of kerosene; "Lubricating Oils," which cover the many different kinds of lubricants used either for light or heavy machinery; and lastly, "Fuel Oil," which, as its name indicates, is used for fuel in place of coal to raise steam.

This book would not be complete without a few words describing the "carriage" of each of these classes of oil.

This chapter is devoted to the carriage of kerosene. The first thing from a Chief Officer's point of view, and also for his reputation as a good "oil-tank man," is that on arrival at a loading port the tanks shall be both "clean and dry" ready for the inspector.

In the chapter on "Cleaning Tanks for Cargo" it is explained how to clean the tanks, but as this is such an important matter I make no apology if I cover the same ground twice.

Assuming that the vessel is outward bound, with ballast in some of the tanks, it is the rule to wash and clean up those tanks which are dry when the weather permits.

As kerosene leaves a heavy gas in the tanks, there is danger of men becoming affected by it while working down in the tanks. Therefore give them a good "blow out" with windsails before starting work below.

If kerosene or spirit had been carried the previous voyage, it will only need a good wash down with the hose, and as the water is pumped out sweep any dirt towards amidships and send it up on deck in buckets. Do not brush it right to the bellmouth of the suction pipe or it may get underneath and escape observation. A good idea is to take a small piece of batten about half an inch thick and feel under the bellmouth to make sure no dirt is hidden there. If any pools of water remain on the floor of the tank, wipe it up with "tank flannel." Do not use waste, because some pieces are always left behind and may cause trouble afterwards.

If it is fine weather, clean sea-water can be put into the clean tanks and the ballast in the remaining tanks pumped overboard, and the tanks cleaned before arrival at the loading port. Every ship is allowed a few hours after arrival to complete the cleaning and drying of tanks, but the main object should be to have the tanks passed by the inspector in the quickest possible time after arrival.

Soon after the commencement of loading the inspector will take a sample of oil from the bottom of the tank, and he can at once detect if the inflow of oil has stirred up any dirt in the bottom which had escaped his attention. Hence the necessity of making sure that the tanks are really clean.

In loading kerosene have all the tank lids down, but remember to leave the plugholes uncovered a little to allow the air to escape from the tank as the inflow of oil displaces it.

When the first tank is loaded and had time to settle, test it for water, because there may have been water in the shore pipe line from the wharf up to the tank.

On one occasion we found three feet of water in our first loaded tank, and on pointing this out to the inspector, he found upon inquiry that the long pipe line from the wharf to the tank had been filled with water when a previous ship had finished discharging and had pressed the last of his cargo into the shore tanks. It is a necessary precaution, as it causes endless trouble at the discharging port if a lot of water is found at the bottom of the ship's tanks.

There are many different grades of kerosene, and nearly all differ in quality, specific gravity, and flash point. A few of the best known grades are "Standard White," "Water White," "Daylight," "Petrolite," and "Prime White."

The grade of kerosene shipped to the European market is much above that which is sent to the markets of the Far East and the flash point is also higher.

The specific gravity of kerosene varies with its grade, but approximately it varies from S.G. ·790 to S.G. ·820. This is probably the two extremes between "very light" and "very heavy" kerosene. The flash point also varies with the grade, being from 112° Fahr. to 125° Fahr.

Looking at a sample of kerosene in a clean bottle, it shows a bluish tint which no other oil attains. After arrival in a ship's tank the temperature will rapidly fall, till about one degree above the temperature of the sea-water outside.

The system for testing the flash point and burning test of kerosene as demanded by the British specification, is called "the Abel closed cup" test. In this "closed cup test" "Prime White" kerosene will "flash" at 73° Fahr. and at 110° to 125° Fahr. by the "open cup test."

The burning test shows 125° Fahr.

CHAPTER XXIII.

THE CARRIAGE OF CREOSOTE IN TANKERS.

During the course of this chapter new ideas will be mentioned in connection with the carriage of creosote in tank steamers, which may be of great value to those engaged in this trade.

Doubtless there will be some criticism of these ideas, but as they are based on the practical experience of a friend who has had twenty years in this trade, I confidently put forward these ideas as well worthy of a trial.

It has been the practice for years for tankers of certain companies to load creosote in the United Kingdom and take it to ports in the United States, usually to the Gulf ports.

Orders have usually been received, that this cargo must be kept heated by the steam coils in the bottom of the tanks to prevent it becoming thicker as the temperature went down. Once getting into this routine, it has always seemed a matter of course to carry it out.

Most officers are aware of the fact, either from experience or hearsay, that creosote is about the worst liquid we have to carry in tankers. It makes the tanks in a terrible mess, and sticks on to the sides, and leaves a thick sediment in the bottom, which is often impossible to pump out, and if the right system is not carried out it makes very hard work for all concerned.

The experience of my friend is as follows, and I confidently recommend it for trial :—

After carrying creosote for many years, it was found that by keeping the cargo heated all the way across the Atlantic the acid properties which it contained, and which is really the most essential part for preserving wood, gradually settled to the bottom of the tanks.

By the time the discharging port was reached, this acid had settled into a solid layer at the bottom of the tanks. It was impossible to pump it out, and generally it had to be scraped out with shovels. Doubtless many officers have had the same experience.

