Steamboat Design and Construction

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David was not only a prolific Model Engineer he was an accomplished machinist and engineer by profession. Among David`s models were his first, a Speedy, still in the Leeds club, A 3 ½" gauge LBSC Maisie and an L1. He built a 5" gauge Black 5 to Don Young design which achieved second place at a Leyland IMLEC. David experimented with gas firing for his 5" gauge Adams Radial Tank engine which he later converted to coal. His masterpiece is a BR Class 4 MT 2-6-4 tank engine in 5" gauge, it will never run as it was built to too fine a detail for operation of the controls to be practical. At 12 inch to the foot David substantially built a Caterham 7 car, at least 2 steam boats and fitted fibreglass hulls with steam plants to his own design, a 5/8 to one-foot steam lorry and a replica Stanley steam car. Sadly, he died on 10 January 2016 just after writing this article.

Model Engineer to Marine Engineer, Part 1

Have you have ever considered building a steamboat? If so, I hope that the following will demonstrate that a model engineer's workshop is capable of producing the necessary parts. My earliest recollection of small passenger carrying steamboats was in the 1970's. I was in London for the Model Engineer Exhibition also visiting the London Boat show where Bossom's had on display a 30 feet steam launch named Patricia. She was elegant with high gloss varnish and bronze fittings that sparkled under the exhibition lighting. An enquiry about the cost quickly cooled my enthusiasm. The interest lay dormant until an advertisement in a 1980 Model Engineer for an 18 feet hull stimulated immediate action. My Model Engineer was delivered on Saturday, I was in Norfolk on Sunday viewing the vessel! It was affordable and could be purchased in many forms from just the hull moulding to complete and ready to go. A hand shake and a signature on a contract before leaving to return home saw the beginning of a new commitment to steam on the water. The hull was going to be ready for collection in about 9 months' time. The intervening time was spent making the steam plant together with a trailer for transportation and launching. This was just the beginning of our ever-growing enthusiasm for the hobby. At this time, I did not know of any club supporting such activities but this was soon to change. I had previously built Speedy and a 5" Britannia was almost complete. My workshop facilities at this time were a Myford ML7 and a self-built Dore Westbury milling machine. It proved possible to produce the steam plant that is necessary for a small hull in a workshop with these facilities. The name chosen for the boat was SL Cherub which seemed appropriate for an elegant hull of 18 feet overall length and 4ft 6ins beam. (I had recently seen a popular Mozart opera hence the name). SL Cherub was to be the focal point of many waterway holidays in England, Ireland, Scotland and Wales for the next 18 years until she was displaced in favour of a Stanley Steam Car. The departure from steamboat ownership lasted for about 6 years but steam on the road can be very stressful and came to an end when being tail-gated by juggernauts became a nuisance. Another hull was ordered and the construction of boiler, engine, feed pump, stern tube and propeller shaft was underway yet again. The name for this new boat? What about SL Cherubino?

SL Cherubino is 16 ft long x 5ft 9ins beam and weighs on its trailer 1,800lbs (3/4 ton). She is seen (Photo 1) moored at Ambleside public jetty gently blowing off after a journey of 6 miles. She will carry 6 adult passengers on canals and rivers cruising at up to 5 miles per hour. Once again, the construction is a glass fibre hull decked and fitted out in varnished hardwood, a combination that gives robust longevity with minimal maintenance, subject to undercover storage. Prolonged exposure to the sun causes varnish deterioration and after the combination of rain and frost readily opens joints in woodwork. As before I purchased a hull and made the interesting components of boiler, engine feed pumps, stern tube, propeller shaft and all other mechanical fittings in a workshop now boasting a Super 7, VMC milling machine, a Boxford shaper and a Harrison M300 lathe. The M300 is not essential but does make some tasks easier. The choice of boat is made to suit your facilities, the scope is great from the small SL Minnow to the other extreme, SL Mosquito. Both are self-build projects, but the equipment and skills used in their construction is proportionate to their size and complexity. SL Minnow is 10 feet in length SL Mosquito 46 feet. To digress, SL Mosquito, shown above, coming into moorings is the ultimate in self-build fast steamboats, with an estimated 100 shaft horse power she has demonstrated her ability to keep pace with skiers before the Lake Windermere speed limit came into force. She was constructed by an accomplished engineer who made every part from drawings to completed vessel including patterns, castings, plate-work and woodwork. She must be considered the ultimate in self-build. I have been lucky to enjoy many happy hours on board SL Mosquito.

