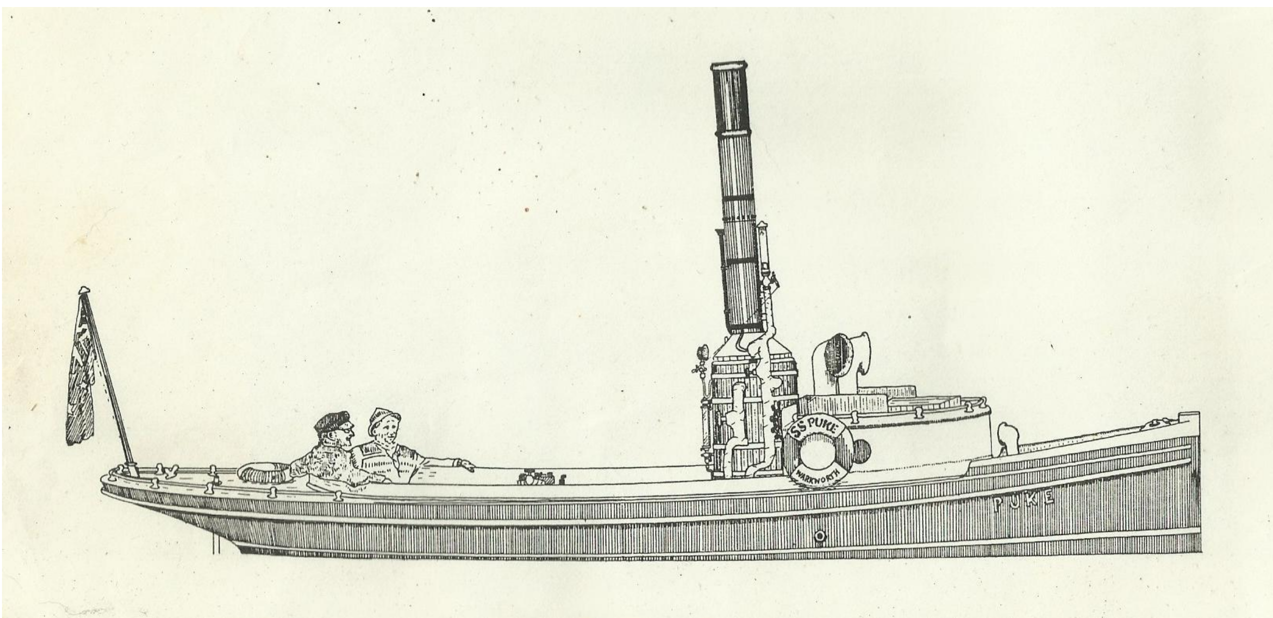
S.S. Puke

Familiarisation and Training Manual



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Contents

Overview

This document is intended to provide information for the successful training and familiarization of potential Masters and Engineers on the New Zealand Maritime Museum’s steam launch Puke. It contains an overview of the vessels design, construction, history, and its operating components. In addition it provides an overview of the principles of steam propulsion, and the basic knowledge required to operate the boat safely. Potential Masters and Engineers should use the information provided as the basis of their initial off the water training.

Design, Construction and History

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Puke is a fairly typical steam launch of the type built in the second half of the 19th century. Puke herself was built by E Thompson in 1872 on the Kaipara Harbour as a tender to the kauri logging trade that flourished in that area at the time. As a tender to the logging trade, she would have done much work towing kauri logs into the booms of the mills, and attending to the larger sailing ships that shipped the milled timber out of the Kaipara. Her hull is typical of the period, being of two skin construction, the inner layer being diagonal planking, the outer fore and aft, copper fastened throughout on stringers, but lacking frames as is the norm with this construction. Her hull has the plum stem with deep forefoot and counter stern typical of the period, with a rounded bilge leading to a built down keel of considerable depth. The elegant shape is ideal for carrying a heavy steam plant, while remaining extremely seaworthy and fast for her size and power. The builders plate on her stern coamings carries the name E Thompson and Sons, Builders, Kaipara, New Zealand, but this was a later addition, the plates being put on all vessels built by Eric Thompson himself and those built once his sons joined the business.

Little is known of Puke’s history until she was found by Mr Alan Brimblecombe in 1977 in the Tamaki River in Auckland, powered by a petrol engine, with a plywood cabin over the cockpit. The unnamed vessel was later discovered to have been called Wai?awa. Alan Brimblecombe, a steam enthusiast removed the engine and cabin, returning her to a more authentic appearance. A suitable vertical firetube boiler was found, along with a steam engine to suit her. The engine was originally built by A and G Price of Thames, Coromandel around 1900, and was used power a conveyor belt in a sawmill. It was originally a horizontal engine, with an enclosed crankcase. It was found by the potter Barry Brickell in the sawmill, and recovered despite having a broken crankcase. It was then given to Ralph Sewell, builder of the museum’s brigantine Breeze, who removed the crankcase and cast the columns, turning the engine into a vertical open crank type. From here Alan Brimblecombe acquired it, putting it into the vessel, renamed Puke, so named after the wharf complex at Paeroa where she was restored. Later John Hannah arranged for the Fink Reversing Gear to be added to the engine, and the engine has stayed basically in that form ever since.

Puke operated from Paeroa for six years, carrying passengers for the Maritime Park Museum at Paeroa, as well as many other trips within the Hauraki Plains and Firth of Thames. She moved to Warkworth in 1983, and was regularly seen on the waters of the Mahurangi River, Kawau Bay and further a field in Auckland. In 1988 she was shipped to Brisbane, Australia and served on the Brisbane River carrying VIPs for the New Zealand Expo Commission at Expo 88. During this time she carried numerous celebrities, officials and heads of government, and also won the Great Brisbane Steamboat

Race.

On her return to New Zealand, Mr Brimblecombe sold her to the Union Shipping Company, formerly known as the Union Steam Ship Company of New Zealand, who donated her to the then forming Auckland Maritime Museum, now New Zealand Maritime Museum. After a period out of use, she was refitted by the museums workshop, with an additional layer of planking and a fiberglass skin added to her hull, and she was re-launched in time for the museums opening in 1993. She has subsequently been an operating feature of the museum ever since, entering Safe Ship Management Survey in 2000. During her engineering refit in 2006, the Sharmen vertical firetube boiler was replaced with a new unit built by Colonial Ironworks of Whangaporoa. Subsequent overhauls have seen plumbing modified to the layout featured in this manual.

Puke in the Wairoa River, Clevedon early 2000s

Steam Plant Operating principles

In order to operate Puke successfully and safely, engineers and skippers need to have an understanding of the principles of operation, the components that compose a steam plant, and how they work in relation to each other.

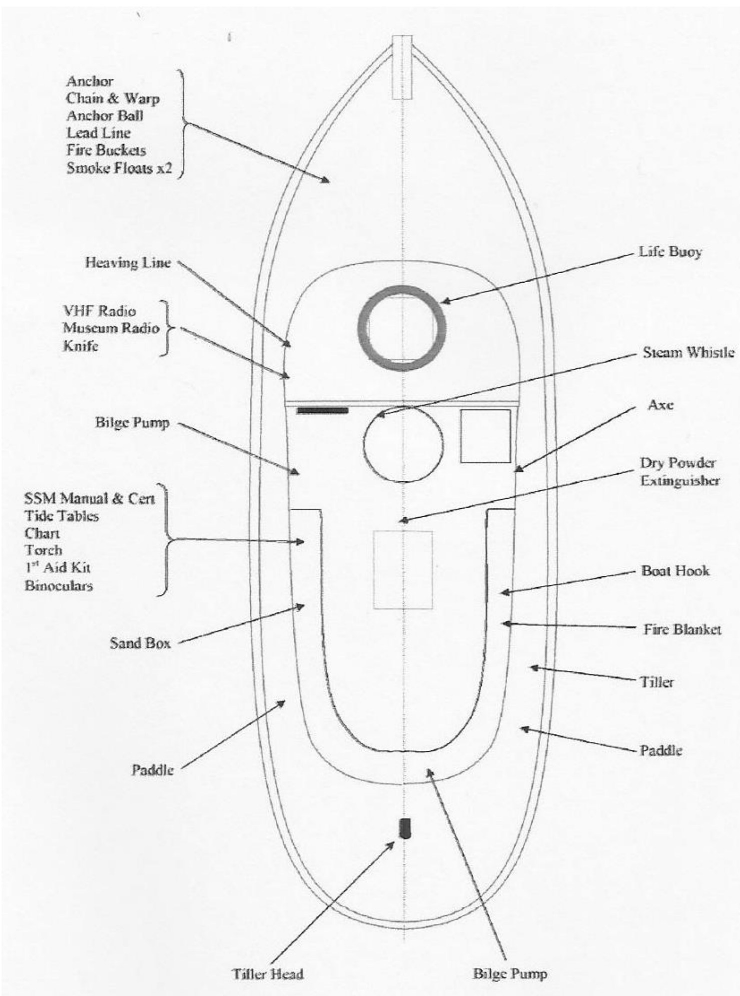
Plant and Vessel Safety

There are a number of possible injuries that can occur as a result of operating the vessel, and operators should be aware of these in order to prevent them as best as possible.

Foremost of these is the likely hood of being burnt. You must always treat all pipework and fittings as hot, and wear suitable gloves when handling valves and fittings, and whilst firing. Any exposed flesh, particularly including upper arms is susceptible to being burnt, as not all pipework is lagged, and even lagged pipework can be hot. Great care should be taken when accessing the cabin, particularly in proximity to the blowdown valve on the port side of the boiler.

The other potential for personal injury is the risk of entrapment by moving parts of the engine and shaft arrangements. Operators must be vigilant at all times, avoiding putting your hands in a position where they can be pinched, or drawn in by moving components. The machinery will not stop, but will crush bone if it has the opportunity to do so. One should always be aware of the risks of loose clothing, gloves and hair, and the dangers of entrapment as a result. The advice often given to passengers is that if it moves it will crush you, if it doesn't move, it will burn you, so don't touch.

When embarking and disembarking, it is important to ensure that everyone stays clear of hot or moving components as they often appear to be superb hand holds. It is also important to ensure that you can get safely on and off the vessel, without falling between the vessel and the wharf.



Passengers must be reminded to keep hands inside the vessel when leaving and entering the berth. All passengers should remain seated at all times, and should only move when invited to do so, one at a time. Crew should be aware that their movements can have an impact on the apparent stability of the vessel.

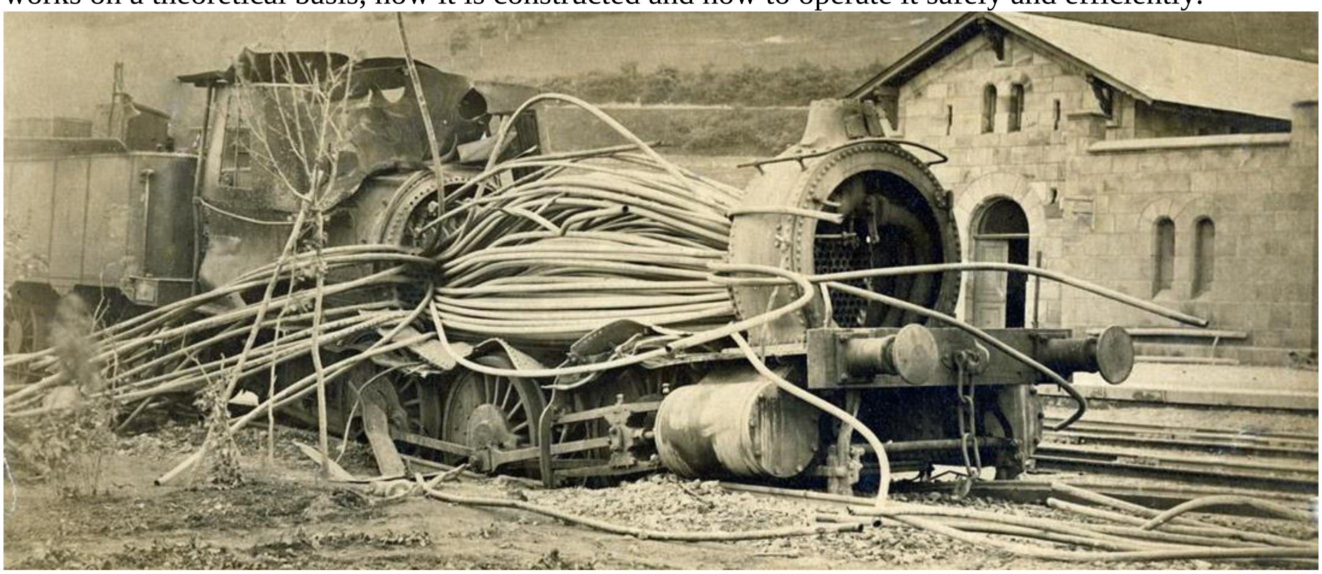
If the plant is in steam, and any work needs to be done on any component, you must first isolate and vent any steam from that part of the system, and ensure that there is no other way that steam can access the component you are working on. If in doubt, the plant should be shut down completely, and left to cool. Be aware that the cooling process can take many hours. Also be aware that cold water cannot under any circumstances be added to an empty but warm boiler, as this could result in catastrophic damage and possible personal injury.

Full safety equipment and first aid gear is carried on board the vessel, and all crew should know where it is and how to use it.

Steam Theory and Operation

Introduction:

The operation of a steam plant, such as that used on the steam launch Puke, is completely unlike the operation of any petrol or diesel engine you may have encountered in other vessels. A steam plant such as this must be handled with great care and respect, as the potential for injury and or death is ever present. This is due to the large amount of energy contained in the boiler, which if allowed to escape rapidly for any reason, can have catastrophic results. Also the engine is of an open type with exposed moving parts which have their own hazards. The steam plant is a system, and must be appreciated as such when being operated. This system can be influenced by factors which have no or negligible effects on conventional internal combustion engines. These factors include: atmospheric temperature, sea temperature, wind, method of firing the boiler and others. This manual will explain how the system works on a theoretical basis, how it is constructed and how to operate it safely and efficiently.

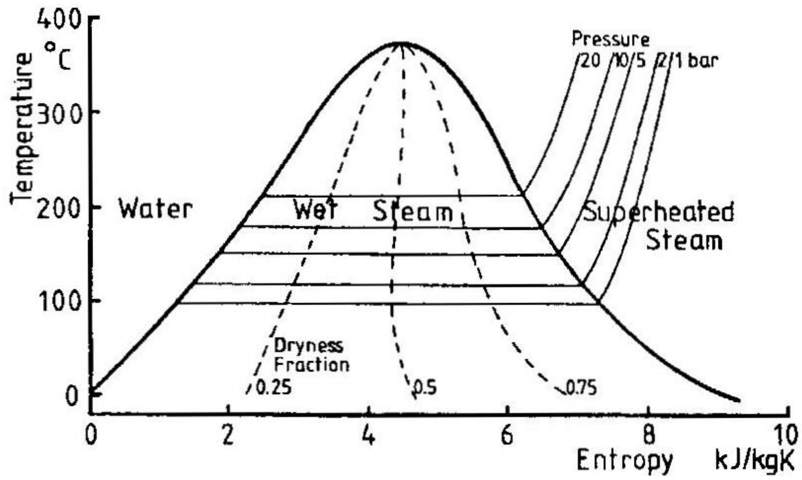


A locomotive boiler after it has exploded; such an explosion would kill everyone on Puke

Basic Steam theory:

Simply put the steam engine is a heat engine, which converts the heat from the burnt fuel into mechanical work at the propeller via an energized gas / fluid, steam. This is known as an "external combustion" engine in that the fuel being burnt is not in contact with the piston, as in an "internal combustion" engine such as a petrol or diesel. As a method of utilising fuel this is much less efficient than petrol or diesel, and is why the steam engine was eclipsed by them in the early twentieth century. This is due to the large losses associated with this system. A large amount of the heat energy is lost to the nitrogen which comprises 70% of atmospheric air which passes through the fire box and boiler, absorbing heat and taking it uselessly up and out of the stack. Other losses are radiation losses from the boiler and pipe work, (hence lagging) and mechanical losses in the engine due to friction, and losses due to propeller inefficiency etc. In total as little as 5% of the energy in the fuel is actually pushing the boat through the water, compared to internal combustion engines that can be up to about 60%.