On one voyage outwards, when loaded with creosote, the order was given that the cargo was not to be heated. The creosote gradually settled thicker as the temperature of the sea-water outside became lower, and the soundings of the "thick" in the tanks showed an increase every day.

When the vessel arrived in the Gulf Stream, which at this place was of a temperature of 78° Fahrenheit, it was found that the action of the warm water outside melted all the thick sediment which had formed, and by keeping in the Gulf Stream as long as possible, the creosote was thus kept thin by natural causes. Just before arriving at the entrance of the Mississippi, the steam heating coils were used and the temperature raised. It was found that the cargo pumped out "quicker, cleaner, and dryer" than ever before, and in this ship steam heating was never used again till nearly at the discharging port.

It was also noted that this vessel always arrived two days quicker than her sister ships in the same trade, but made exactly the same length of passage homewards. It was conclusively shown that the saving of steam was the real reason that made the difference of two days on the outward journey.

No doubt some experts would demur on this question, but the practical results obtained cannot be contradicted.

In the chapter on "Cleaning Tanks for Cargo" it should be stated that when cleaning a "dirty tank" which has had creosote, fuel oil, or any oil of a dirty nature, if it is possible to obtain "hot" water with which to wash down the sides of a tank, much labour will be saved. It is almost useless to steam a tank for hours and then wash it down with "cold" water, because the action of the cold water would solidify the oil on the tank sides, whereas the hot water will hasten its passage down to the bottom of the tank, where it can be dealt with, either by the pump or by bailing with buckets. In nearly every tanker there is a connection by which "hot" water can be sent up to the deck from the engine-room for this purpose.

A good plan when washing down tanks with hot water is to lash the nozzle of the hose on to a long thin pole. It can then be put down into a tank and worked from the deck by turning the pole round till all the sides are washed down. The nozzle of the hose would probably get too hot to hold; and this method also prevents the men having to enter the tank while the hot water is being used.

CHAPTER XXIV.

THE CARRIAGE OF SPIRIT.

THE carriage of spirit is also a most important subject, and a thorough knowledge of its dangers and peculiarities is essential to those who are engaged in its transportation.

The term "spirit" may be said to cover benzine, naphtha, gasoline, petrol, motor spirit, motor essence, and aviation spirit, and although called by different names they are really much alike, except in quality and specific gravity.

The very light grades of spirit are often called "Aviation Spirit," because the strength and light specific gravity of this grade, render it most suitable for aviation purposes.

The specific gravity of "spirit" varies from ·725 to ·760, and the heavier grades are generally used for motor transport and marine motors.

Especial care is necessary when carrying this oil, because the gas which arises from it, will explode almost at any temperature if it comes in contact with a spark.

It is just as necessary to have the tanks clean and dry as for kerosene, and the remarks in Chapter

XXII. on the procedure necessary to prepare the tanks for inspection, apply equally to all cargoes of spirit.

After the shore pipe line has been connected up, and the order given to start loading, proceed to the tank which you intend to load, and by looking down through the plughole (the tank lids being down) it is possible to see the oil coming in, or you can hear it coming in, when it first enters an empty tank. If the oil does not enter the intended tank, it shows that it is going somewhere else, and a thorough inspection of all other valves is necessary.

The strictest precautions should always be taken when loading oil of this nature on account of the gas, which is forced up through the plughole with the air, which is displaced by the oil entering the tank.

The use of chipping hammers or any tools likely to cause a spark while loading or while gas is in the tanks should be strictly forbidden.

When loading at many places a shore official inspects the ship to see all fires are extinguished in the stokehold and galley, and loading will not be commenced till he is satisfied on this point. Smoking aboard the ship while loading is also forbidden, and heavy fines are threatened to those found breaking this rule.

A small steam hose is brought aboard and connected to the deck steam pipe generally close to the pump-room. This supplies the steam necessary to drive the dynamo or to tighten the moorings if required.

All fuses should be removed from the fuse-boxes of lights belonging to the pump-rooms to render an accident from this source impossible.

Directly a tank is finished see that it is well secured by the butterfly screws round the edges, and screw on the plug. This should only be removed while ullages and temperatures are being taken, and immediately screwed on again.

Too much care cannot be taken, because "gas" is the great unseen enemy which is always to be guarded against.

When a tank of spirit has been pumped out the gas still remains, and until the tank has been steamed and well ventilated with the air fan or windsails it is still most dangerous. The gas hangs in all corners and especially under ledges, and has been known to accumulate under flakes of rust, therefore the greatest care is needed. Plenty of wind round the bottom of the tank is what it requires to dislodge it.

During the passage to the discharging port, if the wind is right aft and sparks are coming from the funnel and falling in the vicinity of the tanks, inform the Master at once, who will then use his discretion, whether it is necessary to alter course slightly to bring the wind on the quarter till the sparks have ceased falling.

On arrival at the discharging port all fires have to be extinguished and the shore steam hose connected up to supply the necessary steam to work the pumps.

Ullages, temperatures, specific gravity, and samples are taken before the discharging starts, and the tanks will be tested for water.

