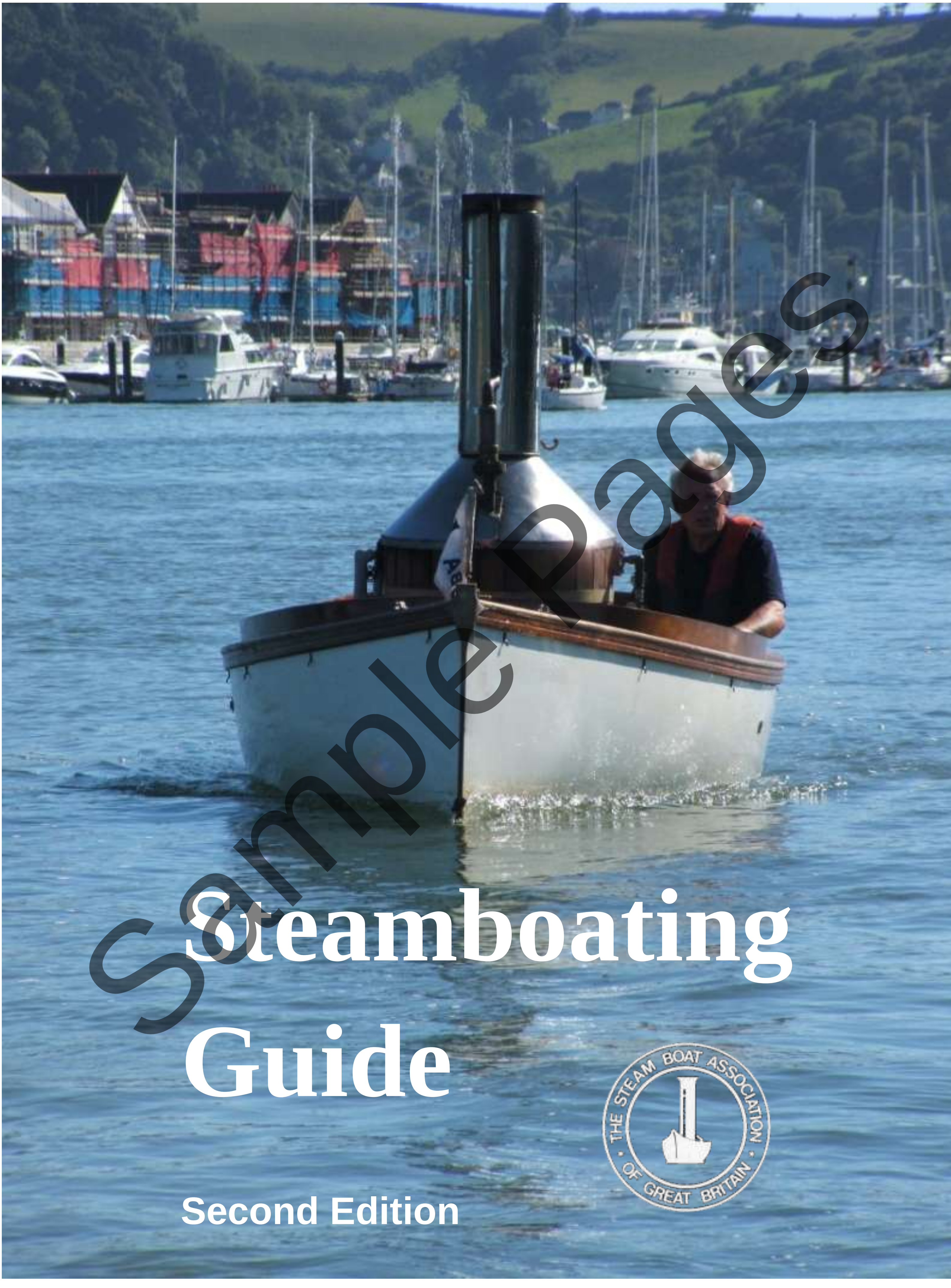


Steamboating Guide

THE STEAM BOAT ASSOCIATION OF GREAT BRITAIN

Second Edition

Steamboating Guide

Edition 2

2010

Edited by

Roger Calvert and Rob van Es

The contributors and editors of this publication have made every effort to ensure the accuracy and relevance of the data presented and the validity and appropriateness of the recommendations made. It is, however, ultimately the responsibility of the owner of a boat to check the data and take the final decisions, in the context of the proposed design. If necessary, appropriate professional advice should be sought. Neither the contributors, the editors, nor the SBA can accept responsibility for any direct or indirect consequences arising from the use of the data or from following the recommendations of this publication.

Table of Contents

Preface

Section A – Introduction

1	Hulls	1-1
2	Boiler Types	2-1
3	Engine Types	3-1
4	Fuels	4-1

Section B – Steamboat Operations

5	Boiler Fittings	5-1
6	Steam Plant Installation	6-1
7	Boiler Operation and Maintenance	7-1
8	Steam Ancillaries	8-1
9	Boat Handling Advice	9-1
10	Boiler Inspection and Testing	10-1
11	Trailers and Towing	11-1

Section C – Technical

12	Propulsion	12-1
13	Valve Setting	13-1
14	Data and Performance	14-1
15	Boiler Design Considerations	15-1
16	Workshop Techniques	16-1

Glossary 17-1

Index 18-1

Preface

The aims and objects of the Steam Boat Association are:

(i) To foster and encourage steam boating and the building, development, preservation and restoration of steam boats and steam machinery, by all possible means.

(ii) To stimulate public interest in steam boats and steam boating.

(iii) To promote high standards of workmanship, safety and seamanship.

The First Steamboating Guide, which was published by Calvert Technical Press in association with the Steamboat Association of Great Britain in 1992, has proved to be an immensely useful source of information for members. This second edition of the Steamboating Guide is built upon much of the material included in the original guide. The content is based strongly upon articles published in FUNNEL, the journal of the SBA, which have been contributed by many members over the years. Research and good practice established in modern times, as well as material circulated in Edwardian and Victorian times, are brought together here to serve as a broad and practical introduction to the creation and operation of a successful steam powered launch.

The production of this new edition has been made possibly by the hard work and careful consideration of a team of volunteers who have compiled and collated information in their respective fields of experience and expertise.

This collection of information should be sufficient to get new steam boaters started, and in several places there are suggestions for further reading on specific topics. A couple of books which will add knowledge of steam launch technology from the other side of 'the pond' are *Steamboats and Modern Steam Launches* (Ed Bill Durham, ISBN 0-9641204-3-7) and *The Steam Launch* (R.M. Mitchell, ISBN 0-85059-609-2). Closer to home, *Steam Engine Principles: their application on a small scale* (N.G. Calvert, ISBN 0-9513620-1-1) takes some of the themes to a deeper level. Perhaps two of the best sources of information are back issues of FUNNEL, or attending SBA events and talking to other experienced steamboat owners.

The contributions of the following members are very gratefully acknowledged in the preparation of this guide, and thanks are also extended to all those past and present who have taken the time to record and publish their knowledge on which we continue to build.