When water is heated to its boiling point in the air, 1 unit of steam will displace 1728 units of air against 1 atm of pressure (14.7 psi). If the steam is contained in a pressure vessel such as a boiler, this expansion rate increases with the temperature and pressure of the steam, so that the steam when released will expand to many thousands of time the volume of the boiler. This is why the boiler has the potential to be so destructive, in fact on the same scale of energy as a large artillery shell exploding. This thankfully happens rarely, and can be easily avoided but must be born in mind at all times.



When the water reaches 100 degrees celcius (212 degrees f), there is a period where the temperature and pressure does not rise, even though heat is still being absorbed. This is called the latent heat of water, which is the energy the water has to absorb to form steam. This is quite noticeable on Puke, and can last several minutes between steam being noticed at the whistle, and pressure starting to rise on the gauge. This is normal. As the boiler pressure on Puke is set to a maximum of 7 atm (7 bar or 100 psi), the steam is said to be saturated ie. the water and steam are at the same temperature. Saturated steam is a vapour including droplets of water, this water acts to lubricate the piston and the cylinder, and the valve and valve chest, meaning no lubricating oil need be added to the steam.

It is the expansive nature of the steam which is utilised in the engine, where the steam enters the cylinder at one temperature and pressure, and exits at a lower temperature and pressure. The energy difference in these figures represents the amount of work being done on the crankshaft. In Puke this about 6HP (4.47 kw) at the most. Note that if a higher pressure and temperature of steam were supplied, this figure would also increase as the boiler is the source of the energy NOT the engine.

The boiler:

The boiler on Puke is described as a vertical fire tube boiler ie. The hot gases pass vertically through 61 tubes, and impart their heat energy to the surrounding water in the boiler drum. The upper part of the drum is the steam space, where the steam is drawn off to the engine and auxiliaries described below:

Some figures on the boiler:

Total volume 131 litres,

Water volume at half glass 86 litres

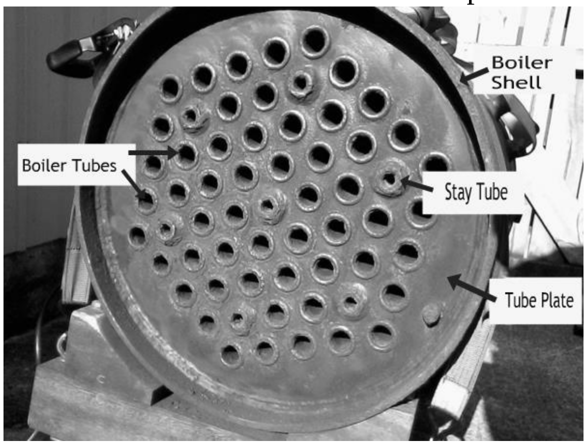
Heating surface area 4.6 meter square

Grate area 0.16 meter square

Grate area to surface area ration roughly 30:1

The boiler construction is as follows:

Boiler shell 10 mm thick single vertical welded seam, upper and lower tube plates 12 mm thick welded to shell. The tubes have an o.d. of 31.8mm and there are 61 in total, 54 having 2.9 mm wall thickness expanded into the tube plates and 7 stay tubes of 6.3mm wall thickness welded to the tube plates as stays. Shell clad with 20 mm kaowool insulation surrounded by 3mm stainless steel wrapper. This in turn is clad with 10 mm wooden strips.



Fire box is steel with fireclay refractory lining. Fire box clad with kaowool, and stainless steel wrapper as per boiler. The grate is of high temperature nickel cast iron alloy in three removable pieces supported by a T shaped bracket standing on the ashpan floor to prevent dropping. Smoke box is of stainless steel double wall with kaowool inside. Boiler design pressure is 200 psi. The safety valve is sized and set for 100 psi. All valves are rated for 150 psi. The boiler was constructed in 1996 to BS2790 1992.

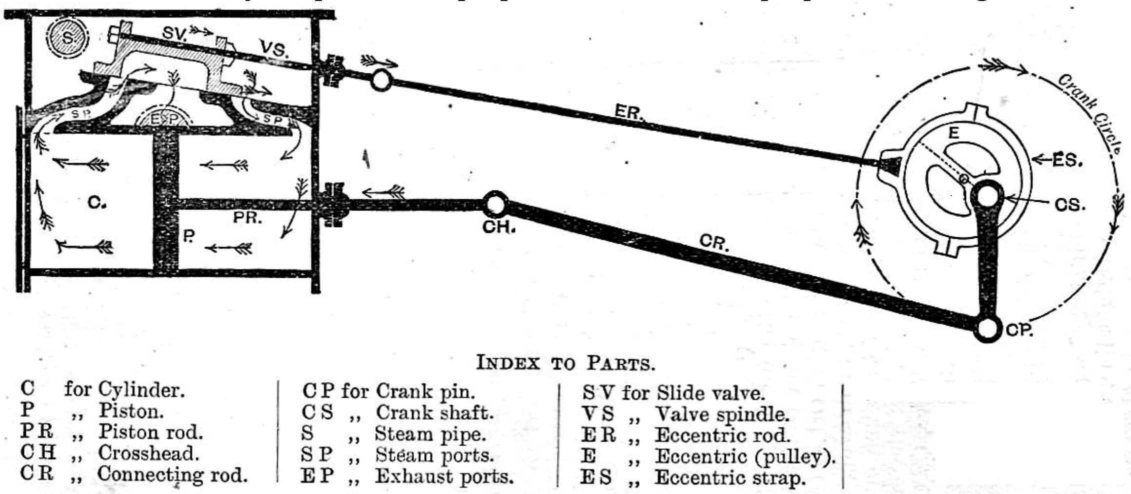
Engine principles

The engine as fitted to Puke can be described as a vertical double acting, simple single cylinder condensing marine engine, with Fink reversing gear. This means the steam is expanded only once in the cylinder, before being exhausted to the condenser. The steam acts on both the upper and lower sides of the piston during one revolution; first on one side the other exhausting then at the end of each stroke the process is reversed. This means that two power strokes are delivered each revolution, hence the phrase “double acting”. Because there is only one piston, a flywheel is fitted to carry the piston assembly over top and bottom dead centres, to prevent stalling. This stalling can still occur, and can be overcome by closing the throttle and manually turning the flywheel to restart the engine. Reversing the engine is achieved by moving the reversing lever, which changes the order of steam admission to either the top or the bottom of the piston, thus reversing its rotational direction. This can be hit and miss at very low speeds, and requires some practice to apply a “puff” of steam by opening the throttle slightly as the lever is put from ahead to astern, or vice versa to prevent stalling. It will be noticed that the drive train is directly fixed to the propeller shaft with no clutch or gear box interposed.

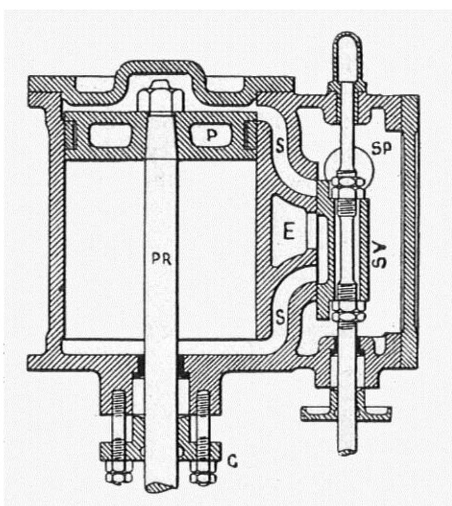
Some figures:
Bore 5 inches (127 mm)
Stroke 4 inches (102 mm)
Maximum torque theoretical 1140 foot pounds (1544 nm)
This is the maximum theoretical torque. Actual torque will be lower but is still comparable to a very large sports car engine. The thing to bear in mind is that this torque is produced at very low rpm, a maximum of about 180 rpm, whereas a car produces its maximum torque at 3000 rpm +. A steam engine produces torque even when it is stopped against a load, unlike a conventional engine. This is why the propeller on Puke is so large and has such a course pitch ie 23 inch diameter (584 mm) by 29 inch pitch (736mm). An outboard motor with an equivalent horse power rating would have a much smaller propeller, in pitch and diameter as it would spin much faster, and the torque would be much less. Thus we like to say that the horses driving Puke are few but have large hairy hooves!

How the Engine Works

The steam engine uses the steam gas to push the piston up and down within the engine. This in turn is converted to a rotating movement, via the connecting rod to the crankshaft. The movement of the crankshaft is directly coupled to the propeller shaft, and the propeller, causing the vessel to move.

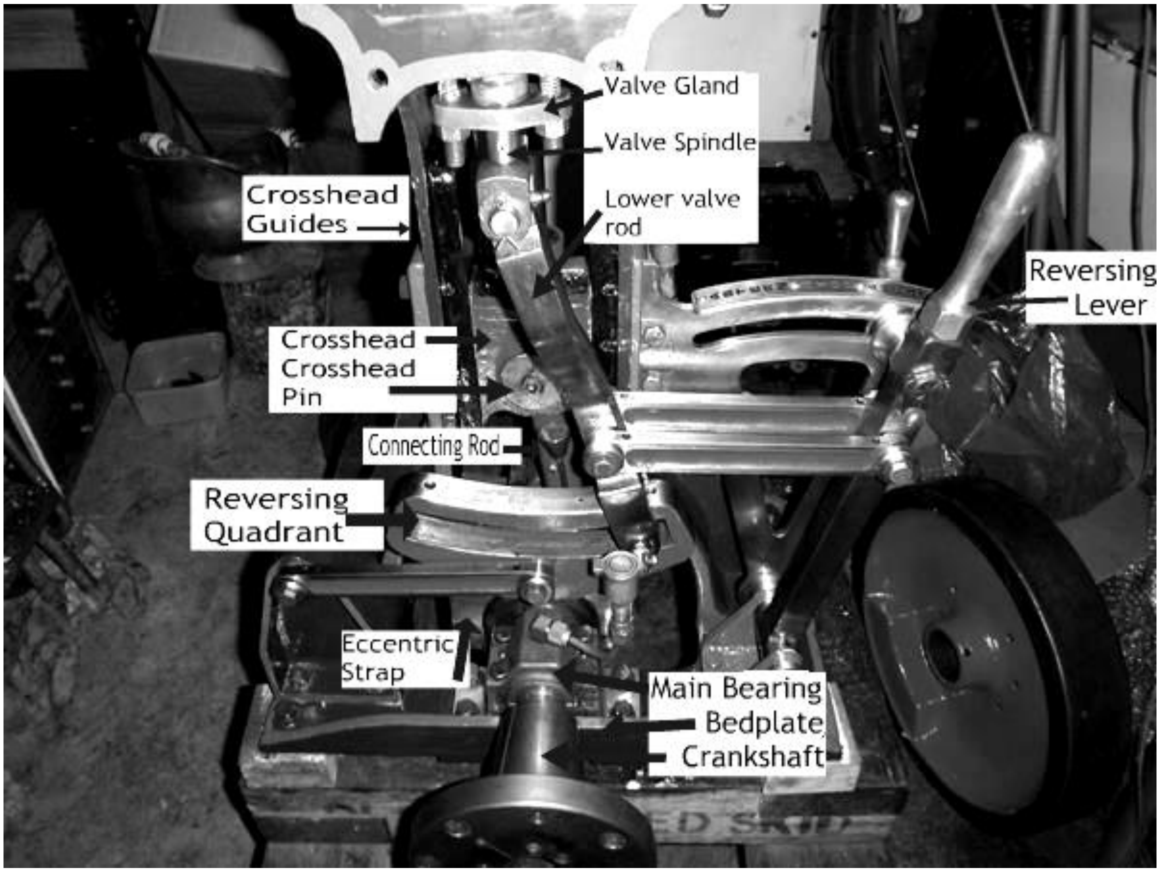


As mentioned above, the steam is admitted to the cylinder on either side of the piston via the slide valve. The cutaway image below shows the movement of steam through the valve chest and cylinder via the valve ports.

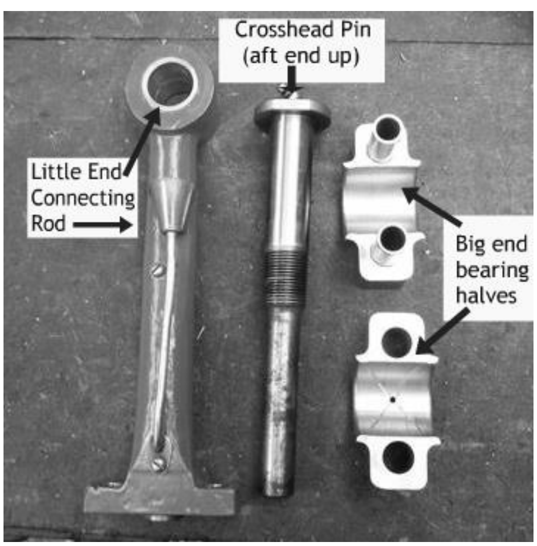


Steam enters via the steam port *SP*, and is admitted by the slide valve *SV* through the upper passage *S* to push down the piston *P*. At the same time, exhaust steam from below the piston passes back up the lower passage *S*, via the valve cavity, to exhaust *E*. As the piston descends, the valve moves upwards to admit steam below the piston and release exhaust from above.

The piston is connected to the piston rod, which passes through the gland out of the cylinder, and meets up with the connecting rod at the crosshead. The crosshead assembly slides up and down in the crosshead guides, and takes the sideways thrust from the connecting rod. The connecting rod and crosshead are linked together by the crosshead pin or wristpin (also known as a gudgeon pin).



The connecting rod converts the movement from vertical to rotational, and couples to the crankshaft via the big end bearing. The big end, like most bearings on Puke, is a split bronze bearing that bolts together around the crankshaft.



The crankshaft is carried by two main bearings fore and aft of the main columns. Ahead of the aft main bearing is the eccentric which operates the valve gear. The eccentric is keyed onto the crankshaft, and transmits the rotational motion of the crankshaft into the vertical motion of the valve spindle, via the reversing quadrant. The reversing quadrant allows the valve to be moved into the ahead or astern position at either end of the quadrant or the stop position in the middle of the quadrant. The die block inside the quadrant is connected to the lower valve rod, which in turn connects to the valve spindle. The reversing lever link arms are connected to the lower valve rod. The valve spindle drives the valve up and down in the valve chest, opening and closing the relevant ports to admit steam in and out of the cylinder.

The crankshaft carries the flywheel which helps carry the engine past the top and bottom dead centres, where the piston receives no steam. On larger multi-cylinder marine engines, the propeller acts as a flywheel (and as a brake to prevent over speed), however Puke needs a flywheel, and it is used when starting the engine to move the engine by hand past the dead centres as mentioned. It is worth noting that multi-cylinder engines do not have the need to be started by hand, as they do no have dead centres to stop on. The propeller shaft coupling is attached to the flywheel.

Plant components

The following is a basic overview of the components of the plant, and how they work.

Major Components:

Boiler

The boiler is the steam producer for the operation of the system. In the case of Puke, the boiler assembly consists of three separate major components:

Firebox:
Located under the boiler, the circular firebox contains the fire, has the combustion space to allow the fire to burn effectively, and has a space for ash under the fire grate. The firebox is the main support for the boiler itself. The firebox is of welded steel construction, is lagged inside with castable refractory and out with Kaowool, and has supporting brackets for the grate. The fire grate itself is of three cast pieces of iron, and are plates with a number of tapered holes in it. These holes allow primary air to come through the fire from the ash pan. The firebox has two doors, the main fire door which is hinged, and the lower ash pit door which is located by two brackets and is lifted out.