If the ship's steam is used for discharging, it is the custom to fit a steel gauze cover or spark catcher over the top of the funnel.

When discharging at a French port, a fireman is stationed aboard the ship with small bags of sand to deal with any outbreak of fire.

If the joints of the hose are leaking, place a bucket or tin underneath to catch the drops. If these drops fall on the deck they quickly evaporate and make gas. All grades of spirit must be kept tightly covered up, because exposure to the atmosphere causes it to evaporate rapidly.

Another kind of inflammable oil which is now being largely carried is "benzol." This is being mixed with spirit for motor transport purposes, and is also used in the manufacture of certain high explosives. It is very similar to spirit in colour, but the smell of the gas it gives off denotes that it is a product of coal tar. It creates more gas than spirit, and a surprising feature is that it solidifies or freezes into a flake, very similar to ice, at a temperature of 50° Fahr. when exposed to the open air.

CHAPTER XXV.

THE CARRIAGE OF LUBRICATING OIL.

The experience of carrying lubricating oil is not so common as the carriage of kerosene, spirit, and fuel oil, therefore a chapter is necessary to describe the procedure in handling this class of oil.

There are many grades of lubricating oil, which all differ in colour, specific gravity, and flash-point. Those generally dealt with in tankers are the following:—"Spindle Oil," "Ruby Oil," "Dorada Oil," "Cylinder Oil," and Engine Oils of various grades.

There are many other grades, but these are the most common. Each of these oils are suited to a special purpose. For instance, spindle oil is rather thin and of a clean yellow colour, and is used for lubricating light and delicate machinery. The other various grades are used for machinery or engines of a heavier nature, until heavy engine oil is reached, and we all know how thick that grade is, especially in cold weather.

The specific gravity varies with the grade, spindle oil being about the lightest, with an S.G. about ·820. The S.G. of the other oils gradually increase, and heavy engine oil is about S.G. ·875 to ·950.

The two most important points to remember in dealing with all grades of lubricating oil is that the flash point must not be lowered by mixing with any other grade of oil; and secondly, that no dirt or water must be allowed to mix with it. For instance, if any dirt or grit was in oil used for lubricating machinery it would cause the bearings to run hot by the friction caused, and the usefulness of the oil would be destroyed.

Therefore the tanks must be absolutely clean and dry, and the inspector is really more particular about the tanks before loading this class of oil than he is with the kerosene and spirit.

In Chapter XII. an example is given of the precautions taken in a tanker carrying oil of this description to prevent any mixing, and the construction of the tanker described in Chapter XXI. is designed to achieve this same purpose.

At sea, when taking ullages and temperatures of this oil, keep a separate ullage stick and oil thermometer for lubricating oil, and do not use one which has been used for oils of a low flash point such as spirit.

In ships which discharge this oil into tank barges, it is always necessary to inspect the interior of the barge's tanks before starting to load it.

On one occasion I refused to load a barge till the pump-well was thoroughly wiped up dry, because kerosene had been the previous cargo and a little still remained in the pump-well.

In this action I was upheld by the owners, charterers, and consignee, and a special entry was put in the log describing the circumstances.

Lubricating oils do not give off any inflammable gases, and being of a very high flash point they are not in any way dangerous to handle.

The flash point of spindle oil is about 320° Fahr., and that of engine oil about 410° Fahr.

CHAPTER XXVI.

THE CARRIAGE OF FUEL OIL.

MANY vessels have been engaged in this trade during the war carrying oil fuel, principally from American and Mexican ports to the naval bases at home and abroad, therefore the conditions of this trade are well known. But to those who have never carried this class of oil, this chapter may be of some use.

Fuel oil is really the residue of crude petroleum after it has been distilled many times, during which the spirit, burning oils, and lubricating oils have been extracted.

Fuel oil varies in specific gravity according to its grade, the American being somewhat lighter than the Mexican oil.

The oil from Borneo is somewhat similar to the American grade. The specific gravity varies from about ·900 to ·950, and the flash point is about 175° Fahr. to 185° Fahr.

When preparing tanks for this class of oil, it is usual to wash the tanks down with the hose, and while the water is being pumped out, sweep the dirt and sediment towards amidships and send it up on deck in buckets. Do not brush it to the bellmouth of the suction pipe, otherwise dirt or thick sediment may get underneath and so escape attention.

The inspector will come aboard on arrival at the loading port, and will insist on the tanks being dry and no sediment lying in the bottom. The scale of cleanliness is not nearly so high as for refined and lubricating oils, but every endeavour should be made to keep the tanks as clean as possible.

When carrying fuel oil in a cold climate, it is sometimes necessary to heat it by means of the steam coils on the tank bottom, because with a low temperature the oil will get thicker and make much harder work for the pumps when discharging.

On arrival at the discharging port an official will visit the ship to take the ullages, specific gravity, temperature, and samples. He will also probably test the tanks for water. The most important point in carrying fuel oil is to prevent any water being mixed with it, because it causes endless trouble in any vessel's stokehold when raising steam and will probably put the fires out.