SL Mosqiuito

SL Minnow

Choosing a Vessel:

You must be asking; how does one decide on a suitable vessel and a suitable steam plant? In choosing the vessel the following must be considered:

- The ability of the towing vehicle to safely handle the all up weight of boat and trailer.
- The ability of the vehicle to competently launch and recover the boat on slipways.
- A place to store the boat on its trailer, ideally under cover if maintenance is to be kept to a minimum. Wood work can deteriorate very quickly if exposed to sunlight, rain and frosts.
- How many passengers do you wish to carry? t The cost of purchase, upkeep and use. When in use most waterways require you to have a licence for which charges are based on the size of vessel and duration on the water.
- Do you desire a vessel displaying Edwardian elegance or a fit for purpose workboat?
- Do you wish to construct the hull or purchase a glass reinforced moulding?
- Do you live on a hill, have a steeply sloping drive? Remember it may be necessary to manoeuvre the boat and trailer manually.

Model Engineer to Marine Engineer, Part 2

The Boiler

Most enthusiasts find the boiler and all the regulations relating to construction, safe maintenance and operation to be a major hurdle. It need not be difficult or onerous if the various stages are undertaken in the correct order. So many times, one hears of people having completed a boiler before even discussing the project with a boiler inspector. The majority of steamboats are coal fired others using central heating oil and a minority using propane. The latter categories have more onerous safety requirements to comply with water-way licensing regulations. I have constructed two boilers of the type shown right, this design is a three drum arrangement similar to the Yarrow with an upper large steam drum and two lower smaller mud drums. This basic pressure frame is a welded steel construction with helically wound copper steam generating tubes silver soldered into nozzles. A true Yarrow type is installed in SL Mosquito and is shown left, note the hairpin superheater located below the steam drum where it benefits from radiant heat. Boiler Construction But before you are put off by too many decisions let us get back to the interesting time spent in the workshop. Potential enthusiasts will see the boiler as a most daunting prospect, either expensive to buy or shrouded in bureaucracy for the home constructor. Boilers are satisfying to make and can offer a new challenge, I hope to convince you of this. First and foremost, obtain a boiler design that has been approved by a Competent Person, or produce your own drawing and have it approved. Next decide who will inspect your boiler during its construction and after when it is commissioned and put into service. When you have found a suitable boiler inspector contact him to discuss your intentions and ascertain what his requirements are.

My design was one of the many approved designs available through The Steam Boat Association (SBA). My inspector was happy for me to purchase certified materials in compliance with those specified on the design drawings. Where formal certification was either expensive or not readily available the inspector was prepared to accept invoices which detailed the standard of the material. It was profitable to shop around, prices varied considerably and my order was comparatively small. It was easy to obtain 6 metre lengths of tube but ½ metre was often attracting extremely high cutting costs. As previously mentioned, my choice was a boiler with a Yarrow configuration but using copper coils instead of straight tube. Left shows the steel pressure vessel before the copper coils were added. Right shows the copper coils that are silver soldered into the nozzles of the top drum and directly into the bottom headers. The steel pressure vessel utilises readily available butt weld fittings complying with British Standard No. 1640 or BS1965 requirements. No doubt these standards have been replaced by Euro Norms but suppliers still recognise British Standard references. Left shows how a reducing tee is used to provide a dome and an excellent access port for the boiler inspector. My Myford Super 7 was used to make weld preparations and bore the holes necessary for nozzles and other fittings. Right shows an end cap being prepared to accept a downcomer tube. The steel pressure vessel was jigged with appropriate weld gaps onto a stout wooden board.

Wooden spacers were used between the bottom drums with steel ties, to hold the assembly ready for welding. I was permitted to use tack welds to help hold things together on the understanding that the qualified welder would totally remove them. Unless your welding competence is to the required standard you will require the services of someone acceptable to your inspector. I have spent a career working in power station maintenance where competent welders were readily available for private work. I recognise that