Boiler:
The boiler itself is located on top of the firebox. The boiler is the pressure vessel, in which steam is made by the heating of water to such a temperature to allow steam to be formed. The boiler is known as a vertical fire tube type, meaning that the hot gases from the fire pass up through the boiler inside vertical tubes, which heat the water surrounding them. The tubes are expanded into flat tube plates at either end of the boiler, the bottom tube plate being heated by the fire. The boiler has a number of valves and specialist fittings to allow the regulation of steam and water within the boiler, as well as access ports for inspection of the internals. The boiler is of welded steel construction.

Smoke box:
The smoke box sits on top of the boiler, and gathers the hot gasses and directs them up the funnel. The smoke box also houses the draft enhancing and soot blowers.

Engine

The engine is a single cylinder marine steam engine by A and G Price of Thames. As with most steam engines, it is double acting, meaning that steam is used on both sides of the piston. Thus steam pushes the piston down, and then pushes it back up again, every stroke being a power stroke. The engine is a reversing engine, meaning the whole engine runs in reverse for the reversing of the vessel. This is achieved through use of Fink reversing gear, located on the back of the engine, which changes the valve position to achieve reversing. There is no gearbox or clutch, the speed being regulated by the amount of steam let into the engine, and the direction being controlled by the reversing lever.

Attached to the engine are two pumps:

Air Pump:
Driven off the crosshead pin, this vertically mounted pump is used to remove the condensate from the condenser. The condensate is returned to the hotwell. It thus pumps water and air bubbles, hence the name Air Pump. Also known as a condensate pump, this unit helps to create a vacuum on the exhaust side of the engine. This is the larger of the two pumps.

Feed Pump:
Also driven off the crosshead pin, this pump is the smaller and most forward of the two. It pulls water from the feed tank, and pumps it back to the boiler, the volume going back into the boiler being regulated by the bypass line.

Condenser

Located on the outside of the hull below the waterline, this copper pipe condenses the exhaust steam back into water, allowing the water to be reused in the boiler. By condensing, it creates a vacuum that with assistance from the air pump, is used to pull on the exhaust side of the piston, helping the engine work more efficiently.

Feed Tank (Hotwell)

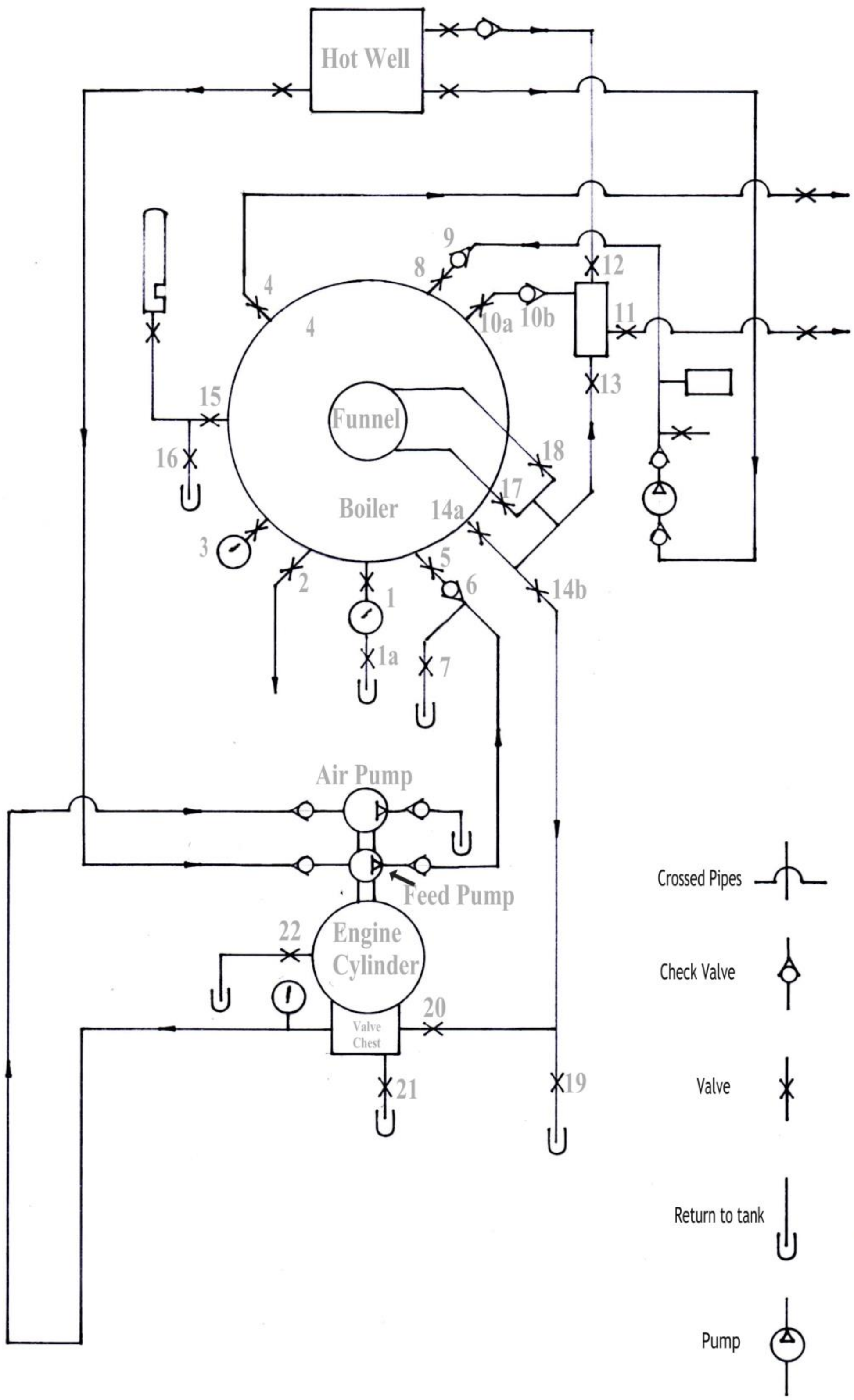
Located ahead of the boiler, this stainless steel tank holds the main water the system requires to operate.

Bunker

This box is located beside the boiler on the starboard side, it contains the necessary coal or wood to feed the fire

Propeller

Under the stern of the boat, this converts the rotary motion of the engine and shafting into thrust that pushes the boat along. Unlike most propellers, it is very large in diameter for the size of boat, and has much more pitch (or twist in the blades) to allow the slow speed of the engine to move the boat effectively.


Hot Well
Funnel
Boiler
Air Pump
Feed Pump
Engine Cylinder
Valve Chest
1
1a
2
3
4
4
5
6
7
8
9
10a
10b
11
12
13
14a
14b
15
16
17
18
19
20
21
22
Crossed Pipes
Check Valve
Valve
Return to tank
Pump

Controls, valves and auxiliaries:

These are the main items the system needs to function, to regulate the plant a number of special valves and fittings are attached to the boiler. By convention all valve handles are colour coded-
Red for steam
Blue for water
Black for drains

Numbers (1…) indicate location on the schematic. The schematic is an approximate indication of the steam and water circuits and item locations

Sight (Gauge) Glass: (1)

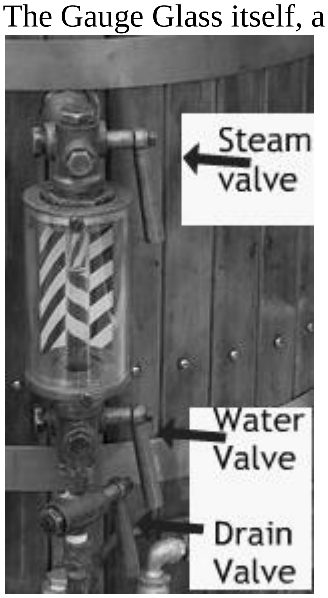
The most important safety item on the boiler is the water Sight Glass, or Gauge Glass. The Gauge Glass shows the level of water contained in the boiler. With any boiler, a lack of water brings potentially destructive and lethal results, hence its importance. The gauge glass is located on the after face of the boiler in full view of the engineer. Any engineer should know where the water level is in their boiler at ***all*** times. The Glass Glass consists of five major components:

Steam Valve
The upper most valve, this allows steam to travel into the glass.

Water Valve
The middle valve allows water into the bottom of the glass.

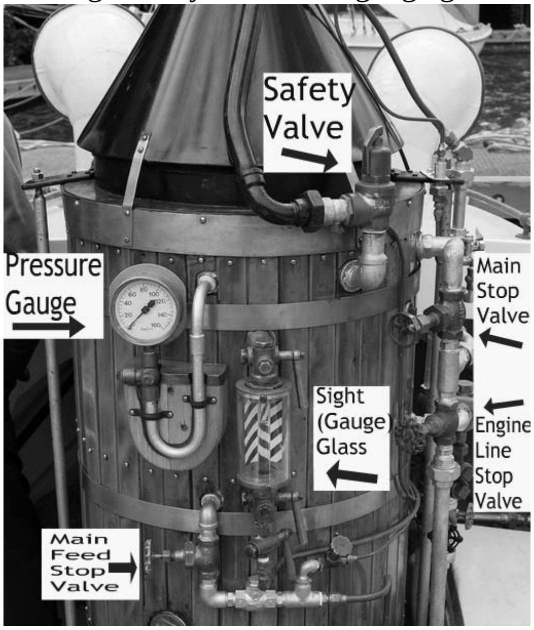
Drain Valve (1a)
The lower valve allows the glass to be drained, and thus tested using the proper testing procedure.

Glass
The Gauge Glass itself, a glass tube which shows the level of water in the boiler.



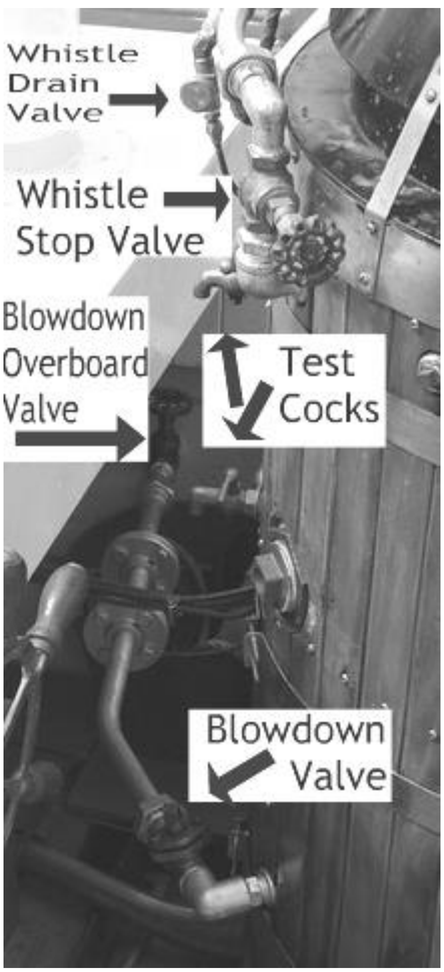
Shield
The glass and brass frame around the gauge glass itself, this protects the operator in the case of a glass failing.

The glass tube itself is supported in the fittings by rubber cones, and is sealed by glands adjusted by the large horizontal nuts at either end of the glass. The hexagonal plugs at the outside of the steam and water valves allow rodding through of the passages into the boiler, in the event of a blockage. This rodding can only be done with the boiler out of steam. Blocking of the steam and water valves of gauge glasses can occur, and thus false readings can be given in the glass, with possibly fatal consequences. To prevent this occurring, the gauge glass must be tested regularly. This should be done every time the boiler is steamed, and at least every few hours when running. Always check the gauge glass if you suspect there is a fault with the reading it is giving.



Safety Valve (2)

The second most important safety device on the boiler is the safety valve. This valve is located on the after side of the boiler at the top on the starboard side, and vents up the back of the funnel. This valve prevents the boiler from containing a pressure greater than it is designed to operate at. The operation is automatic, and it should be tested for correct operation every time the boiler is steamed.



Test Cocks

Located on the forward port side of the boiler, these two brass valves enable a reading of the water level to be taken in the event of a gauge glass failure. Their use is highly unlikely, but an engineer needs to understand the principle of their use in the event of their being needed. To use them, crack the valve very slightly, and observe whether water or steam come from each valve.

Pressure gauge (3)

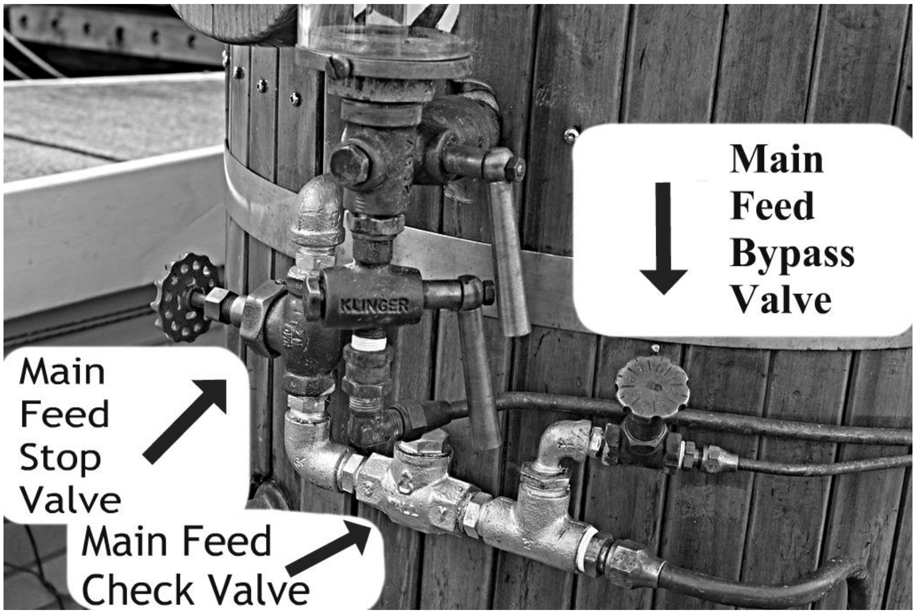
The pressure gauge is located above and to port of the gauge glass. It shows the steam pressure in the boiler. Its operation is automatic.

Blowdown Valve (4)

The lower most valve on the boiler, located to port and below the whistle valve, this valve allows the boiler to be emptied. The line on the square head of the valve indicates closed, when across the flow of the valve. A spanner is needed to operate this valve.

The following valves and equipment allow the addition and control of water level in the boiler:

<u>From the engine driven feed pump:</u>



<u>Main Feed Stop Valve (5)</u>

Located below and to port of the gauge glass, this valve allows the water from the engine driven feed pump into the boiler. This valve should be opened before the engine is run and should stay open when the plant is in use.

<u>Main Feed Check valve (6)</u>

This non return , beside the Feed Stop Valve, prevents steam from exiting the boiler via the feed line, but allows water into the boiler from the pump.