David Beale
Mike Bell
Adrian Birtles
Roger Calvert
John Gibbs
Bill Hall
Ken Johnson
Trefor Milns
John Puddy
Mark Rudall
Terence Sharp
Ivor Slee
Paul Smith
Rob van Es
Sam Wilkinson
John Winn

1 Hulls

This section, as are all the early sections of the Steamboating Guide, is aimed at the newcomer to steamboating and consequently there is much basic information that more experienced SBA members or those with a background in boat building may find unnecessary.

What makes an ideal steamboat hull?

Any craft at all can be used as the basis for a steamer; SBA meetings have seen boats based on canoes, skiffs, sailing dinghies, speedboats, motor launches, electric launches, clinker, carvel, steel, plywood, cold-moulded, and virtually every type of boat and construction you can think of. Your choice must depend on what you want and your resources and skill.

All SBA members have some interest that stimulates them to join the Association and in many cases it is a skill that they can use in the fitting out of a boat. The choice of hull is often dictated by such a skill (or the lack of it).

One of the most important factors in the choice of a hull is to thoroughly examine existing boats and this can be done in comfort at home with a copy of the Steamboat Index either in its printed form or on our website. Most importantly join in at meetings where the opportunity to travel in a variety of boats will help in deciding what is best for you.

The skilled model maker graduating to a steamboat may decide that his skills are suited to building and fitting the steam plant rather than constructing a hull for it. A powerboat enthusiast may prefer to buy a hull to fit a purchased steam plant and a member who is interested in woodwork will very likely build his own hull. Whichever route is adopted the end result will be a proud owner.

Considerations for a steamboat hull:

Hull types

Construction materials

Tenderness

Carrying capacity

Speed required

Fitting out

Trailing on the road

2 Boiler Types

Introduction

Whilst every care has been taken to ensure that the content of this chapter is accurate and robust, expert opinion should be sought before proceeding in a project. In the case of steamboat boilers, there are numerous suitably qualified consultants, and if you are unsure the SBAS might be a good organisation to contact in the first instance.   This chapter starts simple, and contains all that is needed to make decisions about boiler purchase for a given project. Those who are interested can read further and continue to gain understanding of design considerations.

Boilers are safe – if they are designed and operated properly. Folk memories of boilers exploding all over the place date from the days when engineering knowledge and materials were less advanced and before insurance companies and licensing authorities took things in hand. There is no need to be frightened of boilers, but like all engineering equipment, they need to be treated with due respect.

As a comparison: a typical steamboat boiler may have a capacity of about 30 litres (6 gallons) of water at a pressure of 7 bar (100 pounds per square inch (psi)) and a temperature of about 170°C, while a large power station uses 1500 tonnes/hour of steam at about 160 bar (2400 psi) and 540°C.

There are two main types of boiler, with innumerable sub-divisions. The water level boiler contains a roughly constant volume of continuously heated water. Steam is drawn off and cold water fed in as required; it has a large enough capacity to cope with sudden changes in demand. This contrasts with the tubular boiler which has almost no capacity. In a tubular boiler the steam and water flows must balance accurately, and the heat source must change with them. It consists of a single length of heated tubing with water being pumped in at one end and steam being drawn off at the other.

Types known as Shell, Water Tube, Fire Tube, Locomotive or any geographical name (e.g. Cornish) are water level boilers. Flash boilers are tubular boilers where water is pumped into the hot, dry tube as required, to be instantly flashed into steam. Most, though not all, steamboats use water tube or firetube boilers. Flash boilers are widely used in steam cars. Modern tubular boilers (under the name of steam generators) are widely used in industry.

Boilers are described as vertical or horizontal according to the direction of flow of the flue gases on leaving the firebox.

How a Boiler Works

The function of a boiler is to generate steam from water. This requires the input of heat, which comes from the chemical energy released by burning fuel.

Heat can be transferred from one body to another (e.g. gas to metal, metal to water) by three mechanisms:

3 Engine Types

Introduction

When considering a steam plant for a launch it is important to realise that the power that it produces will be largely dependent on the size of the boiler and particularly on its ability to burn fuel fast enough. If the power output is to be sustained it is essential to ensure that the boiler can maintain maximum designed pressure with the throttle fully open. This may seem obvious but I have seen many boats in which boiler size has been more influenced by space in the boat than what the engine really required. Your selection of engine will dictate the size of boiler that should be used.

This chapter introduces the choices which are available for engines suitable for launches and shows how to calculate expected power of engines. We then go on a journey through 30 years of engine building and design with Sam Wilkinson, a recognized expert in the field of steam launch engines.

Steam Engine Choices

There is a large range to choose from but this section will be restricted to those most commonly found on launches.

Number of cylinders

The configurations commonly used are a single cylinder single acting, single cylinder double acting, two cylinder and three cylinder.

One or two cylinder single acting (steam on one side of the piston only): Worth including in the list because a very simple engine can be made by converting motor cycle engines or air compressors. Their big failing is water in the sump which can damage the steel bearings. This can be countered with water repellent oils. Valves have to be changed. In an ex-four stroke engine the camshaft can be modified. They are not usually self starting.

One cylinder double acting (steam acting on both sides of the cylinder): One of the most popular engines in small launches. Simple to construct and maintain. Major shortcoming is that it will probably need a kick start in both forward and reverse.

Two cylinder double acting twin (steam on both sides of the pistons of equal diameter): Again very popular.

Main advantage: instant response to forward or reverse.

Disadvantage: rather thirsty and not the highest efficiency. Thus the engine can be relatively small but the boiler will be large.

Two cylinder compound: Steam is fed into a small diameter high pressure (HP) cylinder which exhausts into a low pressure (LP) cylinder usually about twice the diameter of the HP. In one common form these cylinders drive a crank with two throws at right angles to each other. The alternative is to set the cylinders at right angles to each other driving a common crank journal. This makes for easy crank

4 Fuels

This chapter is arranged in two sections: firstly a general description of the options available, and then a more detailed description of the Combustion Characteristics of Coal, Oil and Gas.

Introduction

What can we burn that will produce the right amount of heat to raise the steam we need, handle easily, not be too costly, be reasonably clean, give the boat the right ambience and smell right? Such are the subjectivities of choosing the right fuel.

Victorian missionary steamboats used to ply the Amazon and the Congo burning the sort of hardwoods we'd want to actually build our craft with today. Hacked randomly from the rainforests these valuable timbers are now either banned imports for us or simply no longer available.

Boats in some parts of the world were fired successfully on what today we would regard as high-bulk biomass fuels – bagasse or coconut husks for example. In the UK none of these exotic waste products are available to us but there is still a very wide variety of possible fuels and, if we get our firebox dimensions and grates right, they could, from a fuel perspective at least, keep costs to a reasonable level.

If you simply wish to get on the water and steam happily for miles at virtually no cost, not overly bothered about high efficiency or cleanliness, you can choose to burn broken pallets or any other rough timber including waste wood fished out of the river, but only if your firebox is big enough and you don't mind carrying lots of bags of timber.