welders may not be so readily accessible to all and to overcome this difficulty designs are available that require no welding whatsoever. An interesting and satisfying task was winding the copper coils, this was achieved using my Harrison M300 lathe, the Myford has neither sufficient centre height or robustness. The coils are ½" o.d. x 18swg wall thickness and are wound left hand and right hand with a helical lead of 11/8" to permit intertwining as seen above. With copper prices being high it was considered sensible to adopt a winding method that would prevent both damage and distortion to the tube. Left shows the arrangement where a shaped roller follows the he-lix in the hard wood former. Most lathes will not cut a helix with such a coarse pitch and to produce the formers it was necessary to remove the leadscrew drive gears and to fit a chain drive. A router or other wood cutting tool is mounted on the tool post and the helix cut in the same way that one would cut a screw thread. I readily accept that a large lathe is required for the above process and if this is not available at home or the club workshop a fellow club member may be interested in the challenge. Alternatively consider a design where tubes are formed using a bench mounted pipe bender. The finished pressure vessel is shown right, the coils having been silver soldered into the headers using EasyFlo 2. An economiser coil is shown formed around the top of the steam drum, this takes advantage of waste heat in the flue gas to heat feed water before it enters the bottom headers. At this stage my boiler inspector required a hydraulic test, all outlets were plugged and twice design pressure was applied for 30 minutes. With this satisfactorily completed the boiler casing could be completed as seen above. Do not under estimate the work content required to make a gas tight casing. You may not like a painted sheet steel finish and choose a wooden exterior more in keeping with Edwardian elegance, the choice is yours. Boiler Types A water tube

boiler giving a large heating surface within a small footprint is the Odfeldt or Lune Valley type. The construction principles are very similar to those adopted for the Black-staff type described above. The copper coils are formed and silver soldered into a steel core. The whole is then encased to give a vertical cylindrical boiler. Left shows the complete pressure vessel undergoing a hydraulic test at 300 lb/ins 2 this being twice design pressure. The vertical steel column seen in the foreground accommodates the water level gauge. This arrangement requires all external connections be they steam or water to be made via the top flange. Any connections made at the bottom of the steel cylinder would be exposed to continuous radiant and convective heat and would require continuous cooling to prevent them burning out. An intermittent feed from, say, an injector or pump would not provide the necessary cooling and the tube would eventually fail. The boiler is a very rapid steamer and more suited to oil firing applications where the heat source can be regulated quickly. Firetube boilers provide more leisurely management due to their large internal volume when compared with water tube types, but are much heavier. They are much easier to clad with insulation and finish with attractive timber. Water tube boilers often require a separate frame or crinoline to hold the insulation and onto which a metal cladding is secured. Right shows a typical vertical fire tube boiler suitable for a launch of up to 18ft in length. A locomotive type boiler is often used where side firing optimises the best use of hull accommodation.

Left shows an example of this type being readied for testing. For the very ambitious why not try a monotube steam generator, I made one for a road vehicle with satisfying success. The leisurely pace of a steamboat makes the all-essential balance of steam take off, water feed and firing much more easily achievable. No traffic lights or hills to contend with on the water. Photo 11 shows my arrangement but I would not recommend a monotube for your first steamboat, although a number of successful examples do exist a vertical fire tube type would be my recommendation.

Model Engineer to Marine Engineer, Part 3

The Engine

Many model engineers that have built locomotives or traction engines will find the construction of a steam launch engine and auxiliary components relatively straightforward.

Again there are decisions to be made:

* Single cylinder or multi cylinder.
* Simple or compound expansion.
* Type of valve gear to be used.
* Direct coupling to propeller shaft or indirect via chain or belt.
* Will the engine exhaust up the funnel or into a condenser.

You will see that the complexity of the steam plant is increasing but totally satisfactory results may be obtained with a simple engine exhausting up the funnel, again as in locomotives and traction engines. In this application boiler feed water is either carried on board or drawn from the river or canal. The downside of exhausting up the funnel is the irritation caused by the noise it can produce, steamboats tend towards a quite tranquillity except for that annoying and elusive engine knock!

If the condensate is reused the oil must be removed to prevent internal contamination of the boiler, this is usually achieved in the hot well with baffles and oil absorbing materials. This closed cycle is essential if you intend steaming on dirty canal water or on sea water, the alternative is to carry on board an adequate supply of fresh water.

I operate a simple total loss system by exhausting the steam into a keel condenser which overcomes this noise problem but requires removal of the oil before discharging to the waterway.

My choice for both SL Cherub and SL Cherubino was for a simple robust single cylinder engine. My very first engine was a Stuart Turner 5a but this rapidly developed knocks and rattles. The lesson here was that the 5a is a large model and not a small workhorse. Bearing proportions are minimal particularly the small end, a component that is also unlikely to receive adequate lubrication. The steamboat engine is called upon to work at full power for many hours unlike many model locomotives and traction engines.

My choice has been to build single cylinder engines because of their simplicity and for my hull size adequate power was readily attainable. Castings were purchased for a 2½" x 2½" which has a three bearing bedplate that is shown being line bored in photo 1, below. The finished engine is shown in photo 2, ready for painting.

Photo 1 above, Photo 2 right