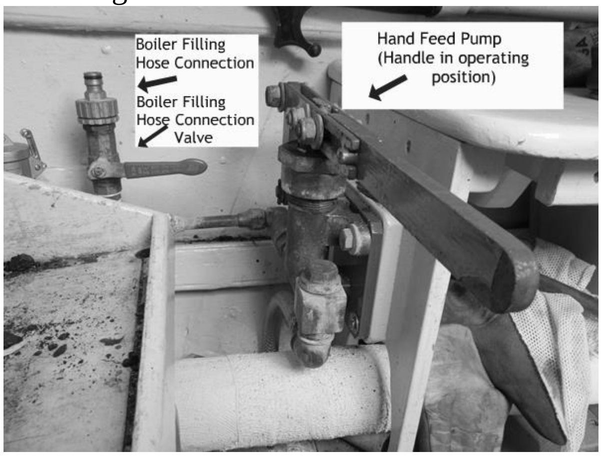
<u>Main Feed Water Bypass Valve (7)</u>

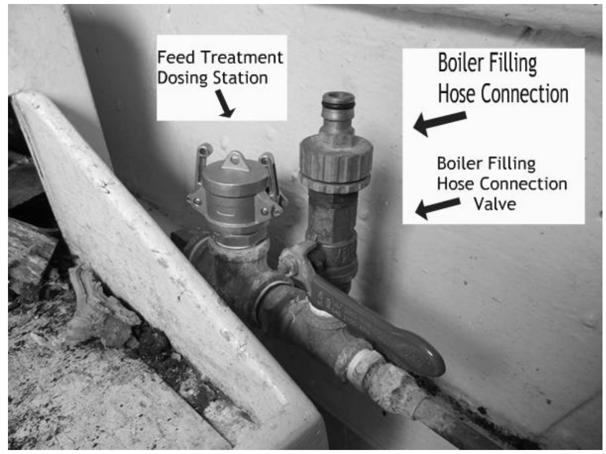
Below and to starboard of the gauge glass, and on the same pipework as the feed check valve and feed stop valve, this brass handled valve allows the engineer to regulate the amount of water going into the boiler from the engine driven feed pump. For ease of use it has a notched handle with numbers on it. The more the valve is open (ie the higher the number beside the brass bar), the less water is fed into the boiler.

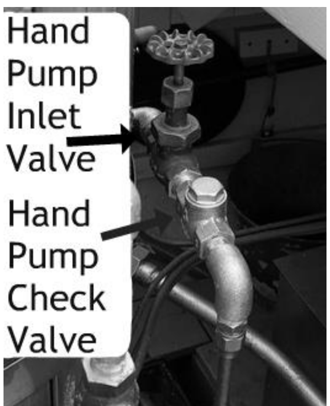
<u>From the hand feed pump:</u>

The hand pump is located beside the engineer’s seat, and allows the engineer to feed water into the boiler without the engine running or in addition to that supplied by the engine driven feed pump. The hand pump stop valve needs to be opened to allow the pump to work.

The line from the hand pump also contains the connection allow the boiler to be filled with a hose, and the dosing station to allow feed water treatment to be added to the boiler.





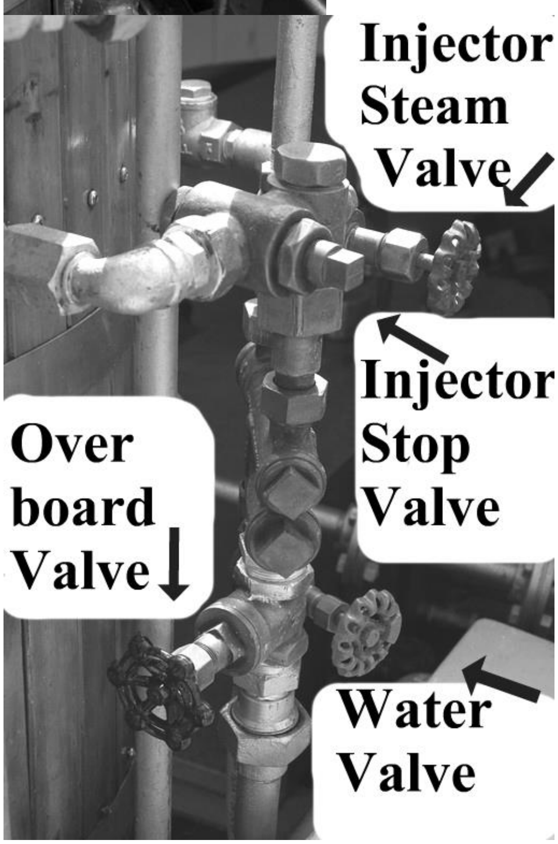


Hand Pump Inlet Valve (8)

Located on the front of the boiler, this valve has a blue handle. It should be opened when the engineer wants to use the hand pump to feed water into the boiler

Hand Pump Boiler Check Valve (9)

Beside the stop valve, this non return valve prevents steam from exiting the boiler via the feed line, but allows water into the boiler from the hand pump



For the Boiler feed Injector:

The injector is located on the starboard side of the boiler. It uses steam, through a series of venturi to suck water from the feed tank, and blow it into the boiler. It has a minimum of moving parts, and has a specific operating sequence. It can be used to put water in the boiler quickly, while not running the engine. The injector puts water into the boiler very quickly, but uses a lot of steam to do so, and cools the boiler in the process. The injector will not work with hot water, so may not work at the end of the day. If it does not work, the engineer has to top the tank up with cold water, or use the hand pump.

Combined Injector Stop Valve and Check Valve (10a & 10b)

This large bronze assembly beside the injector has a square headed valve on it. The line on the starboard face of the square shows whether it is open or closed. The line is vertical when closed. To open, use a spanner to turn the square through 90 degrees until the line is horizontal.

Injector Overboard Discharge Valve (11)

This black handled valve located below the injector needs to be opened to allow the injector to work. The pipework from this valve leads down past the bunker to the discharge skin fitting directly ahead of the bunker. At the beginning of each day, check that the injector overboard skin fitting valve (on the hull side, beside the blowdown overboard valve) is open.

Injector Water Control Valve (12)

This blue handled valve is below the injector and ahead of the overboard discharge valve. It is attached to a plastic hose running down to the feed tank. The valve regulates the flow of water to the injector

Injector Steam Valve (13)

Above the injector, this valve regulates the steam to the injector, and is fed via the main steam line.

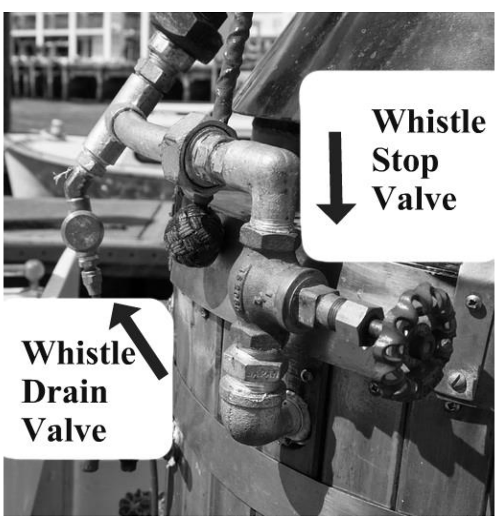
The following valves allow the control of steam from the boiler to the engine and auxiliary items:

Main Stop Valve (14)

Located at the top of the main steam line, this valve allows steam into the main steam line.

Engine Steam Line Stop Valve (14a)

Located directly below the main stop valve, this valve allows the engine pipework to be shut off, but still allows steam to be used by the blowers and injector. This valve is normally left open



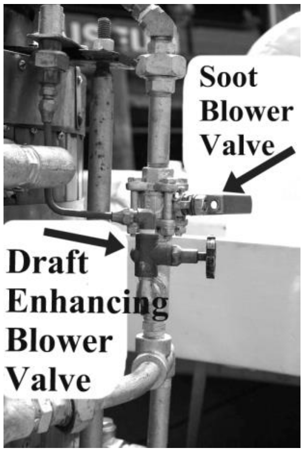
Whistle Stop Valve (15)

Located on the front port face of the boiler, this allows steam to the whistle line. The Whistle is controlled by its own valve on the lanyard

Whistle Drain Valve (16)

This brass handled valve at the bottom of the whistle line allows condensed steam to be drained from the whistle line by the skipper. It should only be opened for a short period of time.

Blower valves – see blower procedures below



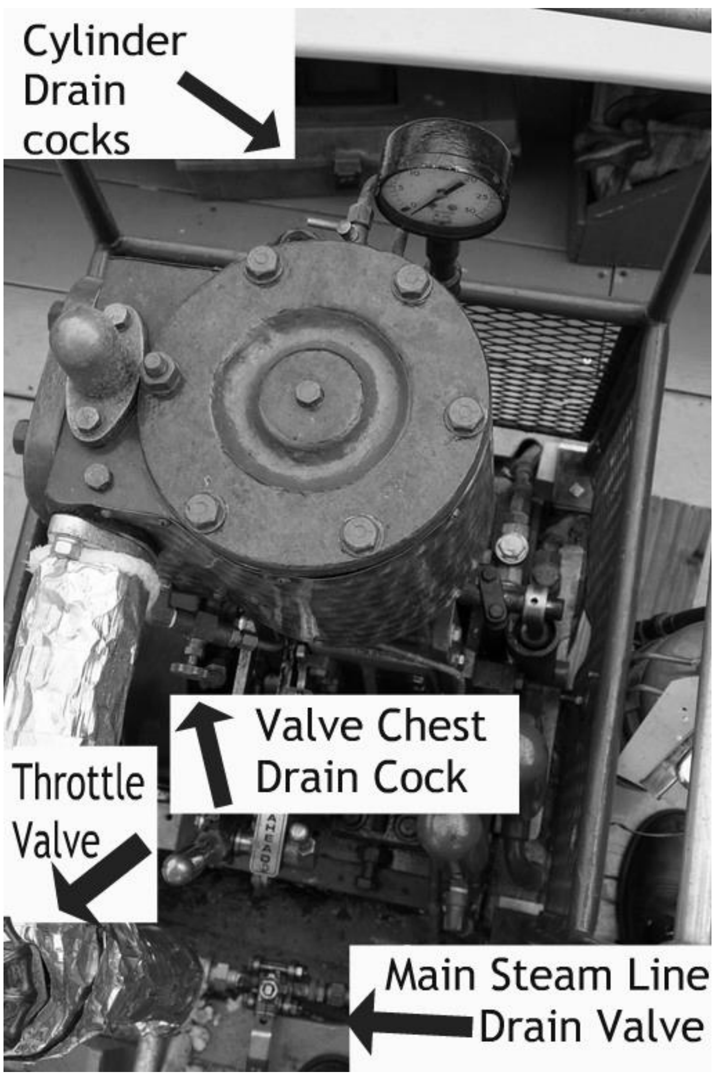
Draft Enhancing Blower Valve (17)

Located on the starboard side of the boiler below the smokebox, this valve has a small round black handle. It is used to allow steam to the small blower to enhance the draft on the fire.

Soot Blower Valve (18)

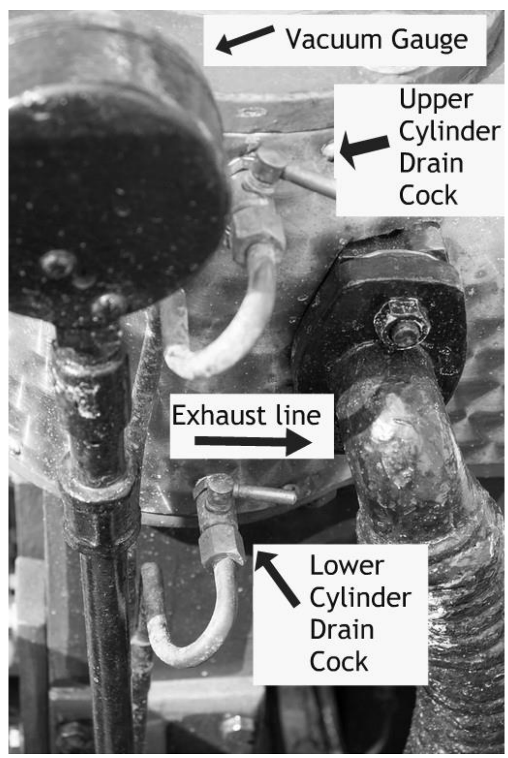
Located beside and ahead of the draft enhancing blower, this valve operates the big soot blower. It should only be opened for very brief periods of time.

Engine valves –see engine procedures below



Main Steam Line Drain Valve (19)

Located at floorboard level beside the engine, this lever valve is used to drain condensed water from the main steam line when warming through.



Engine Throttle Valve (20)

This red handled valve beside the engine is used to adjust the amount of steam fed to the engine, and thus its speed.

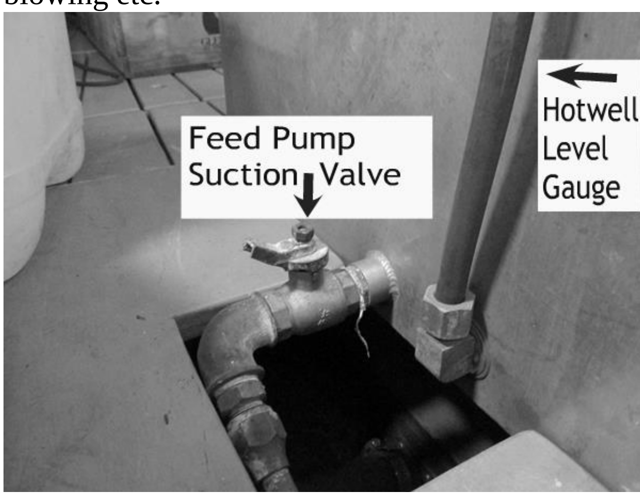
Valve Chest Drain Cock (21)

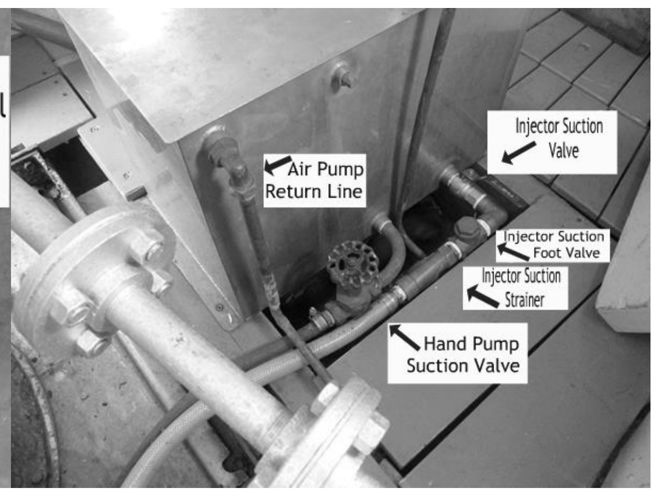
Brass valve located below the steam line entry into the engine, used on warm up, and if the engine locks up due to too much pressure on the valve during manoeuvring.

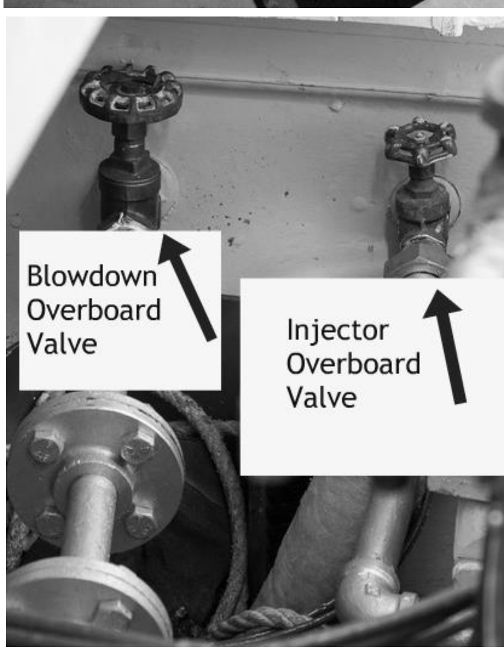
Cylinder Drain Cocks (22)

On the port side of the engine cylinder, these two lever handled valves are used to drain condensed water from the engine during warming through.

All feed suctions, and engine and gauge glass drains originate or end at the hotwell. This is located ahead of the boiler and contains the main running water. Extra make up water is carried in plastic cans, and is used to "make up" the losses that occur due to leaks, evaporation, whistle and safety valve blowing etc.