Steamboating of this sort is enormous fun but you will not need to mind lots of smoke, constant splinters in your hands, wet soot in your tubes, corrosive acids in the funnel, sparks which burn holes in your canopy and large volumes of the sort of irritating light ash that blows all over the boat and makes your hair and clothes smell like a bonfire. A member of the SBA was once turned away by a sniffy waiter from a classy lunch venue on the Thames for this very reason. Sir, if indeed someone smelling that can indeed be called 'Sir', was definitely not welcome to sample HIS hospitality so they had fish and chips instead.

On the other hand, there is a definite skill and sense of achievement in firing with wood. With the right variety, it can be very successful. Hardwoods such as oak burn rather like smokeless fuel. Oily woods such as apple, holly or laurel burn with a long clean flame. Softwoods burn rapidly with a lot of sparks. Most woods produce a very light ash which goes up the funnel and, so long as there is sufficient air, produce very little smoke, soot or tar.

Solid fuels come in many forms and their energy value per kg varies enormously. Coal and wood are accepted as normal, but there is charcoal, compressed 'logs' of one kind and another, coal pellets and so on. Irish steamboaters have found peat to be a delightful fuel, both cheap and fragrant. 'Turf' burns away completely leaving a virtually clean grate with hardly any soot and only modest ash deposits.

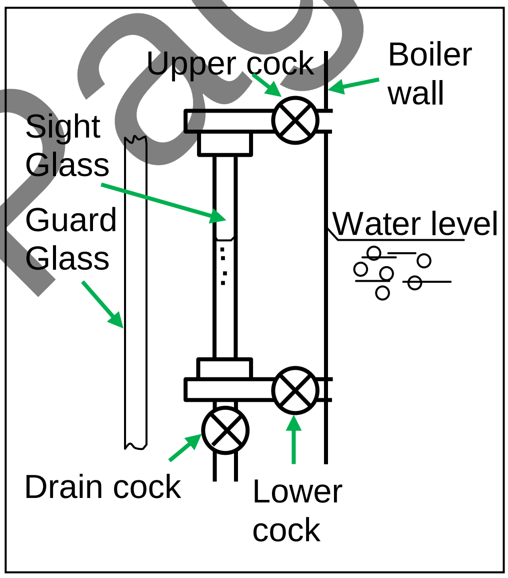
5 Boiler Fittings

The boiler does the main job of turning water into steam, but to do so, it needs a lot of peripheral components to get the water in and keep it in, to get the steam out, as and when required, and to control and monitor its operation. Since these directly connected components are subject to the working pressure and the related temperature they must have appropriate ratings. This rating is the Design Pressure and Temperature for the boiler to which they are fitted. This rating can be found on the Approved Boiler Drawing or if this is not available Boiler Inspection Reports should have this data.

Water gauges

The purpose of the water gauge is to allow the operator to monitor the water level in the boiler.

A transparent tube is connected to the boiler drum through two pipes, one above and one below the nominal working water level. The water level in the tube is thus the same as that in the boiler drum, whatever the pressure in the boiler may be. The connections are positioned by the boiler designer such that, if the water is visible anywhere in the gauge, the water level is satisfactory. Generally, the best level is half to two-thirds of the way up.



The tube is usually made of thick glass or quartz, or is an assembly of brass or bronze and glass. It must obviously be capable of taking the full boiler pressure, at steam temperature The glass must be free of cracks or scratches and cleanly cut – no notches or spikes which cause weakness. It is good practice to replace the glass every so often as a matter of course – and always carry a spare. It is sealed into the fittings with special rubber washers or O-rings; carry spares of these, too.

A gauge glass breaking under pressure is a somewhat traumatic situation. To avoid or minimise the risk the glass must always be enclosed in a protector made of toughened safety glass. This both protects the sight glass from accidental damage and protects you from flying glass, steam and superheated water in the event of a fracture.

If the glass does fail, it must be possible to shut off the steam and water by means of isolating cocks. In an emergency, they can also be used as test cocks to check the water level when the glass is broken (ease them open and make sure that water comes out of one and steam out of the other). Sometimes separate test cocks (or *try cocks*) are fitted to the boiler especially for this purpose.

6 Steam Plant Installation

This guidance sets out to complement and expand upon other contents of this publication and should not be read in isolation.

Installation

Proper mounting – rigid: The boiler is likely to be the heaviest component of the boat contents, and should be mounted on substantial bearers. These are often substantial timbers running along the length of the hull, which also carry the engine mountings and the thrust bearing.

Support whilst on trailer: If the boat is to be trailed, it is worth considering the way in which the weight of the boiler is supported when the boat is on the trailer, and the bearers mentioned above may be bonded into an egg box type lattice, cross-braced with floors. In this way the load may be transferred to the keel, which is likely to be supported on rollers when on the trailer.

Insulation from hull, lagging, wet ashpan: Hot air rises, but when the boiler is in operation there is likely to be heat transfer downwards, by conduction, by ash falling into the ashpan, and by radiation from the underside of the grate. Insulation may be arranged to deal with this and a so called wet ashpan can be very helpful. This latter is arranged to hold water, absorbing heat by gradual evaporation, and quenching any hot ash falling into it.

Insulation is only effective if adequate air circulation removes any heat migrating through the insulation. Similarly air circulation around a wet or dry ashpan is vital. Ceramic insulating materials are not required as general purpose insulation except when such materials are exposed to direct flame radiant heat. Cheaper alternatives are available with equal 'Q' values. See Funnel 97 p62.

Avoiding personal burns: Proper lagging and insulation of the boiler itself minimises heat loss, and at the same time prevents burns to both the operator and passengers in the proximity. Particular attention should be paid to any item which may be grasped in emergency, such as if the boat were to rock**.** Many fire tube boilers are lagged with hardwood strips which really just contain a ceramic fibre mat, which is the principal insulator. Water tube boilers often have refractory lining of the outer casing complemented by ceramic materials.


7 Boiler Operation and Maintenance

Boilers may be of excellent design, well constructed, fully certified and insured, but if they are not operated properly they can be damaged or cause hazards. The following sections cover some important operational aspects.

Boiler Rating (Steam Output/Capacity)

The performance of a boat will depend first on the capacity of its boiler, next on the size of its engine, and last but by no means least on the skill of its operator.

In an ideally designed installation the engine and propeller power and speed will be matched to hull design speed and the boiler should be able to comfortably supply all the steam necessary to run the engine with the throttle valve full open. The boiler will not be operated or forced beyond its design output and, provided it is kept free of scale or oil contamination internally and clean on the fire side, it should have a trouble free life.

Many SBA members, however, have boats that are under boilered – if you opened the throttle fully with a good fire, the boiler pressure would fall away slowly. This may provide a more economical design; continuous running at full throttle is rarely needed, and a smaller boiler will be capable of providing the average requirement with occasional bursts of higher power, but any attempt to run at full power for long will fail. While forcing with the blower may produce more steam, good management of the boiler will help to get the best out of it without going to extremes.