The carriage of fuel oil is a trade with a great future before it, because the increasing use of oil fuel in place of coal in many parts of the world will necessitate the establishment of many oil-fuel bunkering depots, and many tankers will be employed keeping them supplied.

During the war many cargo vessels have been carrying oil fuel as "cargo" in their double-bottom or ballast tanks, and perhaps in the future we may see some of these vessels using oil fuel as bunkers and using their double-bottoms for bunker space.

Some grades of fuel oil have been known to be as light as specific gravity ·888, and some grades of Trinidad oil have been found to be as heavy as specific gravity ·950, but these are probably the two extremes.

CHAPTER XXVII.

A FEW HINTS ON GAS.

This important subject must be mentioned, as it vitally concerns everyone who is aboard a tank steamer. As mentioned in Chapter XXIV., the carriage of "gassy" oils is safe enough if the proper precautions are taken, but if one man aboard the ship is careless, it may mean a serious explosion. Notices are posted up in different parts of a ship warning the crew against the use of naked lights and smoking in unauthorised places, and this rule must be carried out. In some ships, directly a new crew has joined, a search is made for matches, especially fusees, wax matches, and the ordinary red-ended match which will strike anywhere. These kind of matches must not be allowed on board at all, and if found should immediately be destroyed and safety matches issued in their place.

It is the rule in most companies to supply safety matches, so there is no excuse for the dangerous kind being aboard. If a man had loose matches of this kind in his pocket, and some were dropped, the chance is that someone would step on them, causing them to ignite and perhaps cause an explosion.

It must always be rememdered that "gas" is the "Great Unseen Enemy," and must always be guarded against. Most ships are fitted with gas outlet pipes, which lead from the top of the tank, and then to a certain distance up the mast, where the gas can escape with safety.

Assuming that a tank is empty, and is foul with gas, the following procedure should be followed to make it "gas free":—Shut down the tank lids, and put the plugs on. It is not necessary to screw them on, but turn them upside down, and they can be removed quickly if necessary. Shut the tank valves to prevent the gas going into the pipe lines. Then open the tank steam valves, thus allowing a good pressure of steam to force its way into the tank. If the ship is not fitted with steam valves in the tanks, connect the steam hose on to the deck steam pipe, and put the other end down through the plughole as far as possible. The steam hose must be well parcelled around where it enters the plughole to prevent the steam escaping before its work is done.

Steam the tank for six hours, and then remove the plug, still keeping the steam turned on. This will make a current of steam in the tank which will rush up through the plughole, taking a lot of the gas with it. Keep this current of steam on for one hour. Experience has shown that this is a good way of forcing the gas out before the steam cools down and condenses. Next open up the tank lids, and rig up windsails, putting the ends as low as possible in the tanks. There is nothing like plenty of wind for driving the gas out of the corners and recesses, which it seems to cling to.

Also, if the ship has an air fan in the pump-room, send a good current of wind along the pipe line into the tanks, by opening up the air valves and also the suction valves.

A ship must always be made "gas free" before entering a dry dock, and a chemist will come aboard and test the air in the tanks, and no red-hot rivets or naked lights are allowed till he issues his certificate stating that the tank is clear of gas.

When sending men down into a tank which has been foul with gas, watch them closely, because different kinds of gas have different effects.

Some gas will make them laugh and sing and shout, and feel very lively for a time, and then suddenly they become drowsy and want to sleep. Get them up in the fresh air as soon as possible, and the effects will soon disappear. Other gas makes them roll about as if intoxicated, so an officer must always be on the lookout for any signs that something unusual is going on. Every tanker should be provided with a "gas helmet" for use in cases of emergency. It is shaped like a diver's helmet, and fits over the head and straps on to the shoulders.

The helmet is kept supplied with fresh air by a small rubber air pipe, which enters it at the back; the other end being connected to a small air pump, worked by a pair of small bellows. The helmet has windows at the front and sides, and should be tested periodically to make sure it is ready for instant use, either for entering a "gassy" tank or in case of fire down below.

CHAPTER XXVIII.

THE IMPORTANCE OF TEMPERATURE.

THE subject of this chapter is a very important one in all branches of the oil trade, and a few words are required in this book to point out facts which are often overlooked.

The question of temperature invariably arises whenever calculations of oil are being made, and to ignore this factor would certainly make the calculations incorrect, unless by chance the oil happened to be at the standard temperature of 60° Fahrenheit.

This standard temperature of 60° Fahrenheit (or its equivalent 15°·5 Centigrade) is the basis from which all calculations of temperature are made.

A practical illustration is given here to show how the calculated weight of oil in a tanker was affected by tempetature.

The cargo was kerosene, and was loaded in the U.S.A. The temperature of the oil on being tested in the ship's tanks immediately after loading was found to be 80° Fahrenheit, and if the correction for temperature had not been applied, the calculations by the ship's measurements would have shown her to have much more cargo aboard than she really had.

It will be seen that the difference in the temperature of this oil and the standard of 60° Fahrenheit is 20°. As previously mentioned in this book, the average expansion of oil is about $\frac{1}{20}$th per cent. for every degree of temperature. Therefore this difference of 20° would make the correction 1 per cent., and this 1 per cent. on a cargo of 10,000 tons would make exactly 100 tons difference.