The injector overboard line, and the blowdown line both end at the starboard hull side with a second set of valves attached to the skin fittings that pass through the hull side. Both these valves are normally left open, but should be checked at the beginning of the day.

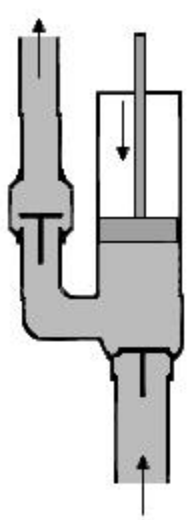
Steam plant operation

The time has come to now consider the engine and boiler as a system, and describe operating procedures.

The steam circuit:

Steam generated in the boiler, passes to the engine via stop valves and finally a throttle valve on the engine itself, which governs engine speed. The steam is expanded in the engine, as described above, and is then exhausted into the condenser. This takes the form of a copper tube fixed to the outside of the hull next to the keel. It then gives up its heat to the surrounding ocean, and collapses into liquid water. It will be noted that after initial warming through of the boiler, the air has been expelled from the system, so that when the steam condenses in this way, a vacuum is created in the condenser. This is indicated on the vacuum gauge fitted to the engine exhaust. It will be further appreciated that this vacuum increases the overall efficiency of the engine greatly, as when steam is emitted to one side of the piston a pressure much less than one atmosphere is present on the other side, adding to the force applied to the crankshaft. This liquid water has a much lower volume than the steam from whence it came, for reasons described above and is now referred to as condensate.

The engine has two pumps mounted in front of it driven by an extension of the wrist / gudgeon pin. One of these is the air pump which removes the condensate and dissolved air from the condensate in the condenser and passes it via non return valves to a tank forward of the boiler, the hotwell. This condensate is then pumped, by the second of the pumps on the engine called the boiler feed pump, back into the boiler against boiler pressure to be reheated generating steam once more. Thus the same water is reused in a looped circuit. The boiler feed pump delivers more water than the boiler is able to evaporate, so a proportion of the feed pumps output is diverted back to the hotwell, via the bypass valve.



(left) Principle of a piston pump: As the plunger moves up, the water is pushed (by gravitational force) and pulled (by plunger suction) into the pump chamber. As soon as the plunger changes direction, the inlet check valve closes and the pump pushes the water out through the outlet check valve. The hand pump, engine driven feed pump and air pump on Puke work on this principle.

By this time, it will be understood that this bypass is the means by which the boiler water level is controlled, ie when the valve is closed, all water from the pump is sent to the boiler and the water level will rise. If the valve is opened fully, the majority of the water will go to the hotwell and the boiler water level will fall. Hence the bypass valve and its operation is crucial to the safe operation of the boiler. The maintaining of the correct water level in the boiler is of FIRST importance. Should the water disappear from the glass, all efforts must be made to fill the boiler and observe the return of water to the gauge glass. If the water level in the boiler is unknown and not showing in the gauge glass that the boiler should be shut down, do not put cold water into an empty or near empty steaming boiler. Having said that if the level has just dropped slightly below due to pitching or rolling etc and the operator knows that there is still plenty of water in the boiler it will be OK to top it up and keep running. If for some reason water cannot be got back into the boiler, the fire must be removed IMMEDIATELY, and the boiler allowed to cool. Over filling, although not as hazardous as an empty boiler can have catastrophic results, if solid water carries over into the engine. Water, being by its nature is incompressible, will cause severe engine damage if allowed to fall into the engine. Low water level is to be avoided at all costs as if the water should all be evaporated the heat of the fire can seriously weaken the boiler shell with the potential for a boiler explosion as the water overheats. A large safety margin exists, as the lower level of the glass is still some 360 mm (1 ft 2 in) above the bottom tube plate, but constant vigilance of the water level is required to ensure the certain knowledge that sufficient water is in the boiler for safety. Two other methods are available to get water into the boiler, the injector and the hand pump which are discussed elsewhere.

Operating the system:

On arrival on board the boiler should be in one of two conditions.

1. Completely full to the top (wedged)
2. Completely empty (blown down)

Ideally it would be in condition one, being completely full, thus the first thing to do is to lower the water level to around half the site glass. Check the level of water in the hotwell forward as if this is in need of topping up the boiler can be emptied into it via the drain on the site glass. To allow air into the boiler so that the water level, can drop it is necessary to open the whistle line. If the hotwell is full, the excess water can be dumped over side via the blow down cock on the lower port side of the boiler. The skin valve on the hull should also be open. Keep a watchful eye on the glass as the level will drop quickly, close valve to stop draining. When the correct water level is obtained the following valves which should have been closed at the end of the previous run need to opened fully.

1. Main feed stop valve
2. Hand pump inlet valve
3. Main stop valve
4. Whistle line (should already be open on filling)
5. Throttle valve on engine (quarter turn open)
6. Cylinder drains and chest drain on engine
7. Feed valve from hotwell (usually open)

Of these the first is the most important as this allows water into the boiler when the engine starts.
Note on valves: Only valves that are shut should be tight to the touch. If a valve is open do not wind valve fully open to the stop, but leave it slightly off fully open. This is so when a valve is tested by hand, one can tell if it is truly open or shut. This is an important safety requirement, as one must be sure that a valve is truly shut and not jammed open.
Remove funnel cap, clean ash from ash pan, lubricate engine and check for any loose components on valve gear etc. Set and light fire.

Engine Lubrication:
All rotating or sliding parts of the engine require manual lubrication from the oil can or grease gun.It is necessary to lubricate these components at least every couple of hours. You should check all pivoting, rotating and sliding parts of the engine, find their lubrication holes, and feed them with a drop or two of oil. Greased points are greased at the beginning of the day. Failure to lubricate the engine can result in seizure of the engine, and serious damage.

The fire:
The fire is controlled by the amount of air supplied to the fuel, either from below (primary air via the damper) or from above (secondary air from the door). When starting and running the damper should be removed. Having the door slightly open on lighting up will help prevent smoke, as this secondary air will help burn the uncombusted gases as they form.

Firing technique: This is one of the most crucial skills to acquire to successfully operate the boiler. It is influenced by several factors; the fuel employed:

1. Wood - this can vary greatly with size and quality. If possible split into even size chunks, ideally 1-2 times the size of a fist. Try to keep the entire grate covered as air will pass through the fire, cooling the boiler. It is best with wood to add new fuel mostly at the front, and push the fire back as the new fire lights. Wood tends to burn more quickly than coal, requiring more attention than coal.
2. Coal – if firing with coal a good hot wood fire needs to be established, before small amounts of coal are added to prevent excessive smoke. When a bed of hot coals is achieved, add coal in small amounts to shallow areas in the fire and avoid smothering the glowing coals, as this will cause the fire to "go black" and will reduce steam production immediately. Complete holes in the fire should be avoided, as these will let cold air through and will immediately cool the fire around it. The same use of a partially open door will help by preventing excessive smoke as will adding small amounts of coal. The old expression is "little and often".

Other factors affecting firing:

1. Wind – the fire is harder to establish on still days and will be easier to maintain on windy days as the wind tends to induce more draught in the funnel.
2. Soot – if the boiler has not had the tubes cleared of soot via the soot blower prior to shutting down, some difficulty in raising steam can be experienced. Due to the proximity to other vessels and the public, it is not possible to do this in the berth, but must be done as soon as possible on clearing the berth in the first run. Soot blowing is done by opening the fire door and quickly cycling the soot blowing valve. Before doing so ensure wind direction will carry soot safely clear of the vessel to either side and not in the direction of other vessels, restaurants etc.
3. Banking – by banking what is meant is the putting of the fire into standby mode. This is where steam pressure is maintained, but not increased when the vessel is to be idle for a period of time. This can be a short time as when going into the berth to change passengers, or for a longer period during lunch breaks or similar. To do this fuel is added to the fire when approaching the berth, usually when level with Rapaki, and fitting the damper into place. This

presumes enough steam is available (70 psi +) to safely manoeuvre into the berth. Obviously if the vessel will be idle for half an hour or more, more fuel is put in prior to the damper being fitted. This is one occasion where putting coal on the existing fire is acceptable as the new fire will "cook", and light immediately when the damper is removed with minimal smoke.

Warming through:

By now the water in the boiler will be getting hotter and eventually the whistle will start to vent the air above the water, and steam vapour will begin to issue from the whistle itself. At this point jiggle the whistle lanyard to shut whistle valve. At the same time steam vapour will begin to enter the engine, and return to the hotwell via the drains as condensate. While this is happening occasionally turn the engine over by hand to let steam into the cylinder above and below the piston. Carefully feel the engine to ensure it is hot. There will be a delay of up to quarter of an hour or more after steam issues from the whistle before a pressure rise will be seen on the gauge. The engine will start at very low pressure <10 psi, and it is a good idea to do so as soon as it will start. This will bring boiler/engine temperature up together to form a 'steady state' ready for operations.

Engine starting:

Before attempting to start, blow condensed water from the main steam line via the drain valve at your feet until a clean 'roar' of steam is heard. Slowly open the throttle to about quarter open, and manually turn engine over with the cylinder drains still open and shut the chest drain cock. Move the reversing lever back and forth if the engine seems to 'stick' in one position. Adjust throttle position until engine is turning over slowly by itself for a few minutes, and then close cylinder drains. This is to ensure all water is expelled and will prevent engine from 'hydraulicing' ie trying to compress water at the end of the stroke, (this is to be avoided at all costs).

With the engine now idling and the pressure slowly rising, a check must be make to ensure water is being pumped by the engine into the boiler. To do this, shut the bypass valve and observe the water level. This should slowly rise over 3-4 mins of pumping. This also has the effect of slowing steam raising, as the excess of cold water has a chilling effect. Sometimes the pump can be 'airlocked' and no rise will be observed. If this is the case open the bypass fully, and look at the bypass return line emptying into the hotwell. You should see a bubble of air and then a continuous stream of water. Close the bypass and look for water level increase again.

By feeling the check valve and stop valve below the sight glass, a cooler temperature will indicate water is being fed to the boiler. If these fittings are hot repeat above procedure until you are confident that water is being pumped. Do not attempt leaving the berth until you are certain this is the case. If feed pumping appears to have stopped while under way, attempt the remedy above, and if not successful, return to berth. Water level may be maintained by injector or hand feed pump until the berth is reached.

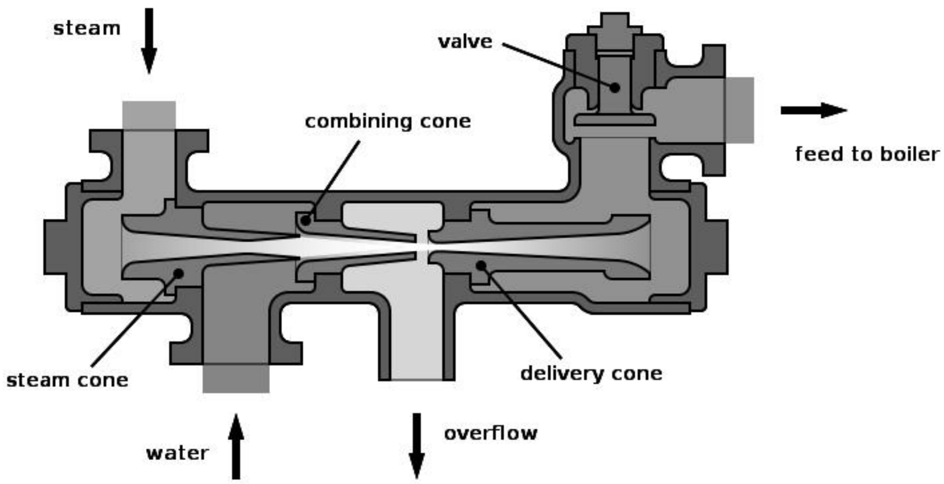
By now pressure should be climbing, a close watch being kept on pressure and water level. Should the pressure increase to approach blowing the safety valve (100 psi), open the throttle and / or fit the damper to prevent blowing off. Blowing the safety valve is not hazardous but can be alarming for passengers especially young ones, and correct maintenance of pressure and proper firing should mean this happens rarely. A good way to control excess pressure and water level is with the use of the injector, which we will now discuss.

The injector:

This is located on the starboard side of the boiler. It is an ingenious mechanism which uses steam from the boiler, to force water into the boiler, via a series of venturi like nozzles. It has very few moving parts and is very reliable if used correctly. Injectors are temperature sensitive and won't 'pick up' when hot, so you need to operate the valves smartly to get water flowing quickly before the steam overheats the injector. The method of operation is this:

1. Ensure cock to boiler is open
2. Ensure valve from hotwell is open (both 1 and 2 are normally open)
3. Open black overside valve fully
4. Quickly open red steam valve fully
5. 'Crack' blue water valve and open slowly until hissing sound indicates injector has 'picked up' and observe no water is issuing from overside vent. If water is still going overside quickly shut water valve and reopen until hissing is heard. Recheck the overside vent and continue doing so if any change in note is heard from the injector.

The injector will operate at pressures above 40psi, but will not start below this figure. A rapid increase in water level and a corresponding drop in pressure will be seen, hence its usefulness in controlling pressure and water level.



(Above) The injector . Puke's injector is slightly more complex, but works the same way.

Hand Pump:

This is located on the end of the seat on the starboard side and has a folding handle. To use ensure feed valve on boiler, and delivery valve on hotwell are open and then pump lever to operate. This pump is for emergencies and if boiler is out of steam and you wish to raise water level. This pump is very slow and it takes a long time to raise water level with it.

Manoeuvring:

By now everything should be up to temperature, pressure in the 80psi or above zone, the engine idling, water at half glass, fire going nicely and we are ready to leave the berth. This is where the operation of this vessel is so different to a conventional one. It is based on teamwork between the Master in charge of the boats speed and direction, and the Engineer responding to his commands to make this occur. The lines will have been cast off and the vessel will be held against a spring with the engine in slow ahead. The master will call for astern, and without closing throttle the reversing lever is put across cleanly and smartly and the vessel will gain sternway. This is done at just above idling speed, and enables the Master to place the spring on the berth where he can retrieve it on return. At this point the Engineer still has one hand on the reversing lever, and the other on the throttle. The Master will call for ahead when he deems fit, and the lever is thrown into ahead whilst opening the throttle. There is a pause while the vessel starts to move ahead and we are under way.

From this point on the Engineer must manage the fire and water level, whilst also being the Masters extra set of eyes and also conversing with the passengers. A habit of continuously glancing at the gauge glass and pressure gauge and responding to changes in level and pressure must be adhered, to as steam plant operation is the complete opposite of a 'hands off' situation, and your alertness to any problems arising is essential. Attention should also be given to any unusual noises, either mechanical or of escaping steam which could occur. The plant is ideally, but not always, near silent, but harsh knocking or banging can indicate something has come loose or broken. If so inform the Master and investigate, stopping the engine if safe to do so.

On returning to the berth, slow the engine down to just above idling speed for the length of the wharf. This enables the vessel to reduce its way but not so much as to loose steering, the engine may squeak at low revs when hot, but this is normal. Ensure the locking handle on the reversing lever is undone before approaching the berth, and reduce to dead slow on command as you near it. As the berth is entered the Master will call for astern, and the lever is thrown smartly across and the throttle opened simultaneously to arrest the way on the vessel. Maintain this until vessel has stopped and spring is secure. The engine may then be put into slow ahead against the spring, and the disembarking of passengers attended to.

While making way, the best way to maintain pressure, along with firing technique, is the throttle setting. There is no need to operate at high revs unless asked for, as running at moderate revs is much kinder on steam demand. At pressure below 60psi it is difficult to increase pressure while under way. It may be necessary to reduce speed substantially and open the bypass if there is sufficient water in the glass to enable the boiler to catch its breath. For this reason it is not wise to leave the berth at pressures under 60psi. Whilst running it is important to know how much steam will be required. You must stay in touch with the Master as to whether you are going into the berth to pick up more passengers, or if you are likely to idle for some time. You need to be at least 20-30 minutes ahead of anticipated steam demand and use the banking techniques previously discussed to balance demand. Whilst operating during the day, blow soot at least once on each trip, or approximately once every half hour.