Preparation

Filling the boiler

Before starting to fill the boiler ensure all drains / blow down valves are securely closed, and any shut off valves on water gauge or pressure gauge are open. When filling the boiler, recognise that the water will expand as its temperature rises, and check all valves and fittings to confirm correct functioning, e.g. blow down is clear but securely closed and water gauge reads correctly. Procedure for doing this is described below under ‘gauge glass replacement and test’, below.

Boiler water treatment

Water treatment is often used in steam boilers. The purpose is to reduce the corrosion of steel, and to reduce the settlement of sediment which could lead to poor heat transfer or pockets of corrosion. The desirable features of the treatment are a pH of about 11, a suspending agent to keep sediment mobile and some antioxidant agent. Many treatments are tannin based and a correct concentration is said to have a colour similar to tea.

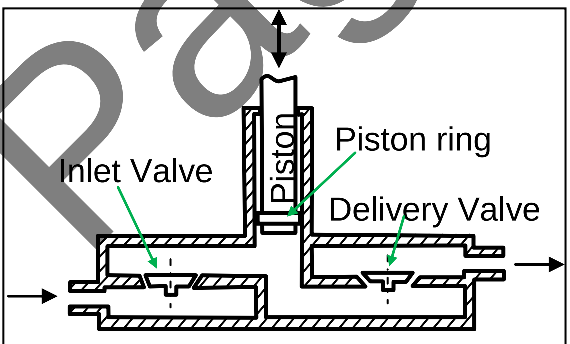
8 Steam Ancillaries

There are many other components which, although not strictly essential, may be added to the system to improve its efficiency, to make operation easier, or just for fun. (Even a feed pump may be dispensed with in principle. When the boiler water gets low, you put the fire out, wait for it to cool, take the lid off and fill up with water, then relight the fire. Some early small steam plant actually did use this procedure.)

Feedpumps

The purpose of the feedpump is to pump water into the boiler as the steam is used. Normally, the pump is driven directly from the engine or propeller shaft. This gives an element of automatic regulation. If the engine runs faster, thus requiring more steam, the pump also runs faster, thus providing more water. Most steamboats have an additional hand pump for use in emergency situations or for maintenance and testing purposes.

Feedpumps on steamboats are usually of the positive displacement type, where a fixed volume of water is delivered for each cycle, as opposed to rotodynamic (e.g. centrifugal), where the delivery depends on both speed and back pressure.



Piston Pump

The most common are piston or plunger pumps, which differ only in the location of the seal: it is on the piston for a piston pump, but on the casing where the piston passes through on a plunger pump. The piston pump requires an accurate bore, but can accept a non-uniform piston. The plunger pump requires an accurately cylindrical piston, in any shape of bore.

When the piston is raised, water is drawn into the cylinder through the inlet valve. The delivery valve is held shut by the back pressure at outlet. When the piston is pushed down, water is forced out through the delivery valve, and the inlet valve is closed.

On the hand pump, the piston is operated by a lever long enough for the operator to easily overcome the back pressure on the piston. On an engine driven pump, the piston may be directly driven from the engine cross-head, or driven by an eccentric on either the engine shaft or another shaft geared down from it (pumps such as this suffer from cavitation if driven too fast – a big, slow pump is more effective and quieter than a small, fast one).

Other types of positive displacement pump which can be used as feedpumps are sliding vane, gear or flexible impeller pumps. But beware – these can pump backwards when you go astern!

9 Boat Handling Advice

Mooring

Probably the most anxious part of steam boating is the same as aircraft: “take off and landing” Very rarely is the water calm with no flow and no wind let alone other boaters who do not know what they are doing, so what chance have you got?

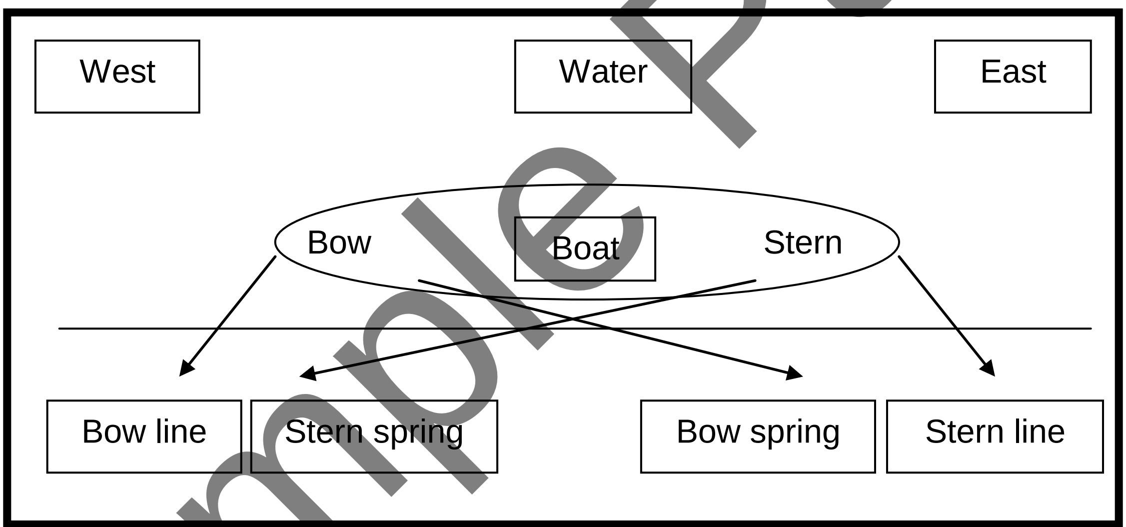
Be prepared!

Ropes or better still “Warps”/ mooring lines.

Each boat must have a minimum of four warps;

One bow line, one stern line, one bow spring and one stern spring as a minimum. A good rule of thumb is that bow and stern ropes should be the length of the boat, and spring ropes should be twice the length. This ensures that you will have plenty of line for all situations, including taking a tow.

Conventional method of mooring a boat



The mooring lines must be fixed to something at the other end. The ideal is a mooring ring, often provided on wharves and jetties. Alternatives are bollards, spikes, trees, railings or anything else convenient.

Care must be taken when using local landmarks for mooring – it is easy to have a line crossing a towpath or other public place, which could cause a trip hazard. If you must do this, make sure it is weighted down onto the ground, and draw people’s attention to it.

Bollards are fine, so long as there is no possibility of the rope being lifted over the top either on purpose (vandals) or accidentally (rising tide or waves).

A mooring spike (or *pin*) is simply a metal rod around 0.3 to 0.5 m (12 to 18 in) long driven into the ground with a hammer

10 Boiler Inspection and Testing

Introduction

This chapter provides information and guidance to the owners of steam launch boilers on boiler inspection practices and procedures. In the great majority of cases these owners are also the operators of the launches and their boilers, and most are amateurs – albeit often very knowledgeable and experienced amateurs. This chapter is not a manual on carrying out boiler inspections for boiler inspectors or anyone else, although it is hoped that the professional inspectors will find that it makes a useful contribution to their purpose of keeping boilers safe and well-maintained. Even less is this a manual for boiler designers and builders, but it is hoped that it may help to reinforce the principle that really successful inspection and maintenance has to be designed in from the earliest stage on the drawing board.