This illustration shows that when the ullages of the ship's tanks had been taken and the cargo weights worked out, she *appeared* to have 10,000 tons of oil in her tanks, but on the correction for temperature being applied she was found to have 9900 tons.

The temperature being higher, the oil had been expanded in volume (but not in weight) and had filled more space in the tanks, but the specific gravity had become less, owing to the oil becoming thinner by this expansion and of less weight per cubic foot.

When the temperature of the oil in the ship's tanks decreased to nearly the temperature of the sea-water outside, it was noted that the ullages increased as the oil contracted, but the specific gravity had risen. She then *appeared* to have less oil in the tanks, but the *weight* was there just the same as when loaded.

It is thus shown how necessary it is to make the correction for temperature, because it is quite a common occurrence to load oil at a temperature of 80° Fahrenheit, and sometimes even more, and on arrival at the discharging port the same oil is found to be less than 60° Fahrenheit; and if the correction for temperature is not applied, a big discrepancy will be found in the ship's calculated weights taken at the loading and discharging ports.

The following table of constants for correction of temperature and a worked example may be found useful :—

For every degree below 60° Fahrenheit add :—
For every degree above 60° Fahrenheit subtract :—

Oil fuel	·00041
Petrol	·00048
Lubricating oil	·00035
Linseed oil	·00035
Methylated spirit	·00050
Naphtha	·00050

Worked Example :—

Cargo, oil fuel; specific gravity, ·930; temperature, 80° Fahr.
Cubic feet of space filled with cargo, 2,500,000.

Constant . .	·00041	2,500,000 cubic feet
Diff. of temperature	20°	·0082 constant for 20°
	0·00820	5000000
		20000000
		20500·0000 reduction

Cubic feet filled at 80° Fahr. . .	2,500,000
Reduction for temperature 20° . .	20,500
Cubic feet filled at 60° Fahr. . .	2,479,500

The oil inspectors who calculate the weights of oil supplied at American ports, correct the gravity of the oil for temperature, and have special tables to consult; but as these tables are not available for insertion, and also because they are calculated for Baumé degrees of gravity, the alternative method is given, which is equally as good.

If loading in a hot climate where the temperature of the oil is high, it is safe to load the oil well up in the expansion trunks of the tanks, because it will contract as the temperature becomes lower.

But if loading oil at a low temperature, and bound to a place where you know the weather conditions are much warmer, be on your guard, and don't fill the expansion trunks up too far, because the oil will expand as the temperature rises.

In the United States the Baumé hydrometer is used for taking the gravity of any oil, and the Baumé scale of degrees are used. At the end of this chapter a comparative scale is given, showing the Baumé degrees and their equivalents in specific gravity.

The thermometer used in America and Great Britain is the Fahrenheit, but in France and many other countries the Centigrade thermometer is in general use. The formulas for converting Fahrenheit to Centigrade and Réaumur and *vice versa* are given :—

Fahrenheit to Centigrade . . $-32° \times 5 \div 9 =$ Centigrade.
Centigrade to Fahrenheit . . $\times 9 \div 5 + 32° =$ Fahrenheit.

Another Method :—

Fahrenheit to Centigrade . . $-32° \div 1{\cdot}8 =$ Centigrade.
Centigrade to Fahrenheit . . $\times 1{\cdot}8 + 32° =$ Fahrenheit.

Fahrenheit to Réaumur . . $-32° \times 4 \div 9 =$ Réaumur.
Réaumur to Fahrenheit . . $\times 9 \div 4 + 32° =$ Fahrenheit.

COMPARATIVE TABLE—BAUMÉ DEGREES AND SPECIFIC GRAVITY.

Baumé.	Sp. Gr.	Baumé.	Sp. Gr.	Baumé.	Sp. Gr.	Baumé.	Sp. Gr.
10°	1·0000	31°	·8707	51°	·7754	71°	·6988
11	·9930	32	·8655	52	·7711	72	·6953
12	·9860	33	·8602	53	·7670	73	·6920
13	·9790	34	·8550	54	·7627	74	·6885
14	·9725	35	·8497	55	·7587	75	·6852
15	·9660	36	·8447	56	·7546	76	·6820
16	·9592	37	·8397	57	·7506	77	·6787
17	·9530	38	·8347	58	·7466	78	·6754
18	·9465	39	·8300	59	·7427	79	·6722
19	·9402	40	·8250	60	·7388	80	·6690
20	·9340	41	·8202	61	·7350	81	·6659
21	·9280	42	·8155	62	·7312	82	·6627
22	·9217	43	·8110	63	·7275	83	·6597
23	·9160	44	·8062	64	·7238	84	·6566
24	·9100	45	·8017	65	·7202	85	·6536
25	·9042	46	·7972	66	·7165	86	·6506
26	·8985	47	·7927	67	·7128	87	·6476
27	·8927	48	·7882	68	·7093	88	·6447
28	·8872	49	·7840	69	·7057	89	·6417
29	·8815	50	·7797	70	·7022	90	·6387
30	·8762						

CHAPTER XXIX.

MISCELLANEOUS INFORMATION.