The last trip of the day calls for careful management. Confirm with front of house via radio that you are on the last trip, and begin to run down the fire and blow soot. This means using a bare minimum of fuel to maintain safe operating pressure (60psi plus). There is a lot of retained heat in the refractory of the firebox, and this will help maintain pressure for last run down the wharf and into the berth. The engine will be sluggish to reverse at very low pressures, so this is a balancing act between having an empty grate but enough pressure to reverse. On berthing, leave fire door open and engine running to use up the remaining head of steam. This will allow the boiler to cool while the rest of the shutdown chores are attended. All valves are now shut.

Blowing down:

If the boiler is to be completely blown down the fire must be completely burned away and the firebox cooled down. Blow down should not be done at pressures above 30 psi, as the sudden release of pressure can strain the boiler, and cause the tubes to move relative to the tubeplate causing leaks. This means blow down should not be done until at least half an hour after shutting down. To blow down the overside valve should be open, and the blow down cock opened for short blasts. This is more effective at removing sediment and scale from the bottom of the boiler than long blows. Eventually all the water and steam will be blown out and the cock can be closed. All other valves should now be closed as well. The boiler will be blown down if the vessel is not to be used for the next 2 weeks or so. In this case the museum maintenance staff will refill the boiler the next day and leave it 'wedged'. After blowing down 150ml of treatment is added to the dosing station and will be automatically flushed into the boiler when it is refilled the next day.

Boiler 'wedging':

This is done when the boiler will be idle for a period of days or weeks and is done to prevent corrosion. The boiler water treatment contains a compound which will remove dissolved oxygen in the water preventing oxidisation of the steel boiler. This maintains a ph level of above 10. To wedge the boiler all valves on the boiler shell are shut except for the whistle line and the hand pump feed valve. A hose is attached to the fitting next to the hand pump, and the valve below is opened to admit the water. When the water is seen coming from the whistle, the hose is turned off and all valves are shut.

Use of Blowers:

There are two blowers attached to the side of the boiler/smokebox assembly. The smaller draft enhancing blower can be used sparingly to assist a sluggish fire. Using the blower puts a jet of steam up the funnel, to help 'pull' the fire. This can be useful if the fire is sluggish, but uses steam and feed water, so can be detrimental on a long run, or if the pressure is too low.
The larger soot blower is only used briefly to clean the boiler tubes of soot build up. It should never be used for extended periods of time. The procedure for this is:

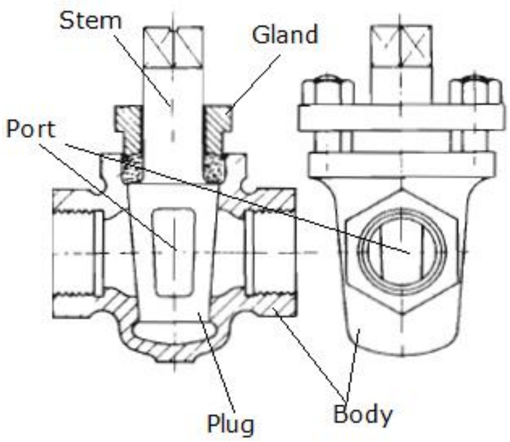
1)Bring boiler pressure as high as possible, and arrange for the skipper to bring the vessel to an area where there is nothing downwind of the vessel.
2) Confirm the wind is blowing over the side of the vessel or from aft
3) Open the firebox door completely
4) In short bursts (2-5 seconds) open the soot blower valve fully, 2-3 blasts should clear the tubes
5) Close firebox door and resume normal operations, after checking there is no indication of fire on the decks.

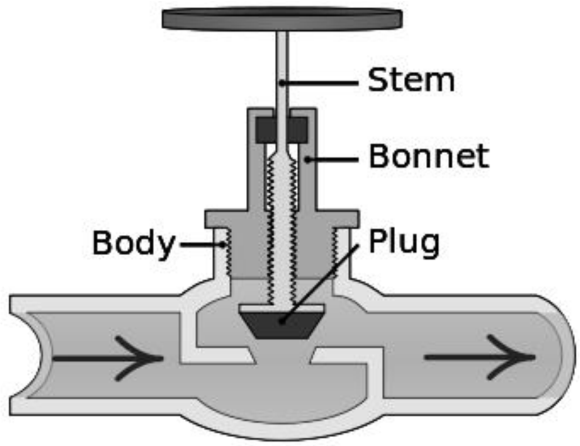
Boiler Treatment

Boiler treatment chemical is added to the boiler to prevent corrosion, and the formation of scale inside the boiler. Engineers should read and understand the instructions on the test kit provided. It is worth noting that too much treatment in the boiler can be detrimental. Large amounts of treatment can cause the boiler to prime, and can destroy the lubricating ability of the steam in the engine.

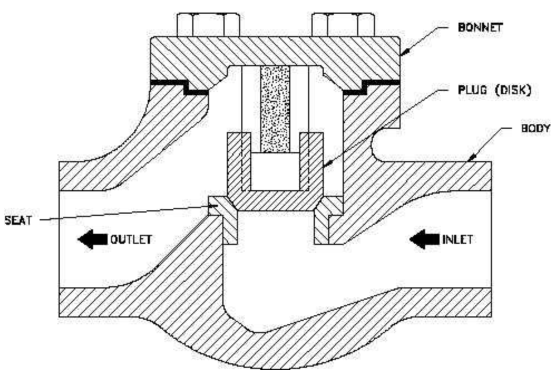
Understanding fittings

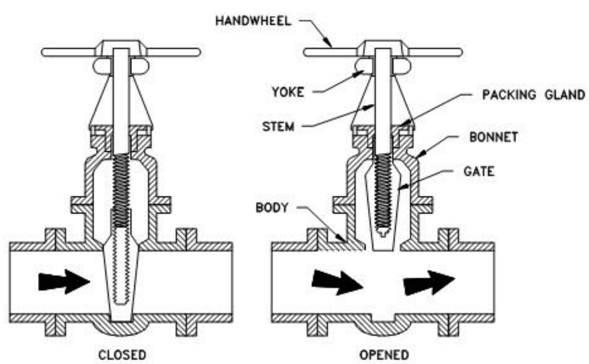
The following illustrations show the various types of vales and fittings used on Puke. Each is selected for their different operating characteristics and suitability for their role.



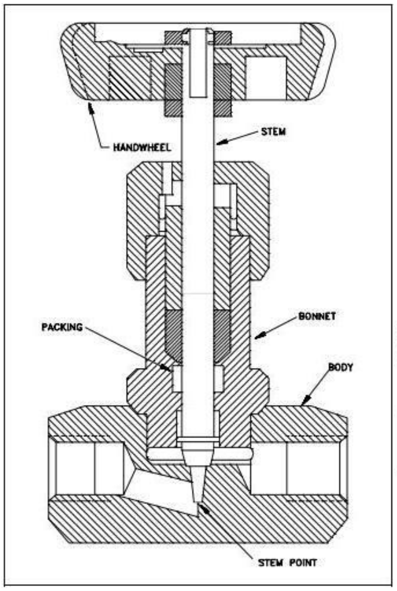


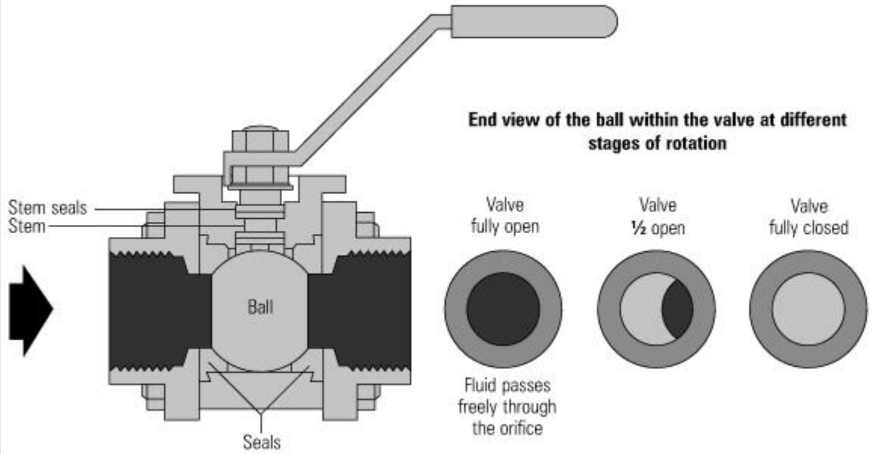
Plug Cocks and Globe Valves are the principle valves used for steam service on the boiler and engine





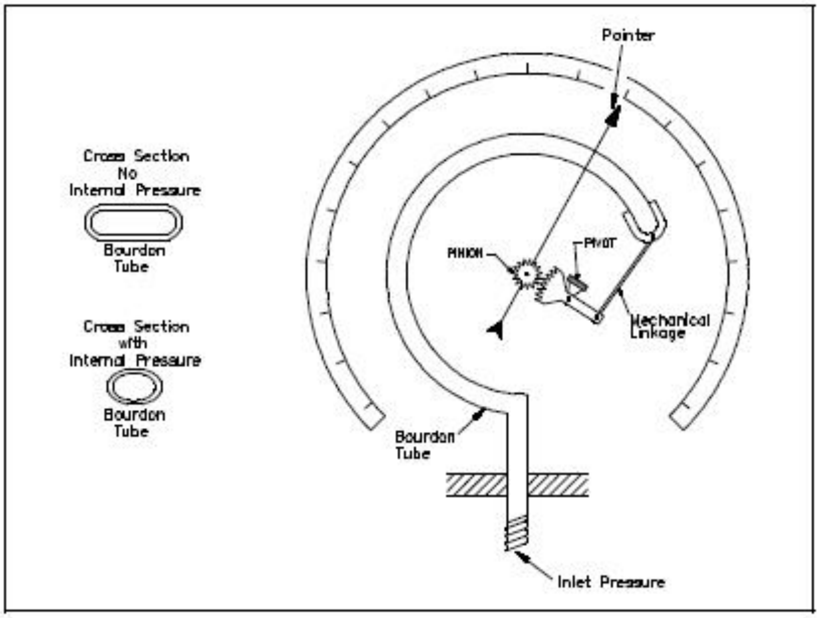
Lift Check Valves are used on most check valves on Puke. Gate valves are used for some water and skin fitting valves





A needle valve is used for the bypass valve. Ball valves are used on the main steam line drain and for the soot blower.

The safety valve is illustrated here for informational purposes only. It should NOT be altered in any way without the express permission of the boiler inspector. The vales operations are automatic, and do not need to be altered by the engineer. However the engineer should test the valve for correct operation each time the vessel is used. If the safety valve does not lift correctly, the plant should be shut down and the valve will need to be serviced by a trained professional.



Bourdon Tube

The Bourdon Type pressure gauge, as used on Puke, is again shown for informational purposes. Again it can only be serviced by professionals, and should not be altered.

Gauge Glass Testing and Trouble Shooting Procedures

Procedure for testing a Gauge Glass:

1-Close the Water Valve (handle horizontal when closed)
2-Open Drain Valve (handle horizontal when open)
3-Allow steam to flow through glass to waste
4-Close Drain Valve
5-Water level will return in glass
6-Open Water Valve
7-Close Steam Valve
8-Open Drain Valve
9-Allow water to flow through glass to waste
10-Close Drain Valve
11-Water level will return in glass
12-Open Steam Valve
All valves will now have their handles in the vertical position.

If, during steps 3 and 9, the steam and water does not pass through to waste, and the water level does not return rapidly, the passage of the offending valve may be blocked. In this case the vessel must return to her berth, the boiler taken out of steam and the valve should be rodded through to clear the passage to the boiler.

During the passage back to the berth, the engineer must ensure that sufficient water is retained in the boiler by adding water with the feed pump and checking the water level using the test cocks.

Note on Test cocks:

Test cocks can be difficult to use as the water usually flashes into steam as it comes out of the test cock, the only way to tell is if more steam comes out of the lower cock than the upper cock, this is an indication that the water level is above the lower cock. Test cocks should only ever be ‘cracked’ open, never open fully.
It is best to test the test cocks, and compare what happens against the gauge glass, before you need to use them.

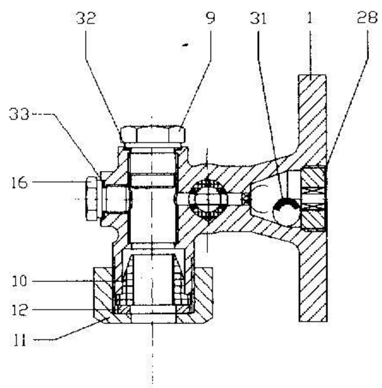
In the event of a gauge glass breaking, the following procedure should be taken.

<u>Procedure for changing a gauge glass</u>:

1-Shut both the valves and open the glass drain cock
2- Remove glass protector shield
3-Loosen and remove both gland nuts
4-Remove any broken glass or other debris from glass valve body
5-Remove plug on top face of upper valve and slide glass into the body, replace plug
6-Place gland nuts and new seals on the new glass
7-Install glass in upper valve first and loosely tighten the nut. Pull glass down to bottom so that the gap in upper and lower valve body is even (this allows for expansion of the glass)
8-Hand tighten both nuts, and then using a spanner, give each nut an additional quarter turn.
9-Refit glass protector shield
10-Crack open steam side valve and allow the steam to lightly blow through to warm the glass. This prevents the glass from being subject to sudden thermal shock. (Should the glass be subject to thermal shock the effects may not be noticed immediately. However, the glass may then be much more brittle and even a slight bump might shatter it.)
11-Close drain valve and crack open valve on water side of glass Observe gland for leakage and tighten as required (this will require closing of the gauge glass steam and water cocks and removal of the protector again, refit before further testing)
12-Open both valves fully.

Note that gauge glasses do wear out over time, and the rubber cones that support the glass can go hard, preventing them from sealing well on the glass. Replacing the gauge glass and its cones is generally done as part of an annual boiler survey. It is easier to replace the glass when cold, than have to do so at sea.

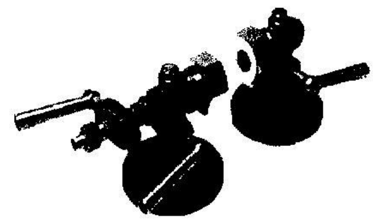
Remember that the knowledge of where the water level is in the boiler *at all times*, is of the utmost importance. A good steam engineer will always check the gauge glass in any boiler room he walks into, whether they are the acting engineer or not. The vast majority of boiler failures, and resulting fatalities are the result of a lack of water in the boiler. This should be kept in mind at all times when operating any steam plant.