The routine inspection – or "examination" – of boilers has a very long history indeed and has been the subject of statutory provisions for well over a century.

The statutory requirements for boilers in industrial and transport use arose from the appalling accident record of boilers at the time of the great expansion of the use of steam power in the second quarter of the 19th century [1]. "Boiler Inspections 1866-78" [2] reveals inadequate maintenance in one form or another as the largest cause of the 1046 boiler explosions recorded, with inadequate design and improper operation also being significant.

These types of fault undoubtedly arose from two basic causes; in a regrettably large number of cases at those early times there was a good measure of dereliction of duty, sheer recklessness, or absence of common sense. Much more basic however, and as true today as ever, is the fact that for all their apparent inherent simplicity, steam boilers are complex structures subject to severe loading conditions in a harsh and inhospitable environment. Furthermore, the parts of a boiler most susceptible to deterioration are frequently those hidden from view in normal service conditions, and the recognition – or at any rate the proper interpretation – of the signs and symptoms of distress requires a specialist knowledge and expertise not often present in the lay operator.

In industry these factors are by no means unique to steam boilers, but are to be found in quite a range of types of equipment. Lifting tackle and lifting machines are two other common examples which are subject to very similar statutory examination requirements to those for boilers – and for the same basic reasons.

Regular routine examination of boilers by an independent expert therefore became – and remains – the norm for boilers, and has become a standard part of the maintenance routine for such plant. This is an important point in itself; although routine inspection started as an essential safety precaution (and safety will always be

11 Trailers and Towing

The legislation governing trailers and towing is inevitably rather complex. This chapter is certainly no legal treatise, but is as far as possible, sensible advice based on a number of reputable sources. In the event of a conflict of advice between these sources, the more rigorous has been presented here. The law changes periodically and any members who do tow their boats on the road should ensure they keep abreast of changes. Although older trailers are not subject to all the current legislation, it is probably prudent to bring older trailers up to the highest modern standards possible in the interests of safety. Ultimately, the driver is responsible for having a 'roadworthy' trailer which is a cover-all and includes attachment of the load, condition of the trailer, as well as adherence to all relevant regulations.

The information contained is applicable to trailers with a combined weight (trailer plus cargo) of up to 3500 kg. Larger trailer weights are possible, but lie outside the scope of this summary.

General Rules

Speed limits whilst towing a trailer are slightly lower than for a car alone. The limit is reduced from 70 to 60 mph on motorways and dual carriageways, and the speed limit on unrestricted single carriageways drops from 60 to 50 mph. It is also important to remember that vehicles with trailers are not permitted in the third lane of motorways (unless there are lane closures). It may also be worth checking the small print of your car and/or boat insurance policies, as you are required to have third party cover for your trailer as well as for the tow car.

If your driving licence was issued before 1 January 1997, you will have categories B+E on your driving licences which allows you to tow a trailer over 750kg. New licence holders will not automatically have this category, and can only tow trailers below 750kg. Passing a B&E test will allow towing greater weights, but there are also age related restrictions here. For owners of very large boats, the category C1+E is required which allows you to tow up to a combined vehicle and trailer weight of 12 tonnes.

Trailer Weight and Size Limits

- The maximum towing weight for the towing vehicle, and maximum permitted loading on the on the towing vehicle coupling must not be exceeded. These values will be found in the manufacturer's handbook.
- Maximum permitted nose and axle loadings and gross weight of trailer plus load must not be exceeded. These values will be found on the manufacturer's plate/s on the trailer.

Unbraked trailer weights

The maximum weight of an unbraked trailer is 750 kg. The kerb weight of the towing car must be at least twice the weight of the trailer, so a 600 kg trailer may only be towed by a car of kerbside weight of over 1200 kg. Unbraked trailers manufactured

12 Propulsion

In many respects, this Chapter is what, literally, joins everything together and can result in either success or failure. What follows is intended to give a guide to success for a “normal” steam launch trying to achieve a respectable performance – it is not intended to give a definitive answer for a truly high performance launch for which it may well give a good starting point, but would inevitably require further research and experimentation.

Basic Principles

Fundamental to successful propulsion is achieving the right balance. The first principal to be understood is that speed is dependent on propulsive power – more of this later – but it follows from this that (and given certain constraints) a given speed is achieved by a specific horsepower and, in turn, this can be developed by a wide range of boiler-engine-propeller combinations. To quote from Simpson Strickland [1]: “*An idea sometimes exists that the speed of a boat is in someway proportionate to the pressure. …. Now, as a matter of practice, the pressure a boat works at has very little to do with the speed at all. The principal advantage of using a reasonably high pressure is economy; but we believe that very little gain in speed is to be obtained by raising pressures, and we shall be pleased to quote for high speed or other boats to suit customers’ requirements, to work at any pressure from 50 lbs to 400 lbs.”*

What this means in practice is that, in principal, the same speed can be achieved for a given boat by boiler pressures of 50 psi and 400 psi and it follows that for the given horsepower required to achieve that speed:

- for the same engine revolutions – this would mean that the lower pressure would require much larger cylinder dimensions. But the propeller would be the same for both engines because the shaft horsepower and rpm are the same. However, herein lies a constraint: the lower pressure engine would probably weigh more, resulting in a marginally heavier boat, which would actually require a bit more power to achieve that same speed. i.e. more fuel!
- for differing engine revolutions – this, of course, gives rise to an infinite number of comparisons ranging from low pressure low speed (and therefore large cylinder dimensions and heaviest engine), through low pressure high speed, high pressure low speed, to high pressure high speed (smallest cylinder dimensions and lightest engine).

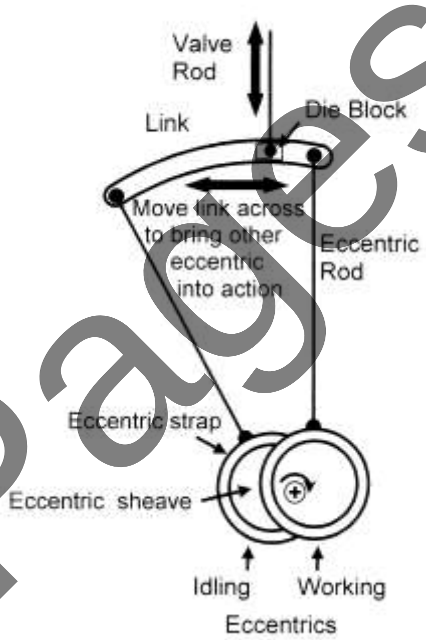
Each of these will require a different propeller, both in diameter and pitch. But given the right selection of propeller, the propulsive thrust will be the same, and the speed the same.

So what matters is balance and choice. Successful propulsion can be achieved by both low and high revolutions – it is up to you to decide whether you want a slower speed engine or not. This is a matter of personal choice but, of course, there are inevitably consequences relating to that choice. In general slow speed engines suffer from additional horsepower losses caused by internal condensation losses, most noticeable in single cylinder engines. Compound and triple expansion engines

13 Valve Setting

This chapter will be of interest to all members who are technically minded, and would like to explore whether the performance of their engine may be improved. As with all other parts of this book, the information here is not exhaustive, but will prove sufficient to get you started.