When comparing the build of different types of cargo-carrying ships, the oil tank steamer takes a foremost place for stability and strength. Having so many transverse bulkheads, which form the different tanks, cofferdams, and pump-rooms, which are all securely fastened to the admidship longitudinal bulkhead, it can be seen at once that they all tend to strengthen the ship. Plenty of ribs, gusset stays, and stringers in the bottom of the tanks complete the strength of this kind of ship.

Owing to their length they all have a certain amount of "spring" when in a seaway, and do not stop absolutely rigid. For this reason all pipe lines are fitted with "expansion joints." These are sometimes called "sleeve joints," because one section of pipe line fits into another section like an arm fitting into a sleeve. Thus when a ship is "working" in a seaway the pipes expand and contract at this "sleeve or expansion joint."

If there were no allowance made for this expansion and contraction, the pipe line would break. The joint is well secured and packed like a "gland" to prevent any oil coming out when the pipe line is working with the motion of the ship. The steam pipes also have to be fixed to allow for motion, and this is done by putting bends in them at intervals, which will allow for contraction and expansion.

If the wheel on the bridge is connected to the steering engine by means of a rod, then at certain places this rod will be slotted to allow for the working of the ship. If it was kept rigid, it would either break or buckle. In the newer type of ship, which are well over 500 feet long, Telemotor steering gear is fitted, which does not need any rod from the wheel to the steering engine. This system is becoming very popular and is worked by small copper pipes, from the bridge to the steering engine, which are filled with glycerine and water. The turning of the wheel increases the pressure of glycerine in one pipe and decreases the pressure in the other. This pressure acting on small valves at the steering engine turns it the required way. These small copper pipes have bends in them at intervals to allow for contraction and expansion. When the wheel and rudder are exactly amidships, the height and pressure of glycerine and water in both pipes should be exactly the same. If this is not the case, the adjustment can be made by opening a small valve on the engine in the bridge wheel-house, but the wheel must not be moved till the valve is shut again.

All pipe lines are fitted with small draining plugs which screw into the pipe lines, and are generally situated on the underneath part and at the after end. This allows water to be drained out dry which the pump will not draw. If loading lubricating oil, it is very necessary to drain all pipe lines, both on deck and below, and these draining plugs allow the little drop of water which has accumulated in the lowest parts of a pipe line to be drained right out dry.

Most modern tankers are fitted for towing lighters. A special towing chock is fitted right aft amidships. A towing engine is installed in a house on deck near the stern. This engine has a very large barrel, around which the big towing wire is wound. This engine is worked by steam and is automatic in its action, giving out some slack wire when a sharp heavy strain is felt, and heaving in the slack again when the strain is eased. They are splendid engines, specially designed and fitted for towing, and could be used for salvage purposes if required.

Ullages are taken either by a steel tape (which is marked in inches and fractions of an inch) or an ullage stick (generally about nine feet long), marked in feet and inches and having a small cross-piece on it to rest across the plughole when taking measurements. This can only be used when the tank is nearly full, or has less ullage than the length of the stick. An ullage line can also be used, and is handy for any depth. It consists of a small line with a small circular piece of wood attached to it. This piece of wood will float on the top of the oil or water, and a correct measurement can be made directly the wood is felt to float. The line is generally marked to feet, and the fractions over can be measured by a rule.

If measurement by the "dip" is required, a steel tape with a weight attached must be used, because in this measurement the actual depth of oil is required. In measuring shore tanks the "dip" is always used, and it is only aboard ship that ullages are taken. The ullage gives the measurement of the vacant space between the top of the oil and the plughole, as has been fully explained before.

A very important thing for a beginner to know is, always be careful not to shut a valve against the pump till it has stopped pumping, otherwise it is quite likely that the increased pressure made by the pump will burst the line.

It is generally the rule when loading or discharging refined oils to hoist a red flag with a small white centre by day, and to hoist a red light in a prominent position by night.

In the United States the "Baumé" hydrometer is largely used in finding the weight and quantities of mineral oils. This hydrometer is of the same shape and form as the ordinary hydrometers which are in use in England, but in this case the "stem" of the hydrometer is graduated to Baumé degrees. The graduated lines start from near the top, which is marked "0," and increase as they go down the stem. It is marked in tens and fractions, the lowest graduated line near the bulb being marked 130°.

A comparative scale between Baumé degrees and specific gravity has been given at the end of the previous chapter.

CHAPTER XXX.

TABLE FOR CALCULATING WEIGHTS OF OIL OR WATER.

COMPILED by the Author, Herbert John White, from the formula given on page 53.

Explanation of Table.

Take number of cubic feet from the tank calibration scale, which is filled with oil or water. Find specific gravity, either by hydrometer or from shore records. Look down the column marked S.P.G., and take out the constant which is the *third* below the given S.P.G. Multiply the cubic feet by this constant, and the result will be tons of oil or water in the tank.*

* The Board of Trade standard for pure fresh water is 62·321 lbs. avoir. per cubic foot at a temperature of 62° Fahr., and barometer 30·00 at sea-level. On multiplying 62·321 by 16 the result is 997·136 ozs. in a cubic foot of pure fresh water, and not 1000 ozs., as is generally taken. In these tables, this is easily overcome by taking 997 as the standard of fresh water instead of 1000, viz. use constant ·02782 instead of ·02790. Another example, S.P.G. 900. Take constant third below, 897 = ·02503. By using this method of selecting the constant of the third line of S.P.G. below in value, all inaccuracy is avoided.