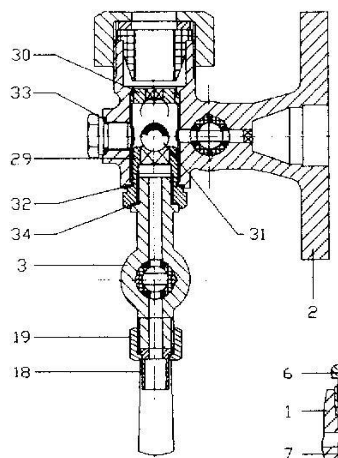


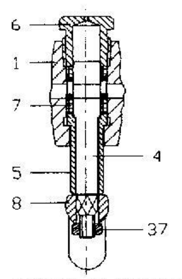
Klinger Level Gauges

AB12 Water Gauge Mount

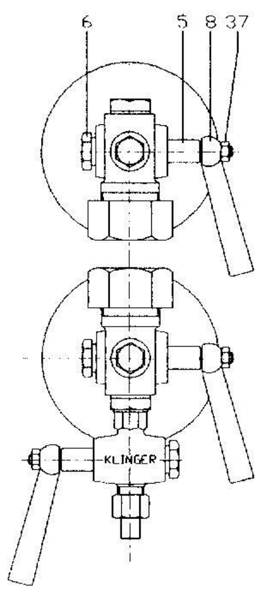
Spares & part numbers







CROSS SECTION
PLUG ASSEMBLY



Klinger Part No	Drg No	Description
-	1	Top Cock Body
-	2	Bottom Cock Body
500134	3	AB12 Drain Cock
400135	4	AB12 S/Steel spindle
400129	5	Brass Neck Bush
400126	6	Tightening Brass Nut
454020	7	AB12 Graphite Packing Sleeve
400130	8	Brass Handle
400136	9	Tube Cleaning Plug
684008	10	Rubber Cone
400216	11	Brass Gland Nut
400232	12	Brass Gland Ring
400156	16	Cleaning plug nut
400096	18	Tail Pipe
400097	19	Tail Pipe Nut
400210	28	Retaining Bush
400233	29	Drain Cock Bush
400209	31	Safety Ball
630022	32	Tube Cleaning gasket
	33	Cleaning plug gasket
	34	Drain cock gasket
Gaskets drg nos 32, 33 & 34 available together as copper washer gasket kit - refer part numbers above for ordering		

Vessel operations for Masters

Due to her means of propulsion, and her size and shape, Puke has some handling differences and operational requirements that set her apart from most motor vessels.

Teamwork

Puke is currently set up for two handed operation, a skipper and engineer being necessary to presently run the vessel. In order to successfully operate the vessel, the master must be aware of the needs of his engineer, and be able to give clear directions as to his intentions for the vessel. He must also be aware that there is a delay in reaction, both by the mental processing of the command by the engineer, and by the effect the engineer is able to have on the vessel. A good skipper will brief his engineer of his intended actions, particularly manoeuvring, well in advance of making the command. The engineer may not be able to give full power at any given moment, depending on the state of his fire, water level and boiler pressure, but he will be able to give it if he has been forewarned, and has thus prepared the machinery. Communication is key, and commands should be confirmed before operating. Remember that the engineer can make the master's role very difficult if they desire. The master must also allow for the fact that the engine can stop on top or bottom dead centre while manoeuvring, which will cause a slight delay while the engineer gets it running again.

Handling Characteristics

The slow revving low horsepower engine that drives Puke is turning a very large propeller that carries a lot of pitch. As result of this, the seemingly low engine revs can result in considerable speed, 180rpm being equal to about 6 knots. This high pitch figure also affects manoeuvring and going astern, as it results in considerable prop walk. The propeller is right handed, so when going astern, the vessels stern will pull considerably to port. Backing to starboard is at best difficult, and often impossible. The prop walk also means that considerable difficulty can be experienced when berthing starboard side to, as she will pull away from the wharf when coming alongside.

Steering, achieved by wheel and ropes or the emergency tiller, is easy and positive with a large semi balanced rudder. It is important though to maintain a firm grip on the wheel, or tiller when going astern, as the rudder can be inclined to bite in and swing hard over if it is allowed to. She will turn more tightly to port than starboard, and is very manoeuvrable in tight confines, but tight turning will result in a considerable loss of speed.

When berthing it is best to berth port side to, at a speed that allows the spring to be secured if the engine fails to go astern. The skipper should notify the engineer of their intentions ahead of time, and ensure that the engineer is on standby. When approaching the berth, the master should bring the vessel into the berth at an approximate angle of 10 degrees to the wharf. The master should call for astern a metre or two before the spring cleat, which should allow the engineer to pull the vessel to a stop before pulling the spring tight. The going astern process will have pulled the stern in towards the wharf, and the vessel should be sitting along side parallel to the wharf. Failure to approach at an angle will cause the stern ride up on the wharf when going astern.

Despite her size and apparent lack of freeboard, Puke is a highly seaworthy vessel, being capable of going to sea in storm conditions that wouldn't be attempted in many modern craft. While such things are now prevented by her survey conditions, this should not be taken as an indication of her seaworthiness. It is however worth noting, that for the comfort of passengers and crew, big seas and particularly wakes from other vessels should be taken on the bow or stern if at all possible. Her deep keel and fine underwater stern profile means that she does not broach, and surfs nicely under control in following seas. In a big head sea she is inclined to pound slightly, and often takes water over the bow, but this doesn't generally cause issues. In a beam sea she will roll comfortably, but short seas can be inclined to bring small amounts of water on board, so are best avoided for passenger comfort.

Trim

Puke can be very speed sensitive to fore and aft trim, and thwartships trim is important for passenger and crew comfort. For ultimate performance, the vessel should be loaded so that its waterline is level or even slightly down by the bow. This prevents the stern wave sucking on the counter stern, and allows greater speed. While the vessel should always be left moored with the bow slightly higher than the stern, it is best to add weight into the cabin before operations to allow better running trim with passengers.

Puke at speed winning the Great Brisbane Steamboat Race, 1988.

Useful Information

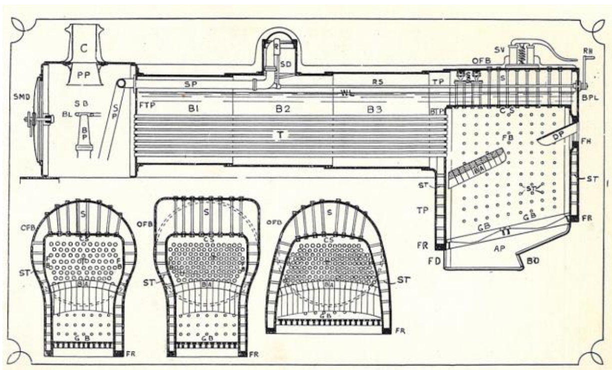
While it is not absolutely essential that masters and engineers know everything about steam, it is useful for understanding the plant, and for being able to talk to passengers if you have knowledge of steam components and fittings that are used on other plants.

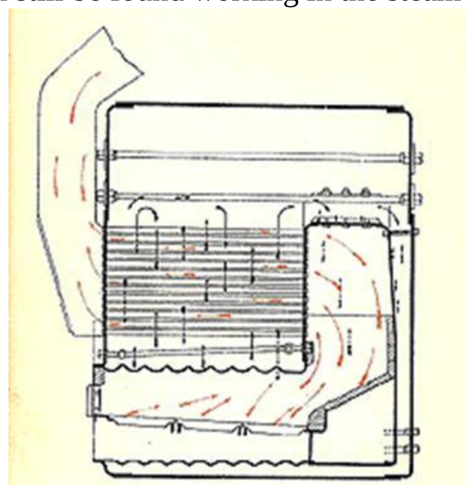
Boilers:

There are a number of different varieties of boilers that have been built for steam use. Boilers can be broken down into two major types, firetube and watertube.
-A firetube type carries the hot gases through the tubes, and heats the water on the outside of the tube. -

-A watertube type carries the water inside the tube, with the water heating being on the inside of the tube.

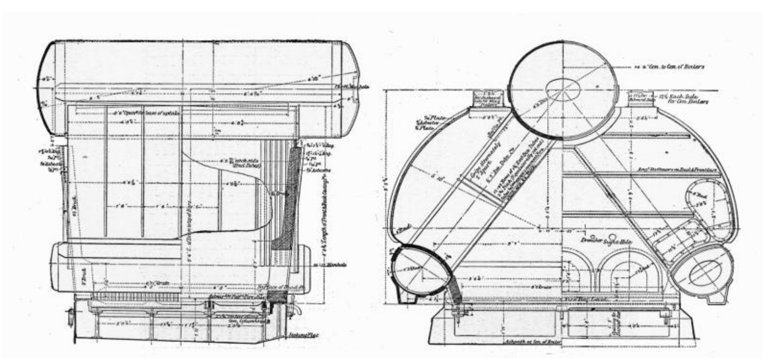
Among the most common firetube types were the locomotive type boiler, and the return tube scotch marine types. Virtually every railway locomotive and traction engine made their steam with a locomotive type boiler. Note that the illustration below shows various firebox arrangements as applied to locomotive type boilers. The vast majority of steamships used the Scotch marine type boiler, both single and double ended. Scotch marine boilers can still be found working in the steam tug William C Daldy.

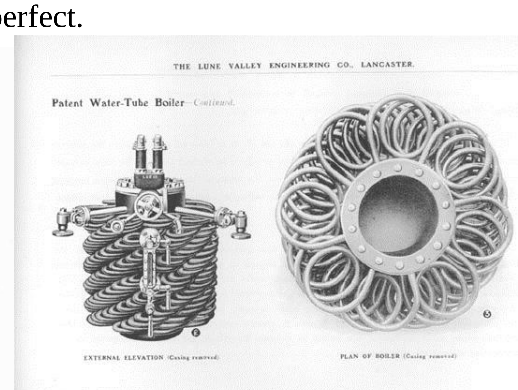




Illustrations of locomotive type
Boiler (above) and return tube
Scotch marine type (right)

A huge variety of water tube type boiler designs existed, some with water and steam drums that the tubes ended in, some with just were a collection of tubes welded together. Water tube boilers are capable of carrying higher pressures than conventional firetube types, and are commonly lighter in construction. Because they carry less water, they are faster to come into steam. As a result of these advantages, water tube types eventually took over the more high performance jobs at the end of steam. They are however more temperamental if the firing is not perfect.





The Yarrow type (left), and Lune Valley type. Both of these types were used in marine applications

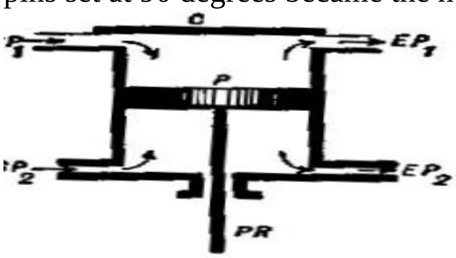
A final variety of watertube boiler is the steam generator or flash type boiler. This type has no drums, and is purely a length of pipe that carries water in it that turns into steam at the other end. Thus it has minimal water capacity, and relies on a perfect balance between the fire, feed water and steam usage. Diesel fired steam cleaner water blasters use this type of boiler.

Engines:

As can be expected, a large number of steam engine designs evolved over the years.

-Simple Expansion

The engine in Puke is the most simple of the type, having only one cylinder. Many single cylinder types were built, from very small model engines, through to large industrial engines weighing many tons. Single cylinder engines have no self starting ability, so twin cylindered engines, with the crank pins set at 90 degrees became the norm for traction use.



Simple Expansion Engine.

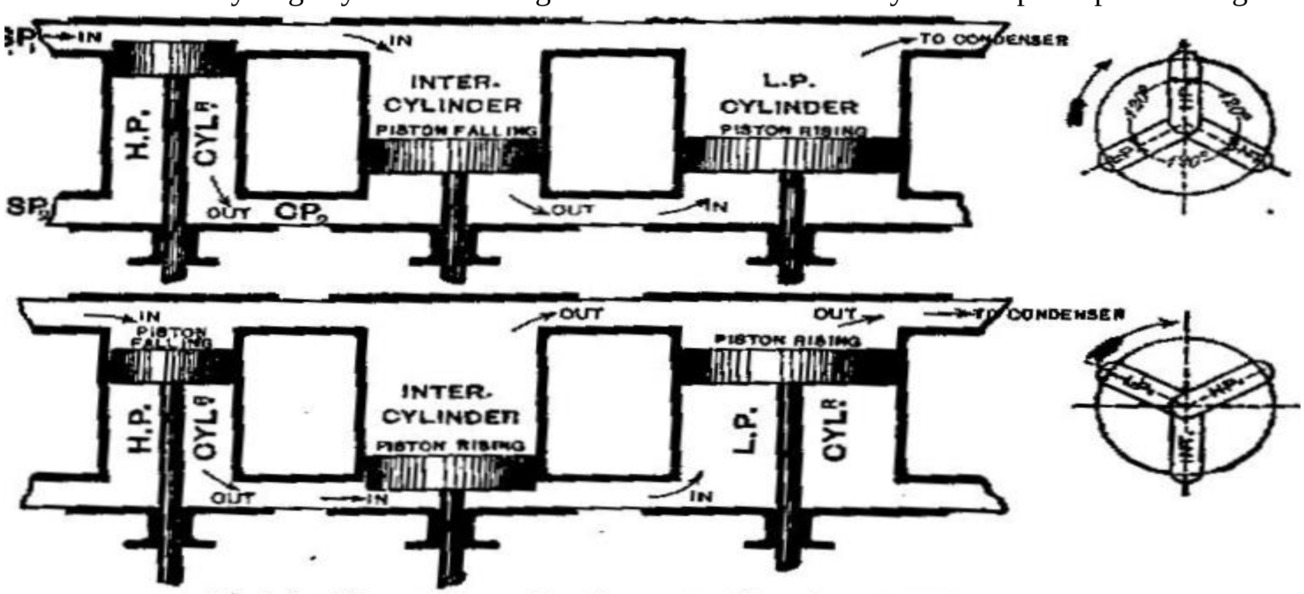
Compound Engine 2 Cranks at Right Angles.

-Compounding

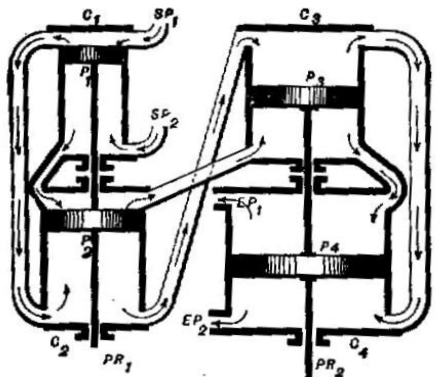
To increase efficiency, compounding was introduced, mainly on marine and industrial engines. Compounding is the use of the steam multiple times before it is exhausted from the engine. As the steam is used, it looses pressure and increases in volume, so has to have a larger second cylinder to produce the same amount of work.

-Triple Expansion

A further increase in efficiency came with the use of a further compounding that used the steam three times. Known as triple expansion engines, these were very common in large ships. The largest triple expansion engines used four cylinders, the third expansion being broken into two separate cylinders, instead of one very large cylinder. The engines of Titanic were four cylinder triple expansion engines.



Triple Expansion Engine. 3 Cranks at 120° apart.



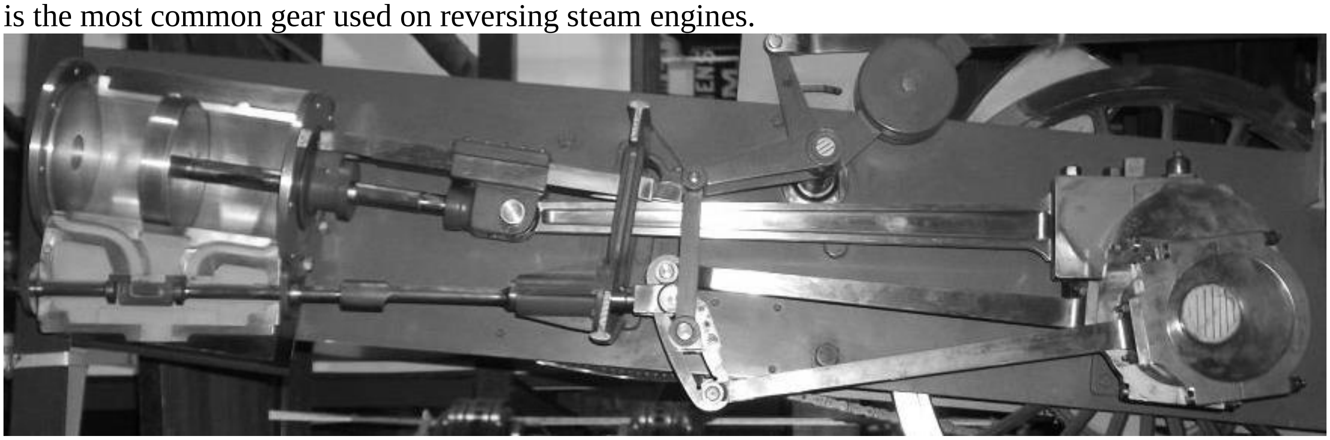
Quadruple Expansion Engine
2 Cranks at Right Angles.