The admission of steam into the cylinder has to be controlled so that steam pushes the piston backwards and forwards to obtain a continuous rotary motion to the crank. The mechanism controlling the steam admission is called the valve gear, and although there are several arrangements of linkage, the overall consequence is that the valve is moved backwards and forwards over the cylinder ports usually by the action of an eccentric. An eccentric consists of a circular disc, which is fastened to the crankshaft and rotates with it. The centre of crankshaft is made offset (eccentric) to the centre of the disc. Thus, when the crankshaft rotates, a point on the centre of the eccentric disc forms a circle around the crankshaft centre. The most commonly used link arrangements in steam launch engines is the Stephenson's link (as shown on the right).



Definitions

The slide valve in a steam engine appears to be a relatively simple device and generally speaking it is very forgiving of poor setting and adjustment. However smooth running and efficiency are worthwhile objectives and their achievement requires correct assembly, a fair understanding of the terminology and the consequences of the adjustments that can be made.

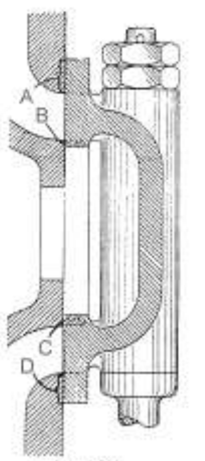


Figure 1

Lap

Short for overlap. Defines the extent to which the valve face edge overlaps the port edge when set in the mid-position. There could be four laps in a valve assembly, therefore they must be designated as follows:

'Top' or 'Bottom' (in a horizontal engine 'Top' will be furthest from the crank) and 'Exhaust' or 'Steam'. Thus referring to figure 1:

A = Top Steam Lap

B = Top Exhaust Lap

14 Data and Performance

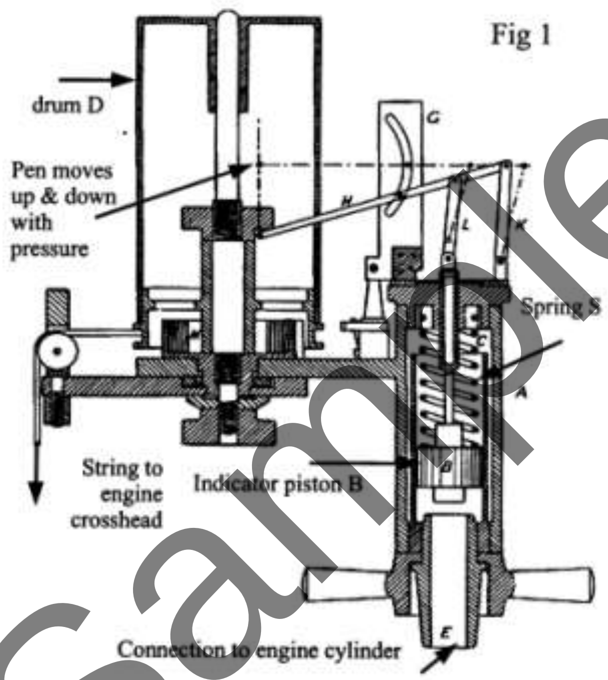
The Engine Indicator and Indicator Diagrams

James Watt defined the Horse Power as 550 ft lbf/s, as a measure of the power of his engines. Incidentally, he deliberately made it rather large, in case somebody came up with a team of horses which could outperform his engine. When challenged, he said that he was thinking of a brewer's dray horse; these are traditionally the most powerful. But even so, he made it a bit bigger again.

The only way he could measure the power of his pumping engines was by comparing the rate at which they pumped water with another pump powered by horses. This was a bit inconvenient and not altogether repeatable.

He therefore devised a system for estimating the power by measuring the pressure in the cylinder, and its variation during the piston stroke. The device he developed became known as the *Engine Indicator*, its graphical output as the *Indicator Diagram*, and its calculated result as the *Indicated Horsepower*.

The Indicator Mechanism



The Indicator, as it developed during the 19th Century, consists of a small cylinder *A* containing a piston *B*, connected to the engine cylinder, together with a spring *S*, a connecting linkage and a rotating drum *D*.

The drum is connected by a system of string, pulleys and levers (the *reducing gear*) to some reciprocating part of the engine – e.g. the crosshead. As the engine runs, the drum rotates to and fro with the crosshead position, while the piston goes up and down according to the pressure in the cylinder. A stylus draws a loop on a piece of paper clipped to the drum, which is a graph of cylinder pressure against piston position.

15 Boiler Design Considerations

General

This chapter is neither intended as a text book for pressure vessel design nor a manual for boiler construction. The content will prove of significant interest to those wishing to commission a boiler from a qualified engineering concern, or perhaps improve aspects of their own plant by better understanding key features of its design.

Any member considering the manufacture of a boiler is recommended to consider using a validated design taken from the SBA Services (SBAS) Design Library.

Unless stated otherwise, this section applies to boilers constructed of either copper or steel and to both fire tube and water tube boilers. Many of the principles also apply to tubular boilers, but these are not covered in depth as there are very few currently fitted in launches.

A comparative table of design characteristics for various boiler types is at the end of this chapter (page 15-10)

Power of a boiler, or boiler rating

The first matter to be considered is the output required of the boiler or boiler capacity.

Design feature: Provide the boiler with sufficient grate area, furnace volume and heating surface to produce enough steam at a pressure adequate to run the associated engine, at the required power, without recourse to forcing.

Serial Number
Certified [name of manufacturer]
Maximum allowable working pressure
Heating Surface
Year of manufacture
Maximum design steaming capacity

The boiler should be marked with an identifying number and provided with documentation giving:

(Note that industry codes require boilers to be *stamped* with much of this information.)

The output of the boiler should be matched to the engine. If in doubt, go for a

16 Workshop Techniques

Bushes, Split bearing type

To produce accurate split bushes, firstly rough machine the bush, leaving 3mm (⅛ in) finishing allowance all over. Carefully mark the position of the split along the sides and across the ends. Cut in half with a hacksaw, cutting along the lines from both sides to the centre. Now set up sideways in a four jaw chuck and skim to clean up both butts. Tin the butts with soft solder, wiping off any surplus. Gently clamp the two halves together in a vice, lining up the two butts accurately. Heat with a blow-lamp until the solder melts and then test with a touch of solder on the OD. Gently tighten the vice to squeeze out any surplus solder and allow to cool. The bush can now be machine finished to tolerance, keeping the line of its split on the centre line. Remember when machining to ensure that the joint is in line with one of the chuck jaws. It can then be split by gently heating with a blow lamp and while hot, wiping away any remaining solder with a screwed up newspaper.

Copper Pipe

Precautions

Copper pipes work harden in use and, if they are subject to vibration, they will be liable to fracture after two or three years. It is a good idea to anneal them every third year. Simply heat with a gas blow lamp until they become cherry red – then plunge into water. They should bend easily after this treatment and won't fracture.