S.P.G.	Constant.	S.P.G.	Constant.
·500	·01395	·515	·01437
·501	·01398	·516	·01440
·502	·01400	·517	·01443
·503	·01403	·518	·01445
·504	·01406	·519	·01448
·505	·01409	·520	·01451
·506	01412	·521	·01454
·507	·01415	·522	·01456
·508	·01417	·523	·01459
·509	·01420	·524	·01462
·510	·01423	·525	·01465
·511	·01426	·526	·01468
·512	·01429	·527	·01470
·513	·01431	·528	·01473
·514	·01434	·529	·01476

S.P.G.	Constant.	S.P.G.	Constant.
·530	·01479	·574	·01602
·531	·01482	·575	·01604
·532	·01484	·576	·01607
·533	·01487	·577	·01610
·534	·01490	·578	·01613
·535	·01493	·579	·01615
·536	·01495	·580	·01618
·537	·01498	·581	·01621
·538	·01501	·582	·01624
·539	·01504	·583	·01627
·540	·01507	·584	·01629
·541	·01510	·585	·01632
·542	·01512	·586	·01635
·543	·01515	·587	·01638
·544	·01518	·588	·01641
·545	·01521	·589	·01643
·546	·01523	·590	·01646
·547	·01526	·591	·01649
·548	·01529	·592	·01652
·549	·01532	·593	·01655
·550	·01535	·594	·01657
·551	·01537	·595	·01660
·552	·01540	·596	·01663
·553	·01543	·597	·01666
·554	·01546	·598	·01669
·555	·01549	·599	·01671
·556	·01551	·600	·01674
·557	·01554	·601	·01677
·558	·01557	·602	·01680
·559	·01560	·603	·01682
·560	·01562	·604	·01685
·561	·01565	·605	·01688
·562	·01568	·606	·01691
·563	·01571	·607	·01694
·564	·01574	·608	·01696
·565	·01576	·609	·01699
·566	·01579	·610	·01702
·567	·01582	·611	·01705
·568	·01585	·612	·01708
·569	·01588	·613	·01710
·570	·01590	·614	·01713
·571	·01593	·615	·01716
·572	·01596	·616	·01719
·573	·01599	·617	·01722

S.P.G.	Constant.	S.P.G.	Constant.
·618	·01724	·662	·01847
·619	·01727	·663	·01850
·620	·01730	·664	·01853
·621	·01733	·665	·01855
·622	·01735	·666	·01858
·623	·01738	·667	·01861
·624	·01741	·668	·01864
·625	·01744	·669	·01867
·626	·01747	·670	·01869
·627	·01750	671	·01872
·628	·01752	·672	·01875
·629	·01755	·673	·01878
·630	·01758	·674	·01881
·631	·01761	·675	·01883
·632	·01763	·676	·01886
·633	·01766	·677	·01889
·634	·01769	·678	·01892
·635	·01772	·679	·01895
·636	·01775	·680	·01897
·637	·01777	·681	·01900
·638	·01780	·682	·01903
·639	·01783	·683	·01906
·640	·01786	·684	·01908
·641	·01789	·685	·01911
·642	·01791	·686	·01914
·643	·01794	·687	·01917
·644	·01797	·688	·01920
·645	·01800	·689	·01922
·646	·01802	·690	·01925
·647	·01805	·691	·01928
·648	·01808	·692	·01931
·649	·01811	·693	·01934
·650	·01814	·694	·01936
·651	·01816	·695	·01939
·652	·01819	·696	·01942
·653	·01822	·697	·01945
·654	·01825	·698	·01948
·655	·01828	·699	·01950
·656	·01830	·700	·01953
·657	·01833	·701	·01956
·658	·01836	·702	·01959
·659	·01839	·703	·01961
·660	·01842	·704	·01964
·661	·01844	·705	·01967

S.P.G.	Constant.	S.P.G.	Constant.
·706	·01970	·750	·02093
·707	·01973	·751	·02095
·708	·01975	·752	·02098
·709	·01978	·753	·02101
·710	·01981	·754	·02104
·711	·01984	·755	·02107
·712	·01987	·756	·02110
·713	·01989	·757	·02112
·714	·01992	·758	·02115
·715	·01995	·759	·02118
·716	·01998	·760	·02121
·717	·02001	·761	·02123
·718	·02003	·762	·02126
·719	·02006	·763	·02129
·720	·02009	·764	·02132
·721	·02012	·765	·02134
·722	·02015	·766	·02137
·723	·02017	·767	·02140
·724	·02020	·768	·02143
·725	·02023	·769	·02146
·726	·02026	·770	·02148
·727	·02028	·771	·02151
·728	·02031	·772	·02154
·729	·02034	·773	·02157
·730	·02037	·774	·02160
·731	·02040	·775	·02162
·732	·02042	·776	·02165
·733	·02045	·777	·02168
·734	·02048	·778	·02171
·735	·02051	·779	·02174
·736	·02054	·780	·02176
·737	·02056	·781	·02179
·738	·02059	·782	·02182
·739	·02062	·783	·02185
·740	·02065	·784	·02187
·741	·02067	·785	·02190
·742	·02070	·786	·02193
·743	·02073	·787	·02196
·744	·02076	·788	·02199
·745	·02079	·789	·02201
·746	·02081	·790	·02204
·747	·02084	·791	·02207
·748	·02087	·792	·02210
·749	·02090	·793	·02213