-Quadruple Expansion
The final step beyond the triple was the Quadruple expansion engine. This used the steam four times, but did require a very high inlet pressure, otherwise the final expansion could do no real work. Four crank quads were rare, but a large number of tandem or steeple quads were built using two cranks. These engines had two pistons on each piston rod, so creating a very efficient but short engine.

-Steam Turbine
Reciprocating engines were eventually phased out after the introduction of the steam turbine. The steam turbine uses a rotor that is spun at high speed, using steam coming through nozzles that acts on the rotor blades. The minimal number of moving parts, the higher horsepower outputs, low vibration and smaller footprint, meant the turbine became the eventual norm for steam propulsion. Steam turbines are still used today in power stations and on nuclear powered situations (the nuclear reactor creating the steam to run the turbine).

Valve gears:
A number of different types of valve gears have appeared on reciprocating steam engines over the years, all with the same purpose of driving the valve, and allowing the engine to be reversed. The Fink valve gear on Puke is by no means normal. Common valve gears are the following:

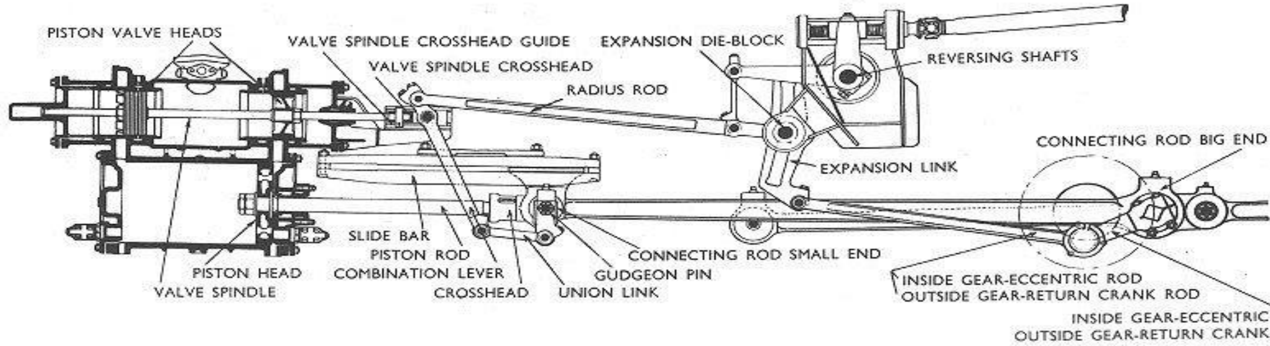
-Stephenson's Link Motion: Named after Robert Stephenson, this very simple two eccentric valve gear is the most common gear used on reversing steam engines.



Stephenson's link motion, shown on a cut away display. The two eccentrics and valve gear are shown driving the valve at the bottom of the picture.

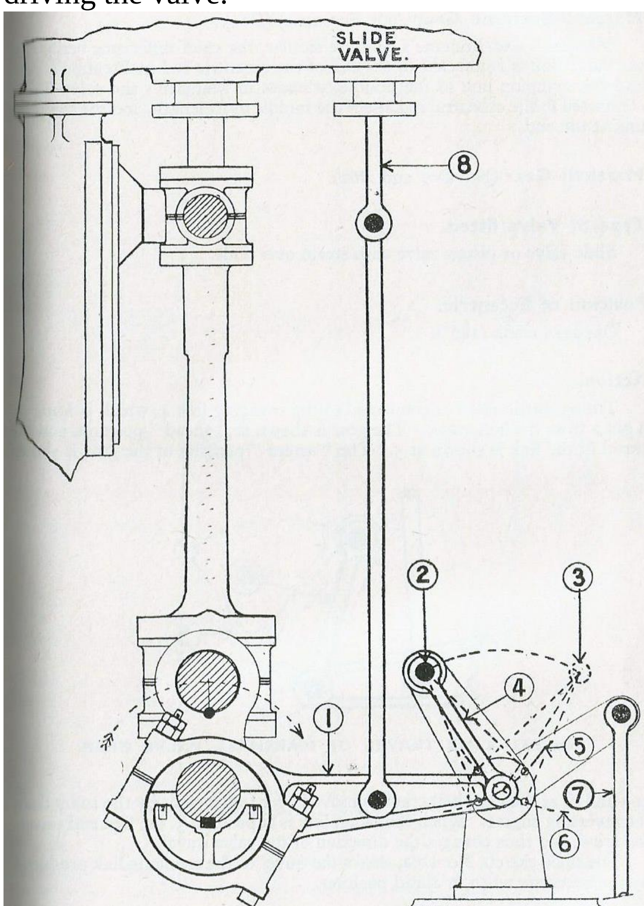
-Walschaert's valve gear was one of the most common valve gears used on railway locomotives. Its design allows it to be easily mounted on a steam locomotive, and gave good adjustment of cut off settings, essential on a locomotive.

WALSCHAERTS VALVE GEAR



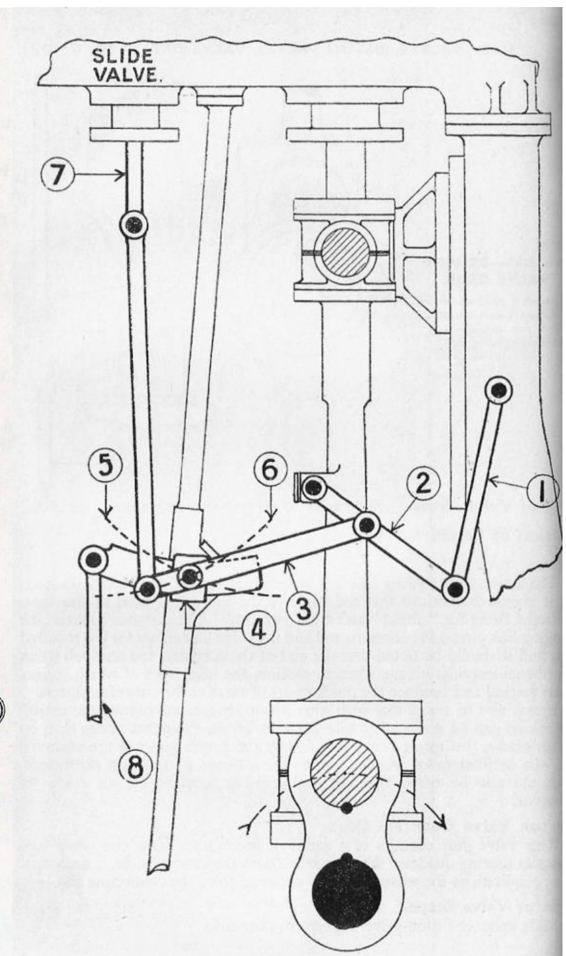
-Marshall valve gear was commonly used on later marine engines, having the advantages of only one eccentric, and being able to be mounted beside the engine, thus allowing the engine to be shorter.

-Joy valve gear has similar advantages, but has no eccentric at all, rocker arms from the connecting rod driving the valve.



No. D61.—MARSHALL VALVE GEAR.

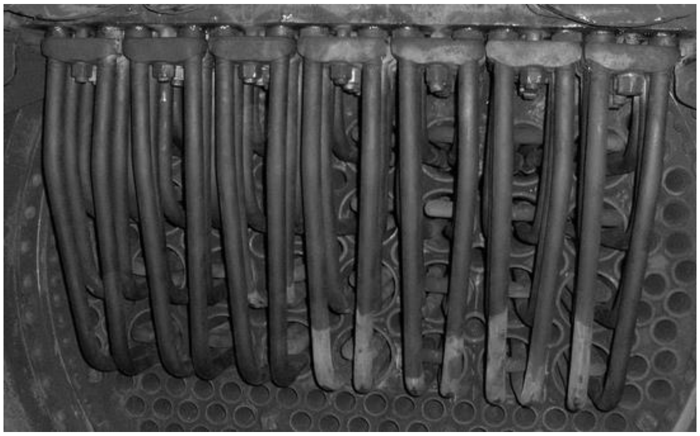
1, Eccentric rod.
2, Swinging link centre on reversing bell crank.
3, Astern position of swinging link centre.
4, Swinging link (radius rod).
5, Link travel for "ahead."
6, Link travel for "astern."
7, Reversing engine.
8, Slide valve spindle.



No. D65.—JOY VALVE GEAR.

1, Suspended link.
2, Compensating link.
3, Lever connecting compensating link and valve rod through quadrant block 4.
4, Quadrant block (travelling).
5, Angle of quadrant for "ahead."
6, Angle of quadrant for "astern."
7, Slide valve spindle.
8, Reversing engine rod.

Saturated and Superheated steam:
Puke uses saturated steam, thus the steam is taken out of the top of the boiler, above the water and used as it is. In plants that are more sensitive to water droplets in the steam, or require higher power outputs, the steam is taken out of the boiler, and reheated to dry the steam and increase its temperature and energy before it is used in the engine. Superheaters are commonly used on modern express steam locomotives and turbine plants.



(left) A superheater header and superheater tubes on a steam locomotive

Glossary

Air Pump
Pump used to remove the water and air from the condenser

Big End
The end of the connecting rod that carries the crank pin bearing

Blow Down
The process of discharging a boiler by using a low level cock; used to clear sediment and empty boiler

Boiler
Pressure vessel in which water is converted into steam

Boiler Tubes
Tubes that allow the transfer of heat from the hot boiler gasses to the water. Can be in the form of water tubes or fire tubes

Carry over
Water taken with the steam into the engine

Check valve
Non return valve that allows the passage of water in one direction only

Cock
A rapid action form of valve. Generally a rotating plug which is drilled along a diameter

Compound
The dividing of expansion in an engine into a number of stages. In practice it refers to a two stage expansion

Condenser
The device that turns exhaust steam back into water

Connecting Rod
The rod that connects the reciprocating, to the rotational part of the engine. ie crosshead to the crankshaft. Connecting rod can be known simply as a crank.

Crankshaft
The shaft that the engine turns to convert up and down movement into rotational movement

Crosshead
The structure that connects the connecting rod and the piston rod

Crosshead Pin
See Gudgeon pin below

Cut off
The closing of the inlet of live steam into a cylinder

Damper
A device for controlling airflow to the fire

Dead centre
The extremities of the engine stroke, where neither thrust nor tension in the connecting rod can assist rotation. Top and bottom dead centre (TBC/BDC) are relative to the cylinder

Double-Acting engine
An engine in which the steam acts on both sides of the piston

Draught
The pressure forcing air through the fire

Eccentric
A disc off centre on the shaft, generally used to drive a valve or pump

Eccentric Strap
Split bearing around the outside of the eccentric

Efficiency
The proportion of the energy leaving a plant in the desired form, compared with the total energy put into it.

Expansion
The practice of allowing steam trapped behind the piston to do further work after the inlet cut off

Die Block
The block that slides in the quadrant that converts the lower valve rod movement to/from the eccentric

Drain Cock
Cock used to remove the water from a cylinder

Feed Pump
The pump that supplies water to the boiler

Feed Water
Water used to fill the boiler

Fink Gear
Form of single eccentric reversing gear

Fire bars
Bars that support a solid fuel fire in a furnace

Fire Tubes
Tubes passing through the boiler that carry hot gasses. Used to help heat boiler water

Flash Boiler
A single tube kept at high temperature. Water introduced at one end is 'flashed' into steam for immediate use at the other end

Flues
Ducts that carry hot gasses. May or may not pass through a boiler

Flywheel
A heavy wheel mounted on the crank shaft to assist uniformity of rotation

Forced draft
The use of forced air or steam to increase the draft on a fire

Foot valve
Non return valve at the bottom of a supply of water

Funnel
Chimney on a marine plant

Gauge, Pressure
A device to indicate pressure

Gauge, Water
A device to indicate water level in a boiler or tank

Gauge, Vacuum
A device to indicate the vacuum in a condenser

Gland
A component of the stuffing box that seals a rotating or sliding shaft

Gland Packing
The material inside a gland that presses on the shaft and forms the seal

Gudgeon Pin
The bearing pin at the connecting rod/ piston rod junction in the crosshead

Heat Engine
Any engine that converts heat to work

Heating Surface
The area subject to heat, directly or indirectly from the fire

Horsepower
A unit of power introduced by James Watt, now superseded by the kilowatt, 1 HP equals 0.746 KW

Hotwell
The tank that receives return feed water from the condenser

Injector
A form of steam jets that are used to pump water into the boiler

Lap
The amount that slide valve overlaps the ports when in mid position

Link Motion
A controlling and reversing device using two eccentrics. Stephenson’s is the best known type

Locomotive
A self propelled steam power unit

Monotube boiler
See flash boiler above

Motion
General term used for the various moving parts of a steam engine

Natural Draft
The use of a tall funnel to draw air through the fire without assistance

pH
The measurement of hydrogen ions in a substance, ie the acidity or alkalinity of that substance. 7 being neutral, below 7 is acidic, above 7 alkaline

Pipes
Sealed tubes used to carry water, steam etc

Piston Rod
The circular rod that connects the piston to the crosshead

Port
The opening in a valve face that communicates with the cylinder

Priming
(In Boilers) the sudden release of steam thought the boiler leading to a very wet steam and water mix

Propeller
Rotating device consisting of angled blades on a shaft, to force water movement and allow movement of the vessel.

PSI
Pounds per Square inch- Imperial measurement of pressure.

Quadruple expansion
An engine in which the steam is used in four successive stages

Radiation
Linear transmission of heat energy from the fire

Return Tube Boiler
Boiler where the hot gasses from the firebox return to the same end the air entered the firebox

Rivet Counter
Humanoid full of effluvious information, best kept away from plant operations

Safety valve
Essential valve that releases steam if the pressure rises above safe working pressure

Shell boiler
Any boiler that mainly consists of one large pressure vessel

Sight Glass
See Gauge Water above

Simple engine
An engine in which the steam is used only once

Skin fitting
Fitting that allows water or steam transfer from the inside to outside of the hull

Slide valve
The valve that slides over the ports to cover and uncover them, allowing steam to pass into and out of a cylinder..

Stay Tubes
Heavy boiler tubes that help support the flat surfaces of the tube plate against steam pressure

Steam Chest
Box like structure on engine cylinder that encloses the ports and slide valve

Steeple Engine
Engine that makes use of two pistons on one piston rod to work on the same crank

Stop valve
Screw down valve closest to the engine on the steam supply

Stuffing Box
The assembly that holds the gland and gland packing on a moving shaft to prevent leakage

Superheated Steam
Steam that is heated and dried outside the body of water it was formed in, and before use

Tandem engine
See Steeple Engine above

Thermodynamics
The science of the relationship between heat and work

Throttle valve
The valve that controls the input of steam into the engine

Traction Engine
A locomotive that works on roads rather than rails

Triple Expansion Engine
An engine that uses the steam in three successive stages

Tube Plate
Plates at the end of a firetube boiler that the boiler tubes are expanded or welded into

Vacuum
The pressure below that of atmosphere

Valve
A device for controlling the flow of steam or water

Valve Spindle
Rod that carries the slide valve

Water Tube Boiler
A boiler in which the heating surface is mainly or totally small tubes carrying water inside them

Wrist Pin
See Gudgeon Pin above

Quadrant
The curved and slotted bar on the reversing gear that the die block travels in to change direction of the engine