Joining pipes

The sizes of copper pipe selected will be influenced by what is readily available, but if the pipe is intended for steam, then unless the diameter is small (8-10 mm), a wall thickness greater than domestic pipe should be sourced.

Where unions are used, it is essential that they are silver soldered for steam pipes. The best approach is to flux and silver the inside of the nipple. Clean and flux the pipe then heat the assembly and push together. This should give a clean joint with a neat fillet of solder at the edge of the fitting. When heating make sure that the pipe gets up to solder melting point which will be indicated by the absence of a meniscus where it joins the pipe.

The palm joint allows junctions to be made at any angle between different pipe sizes with a very tidy appearance. The procedure is to flare the annealed end of the joining pipe to produce a trumpet-like flange twice pipe diameter for small flanges, reducing to one and a half times for the larger sizes. A piece of metal round bar the same size as the main pipe is required as a former. The flange is annealed again, the former is positioned across it at the angle required, and the flange is tapped into conformity with it using a small soft hammer. To facilitate this operation grip the former in a vice and hold the pipe by hand. The outside edge of the palm or flange should be cleaned up with a file. In some cases its appearance may be improved by making it oval.

Glossary

Air Pump
Usually an engine driven pump which draws water from the condenser to return to the hot well. In practice, the pump pulls more air than water by volume. This pump produces a vacuum well below atmospheric pressure in the exhaust system.

Air Vessel
A bottle-shaped vessel attached neck downward by a T-junction at the suction and/or delivery from a reciprocating pump. Compression of the air in the vessel acts as a shock absorber and reduces `water hammer' or shock waves in the pipe.

Angle of Advance
The angle in excess of 90° by which an eccentric is in advance of the crank when an outside admission slide valve is used.

Annealing
Heating a metal to reduce crystalline alignment in the structure of the metal. Necessary in some copper steam or feed pipes which can become work-hardened over time. Copper pipes containing hot (i.e. high pressure) steam will anneal in normal use. But exhaust and feed pipes may work harden.

Back Pressure
The pressure which resists the free exhaust of a steam engine or turbine.

Balance (or Bob) Weights
Weights attached to the crankshaft which help to neutralise forces arising from the crank and the big end of the connecting rod.

Balanced Slide Valve
An arrangement for equalising pressure on both sides of the D slide valve, reducing friction and reducing loads on valve linkages.

Bearings, ball
The ball only makes point contact with the bearing surface. Bearing races may be sealed; grease lubrication is possible.

Bearings, needle roller
Long thin rollers, suited for low speeds and moderate loads.

Bearings, roller – can be tapered also
Higher load capacity than ball bearings. Tapered rollers can take axial load in one direction only. Paired back to back bearings are required for forces in both directions.

Bearings, white metal
Tin-lead alloy which can be cast and machined to make split bearings, particularly on the big end to absorb shocks on the power strokes. Lubrication is essential as white metal has a low melting point, and overheating will be destructive.

Index

air pump, 8-3, 8-4
anchoring, 9-6
ancillaries, **8-1**

bearings
- support, 12-9
- thrust, 12-7, 12-8
- wheel, 11-5

bilge
- ejector, 8-8
- keel, 1-9, 8-3

blast pipe, 8-5
blow down, 5-2, 6-2, 15-7
blower, 8-5
boiler
- capacity, 3-3
- corrosion, 7-1, 7-5, 7-6, 7-7
- design, **15-1**
- hydraulic test, 10-10
- inspection, **10-1**
- insulation, 6-1
- lagging, 6-1
- laying up, 7-6
- maintenance, **7-1**
- mountings, 6-1
- rating, 7-1
- steam test, 10-11
- types, 7-8

boiler examination report, 10-12
boiler fittings, **5-1**
- bourdon gauge, 5-4
- check valve, 5-5
- gauge glass, 5-1
- pipework, 5-5
- pressure gauge, 5-3
- safety, 5-5
- safety valve, 5-2
- stop valve, 6-2
- valves, 5-5
- water gauge, 5-1, 7-3

boiler operation, **7-1**
- blow down, 6-2
- cleaning, 7-2, 7-6
- emergency procedures, 7-8
- feedwater, 7-5
- firing, 7-4
- gauge glass replacement, 7-9
- hand pump, 5-5
- log, 7-7, 10-6
- raising steam, 7-2
- water level, 7-3
- water treatment, 7-1

boiler rating, 7-1, 15-1
boiler types, **2-1**
- Babcock, 2-6
- Belville, 2-7
- Blackstaffe, 2-7
- Bolsover, 2-5
- Cochran, 2-7
- cross-tube, 2-5
- fire tube, 2-3, 2-4
- flash. *See* tubular
- gunboat, 2-4
- Kingdon, 2-4
- locomotive, 2-4
- Lune Valley, 2-6
- Merryweather, 2-5
- monotube. *See* tubular
- Mosher, 2-6
- Ofeldt, 2-5, 2-7
- porcupine, 2-5
- Scotch, 2-4
- Stanley, 2-4
- thimble tube, 2-5
- Thornycroft, 2-6
- tubular, 2-1, 2-8, 8-7, 10-4, 10-7
- water leg, 2-4
- water tube, 2-3, 2-5, 2-6, 2-7
- Yarrow, 2-6

brake power, 3-7
Bremme valve gear, 13-13
burgee, 9-5
burner
- gas, 4-11
- Lune Valley, 4-10, 16-6
- oil, 4-2, 4-10

bushes, split, 16-1

carrying capacity, 1-6
clack valve, 5-5
cleaning
  brass and bronze, 8-11
  inside boiler, 15-6
  propeller, 12-12
  scale, 7-6
  soot, 7-7
clinker, firebox, 7-9
clinker, grate, 7-4
coal, 4-2
  fuel, 4-6, 7-8
  types, 4-5
cock
  blow down, 6-2
  isolating, 6-2
  water gauge, 5-1
collision avoidance, 9-6
combustion, 4-4
  air mixture, 4-7, 4-9, 4-10
  coal, 4-2, 4-6
  gas (LPG), 4-3, 4-11
  kerosene, 4-9
  oil, 4-2, 4-9
  paraffin, 4-9
  wood, 4-1, 4-4
compound engine. *See* engine, compound
condensation, 2-9, 7-6, 12-1
condenser, 1-9, 3-2, **8-3**
conduction, 2-2
convection, 2-2
copper pipe
  joining, 16-1
  precautions, 16-1
copper pipes
  bending, 16-2
corrosion
  boiler, 4-8, 6-2, 7-1, 7-5, 7-6, 7-7
  cylinder, 3-8
  fire bars, 15-2
  propeller, 12-12
  superheater, 2-10
  trailer couplings, 11-5
  wheel bearings, 11-5
coupling
  drive belt, 12-7
  flexible, 12-8
  gearbox, 12-7

damper, 6-3, 7-4, 7-9
downcomers, 15-5
draught, 8-5
  forced, 8-5
drill
  sharpening, 16-7
  thin metal, 16-3
drive belt, 12-7
dry steam, 8-7