S.P.G.	Constant.	S.P.G.	Constant.
·794	·02215	·838	·02338
·795	·02218	·839	·02341
·796	·02221	·840	·02344
·797	·02224	·841	·02347
·798	·02227	·842	·02349
·799	·02229	·843	·02352
·800	·02232	·844	·02355
·801	·02235	·845	·02358
·802	·02238	·846	·02360
·803	·02241	·847	·02363
·804	·02243	·848	·02366
·805	·02246	·849	·02369
·806	·02249	·850	·02372
·807	·02252	·851	·02374
·808	·02254	·852	·02377
·809	·02257	·853	·02380
·810	·02260	·854	·02383
·811	·02263	·855	·02386
·812	·02266	·856	·02388
·813	·02268	·857	·02391
·814	·02271	·858	·02394
·815	·02274	·859	·02397
·816	·02277	·860	·02400
·817	·02280	·861	·02402
·818	·02282	·862	·02405
·819	·02285	·863	·02408
·820	·02288	·864	·02410
·821	·02291	·865	·02413
·822	·02294	·866	·02416
·823	·02296	·867	·02419
·824	·02299	·868	·02422
·825	·02302	·869	·02425
·826	·02305	·870	·02427
·827	·02307	·871	·02430
·828	·02310	·872	·02433
·829	·02313	·873	·02436
·830	·02316	·874	·02439
·831	·02319	·875	·02441
·832	·02321	·876	·02444
·833	·02324	·877	·02447
·834	·02327	·878	·02450
·835	·02330	·879	·02453
·836	·02333	·880	·02455
·837	·02335	·881	·02458

S.P.G.	Constant.	S.P.G.	Constant.
·882	·02461	·926	·02584
·883	·02464	·927	·02586
·884	·02466	·928	·02589
·885	·02469	·929	·02592
·886	·02472	·930	·02595
·887	·02475	·931	·02598
·888	·02478	·932	·02600
·889	·02480	·933	·02603
·890	·02483	·934	·02606
·891	·02486	·935	·02609
·892	·02489	·936	·02612
·893	·02492	·937	·02614
·894	·02494	·938	·02617
·895	·02497	·939	·02620
·896	·02500	·940	·02623
·897	·02503	·941	·02625
·898	·02505	·942	·02628
·899	·02508	·943	·02631
·900	·02511	·944	·02634
·901	·02514	·945	·02637
·902	·02517	·946	·02639
·903	·02520	·947	·02642
·904	·02522	·948	·02645
·905	·02525	·949	·02648
·906	·02528	·950	·02651
·907	·02531	·951	·02653
·908	·02533	·952	·02656
·909	·02536	·953	·02659
·910	·02539	·954	·02662
·911	·02542	·955	·02665
·912	·02545	·956	·02667
·913	·02547	·957	·02670
·914	·02550	·958	·02673
·915	·02553	·959	·02676
·916	·02556	·960	·02679
·917	·02559	·961	·02681
·918	·02561	·962	·02684
·919	·02564	·963	·02687
·920	.02567	·964	·02690
·921	·02570	·965	·02693
·922	·02572	·966	·02695
·923	·02575	·967	·02698
·924	·02578	·968	·02701
·925	·02581	·969	·02704

S.P.G.	Constant.	S.P G.	Constant.
·970	·02706	·999	·02787
·971	·02709	1·000	·02790
·972	·02712	1·001	·02793
·973	·02715	1·002	·02796
·974	·02718	1·003	·02799
·975	·02720	1·004	·02801
·976	02723	1·005	·02804
·977	·02726	1·006	·02807
·978	·02729	1·007	·02810
·979	·02732	1·008	·02812
·980	·02734	1·009	·02815
·981	·02737	1·010	·02818
·982	·02740	1·011	·02821
·983	·02743	1·012	·02824
·984	·02745	1·013	·02826
·985	·02748	1·014	·02829
·986	·02751	1·015	·02832
·987	·02754	1·016	·02835
·988	·02757	1·017	·02838
·989	·02760	1·018	·02840
·990	·02762	1·019	·02843
·991	·02765	1·020	·02846
·992	·02768	1·021	·02849
·993	·02771	1·022	·02852
·994	·02773	1·023	·02854
·995	·02776	1·024	·02857
·996	·02779	1·025	·02860
·997	·02782	1·026	·02863
·998	·02785		

Every constant worked out by myself, and not taken from any other book or tables.

H. J. WHITE

PRINTED IN GREAT BRITAIN BY NEILL AND CO., LTD., EDINBURGH.