eccentric, 13-1
economiser, 8-7
efficiency, 3-2, 3-4, 3-7, 4-4, 12-4, 14-3, 15-3, 15-7
ejector, 8-8
engine
  building, 3-18
  indicator, 14-1
  power, 3-3, 3-4
engine types, **3-1**
  compound, 3-1, 3-6, 12-1
  double acting, 3-1, 3-5
  oscillating, 3-2
  single acting, 3-1
  steeple, 3-2
  triple expansion, 12-1
  uniflow, 3-2

feed water heater, 8-6
feedpump, 8-1
filters, 7-5
fire bars, 15-2
fire extinguisher, 9-9
fire grate, 6-3, 7-4, 15-2
firebox, 4-8, 6-3, 15-2
firing, 4-8
fitting out, 1-7
fittings, safety, 5-5
flash boiler. *See* boiler types, tubular
forced draught, 2-3, 8-5
forcing, 2-3
frost, 7-6
fuel pressure, 4-10
fuels, **4-1**, 7-8
fusible plug, 6-2

gas (LPG)
fuel, 4-3, 4-11
storage, 4-12
gearbox, 12-7
grate area, 15-3
GRP
fitting out, 16-3
hull construction, 1-3
hull fixings, 16-3
guard
water gauge, 5-1

Hackworth valve gear, 13-13
hand pump, 5-5
heating surface, 15-5
hot well, 7-5, 8-5
hull
capacity, 1-6
design for efficiency, 14-5
speed, 1-6, 14-6
hull construction
carvel, 1-2
clinker, 1-2
GRP, 1-3
lapstrake, 1-2
metal, 1-5
plywood, 1-4
strip plank, 1-4
timber, 1-3
hull type
counter stern, 1-2
fantail, 1-2
hard chine, 1-3
transom stern, 1-2
hulls, **1-1**
hydraulic test, 10-10

impulse valve, 3-2
indicated power, 3-3, 14-1
indicator diagram, 14-2
injector, 5-5, 8-2, 8-6
insulation
ceramic fibre, 2-8, 6-1
glass fibre, 2-8, 6-2

Joy valve gear, 13-13

knots, 9-10

lagging. *See* insulation
pipe, 16-4
lathe tips
chatter, 16-3
interrupted cuts, 16-3
launching, 11-7
link, 13-1
lubricator
displacement, 3-8
gravity, 3-8
mechanical, 3-8
wick, 3-8, 16-9

make up valve, 8-6
Marshall valve gear, 13-13
metal hull construction, 1-5
mooring, 9-1, 9-2

obliquity, 13-3, 13-8
oil
fuel, 4-2, 4-9
lubrication, 2-9, 3-7, 7-5
separation, 7-5

paint, 16-4
passenger
regulations, 10-3
safety, 5-3, 6-1, 9-8
pipe bending
copper, 16-2
steel, 16-6
pipe lagging, 6-2, 16-4
pipework, 6-2
piston valve. *See* slide valve
planimeter, 14-3
plywood
hull construction, 1-4
polishing, 8-11
power
engine, 3-4, 15-3
indicated, 3-3, 14-1
shaft, 3-7, 12-4, 14-2
priming, 5-2
propane. *See* gas (LPG)

propeller, 12-1, 12-12
DAR, 12-3
pitch, 12-3, 12-4
shaft, 12-5
shaft couplings, 12-7
size, 12-3
slip, 12-4
propulsion, **12-1**
protector, water gauge, 5-1
puffing, 6-3
pump
air, 3-6, 8-3, 8-4
diaphragm, 8-4
extraction, 8-3, 8-4
piston, 8-1

radiation, 2-2
reamers, 16-4
Red Ensign, 9-4
regulator
gas (LPG), 4-11
steam, 6-2
relief valve, 5-2
rotation speed, propeller, 3-3
rudder, 12-10
Schilling, 12-11

safety, 6-2, 9-8
blowdown, 6-2
boilers, 6-2
emergency procedures, 7-8
firebox pressurisation, 6-3
passenger, 6-1, 9-8
pipework and fittings, 6-2
pipework and valves, 5-5, 5-6
safety valve exhaust, 6-3
trailers, 11-1
saturated steam, 2-9, 8-7
scale, 7-6
separator
oil, 7-5
steam, 6-3, 8-8
shaft power, 3-7, 12-4, 14-2
signals, 9-7
silver solder, 5-6, 6-2, 16-4
simpling valve, 3-2
siren, 8-10
skeg, 12-10
slide valve, 3-2, 13-1
slipway, 11-7
smoke, 4-7
smoke legislation, 4-6
Spanish windlass, 16-5
spares, 7-8
speed, 1-6
springs, mooring, 9-1
stainless steel, 16-6
brake cables, 11-6
firebars, 15-2
propeller shaft, 12-6
superheaters, 2-10
steam
cylinder oil, 3-8, 7-5
dryer, 8-7
oil. *See* cylinder oil
pressure, 3-3
separator, 8-8
temperature, 2-9
trap, 8-8
steam generator. *See* boiler types, tubular
steam plant installation, **6-1**
steam test, 10-11
stern gear, 12-10
stern gland, 1-9
stern tube, 1-9, 12-10
strip plank
hull construction, 1-4
stud driving, 16-7
superheater, 2-10, 8-7

taps, 16-7
tenderness, 1-6
thrust bearing, 6-1, 12-7, 12-8
toothed belt, 12-7
towing, 1-8, 9-5, **11-1**
trailer
couplings, 11-5
lighting, 11-3
tyre load limits, 11-2
weight braked, 11-2
weight unbraked, 11-1
trailers, 1-8, **11-1**
trimmings, 16-9

vacuum, 3-6
gauge, 5-3
pump. *See* pump, air

valve
blow down, 6-2
bypass, 8-2
check, 5-5
gas (LPG), 4-11
lubrication, 3-7
main steam, 6-2
safety, 5-2
types, 5-5
water gauge, 5-2
valve gear
radial, 13-13
Stephenson's, 13-1, 13-4
vapoursising burner, 4-10
varnishing, 16-8
vee belt, 12-7
warps, 9-1
water
feed water heater, 8-6
feedwater, 7-5
gauge, 5-1
hardness, 7-5
treatment, 7-1, 7-6
wheel bearings, 11-5
whistle, 8-10, 9-7
wicks, 16-9
winch cables, 11-7
Windermere kettle, 8-9
wood
fuel, 4-1, 7-8
hull construction, 1-3
woodscrews, lubrication, 16-9

The publication of this collective work coincides with the 40th year of the Steamboat Association of Great Britain.

This guide is a synthesis of knowledge and experience gathered over the years which is intended to assist members in building, running, and improving a steam powered boat. Steamboating is by nature highly individualistic, whilst also being highly cooperative and sociable. This guide is not intended to be restrictive or authoritarian, but to be a source of up to date and trustworthy guidance for good practice to help all members enjoy this stimulating interest.

www.steamboat.org.uk

SBA