The Construction and Working of Belleville Boilers

A. E. Tompkins Engineer, R.N.

To cite this article: A. E. Tompkins Engineer, R.N. (1897) The Construction and Working of Belleville Boilers, Royal United Services Institution. Journal, 41:230, 490-496, DOI: [10.1080/03071849709416018](https://doi.org/10.1080/03071849709416018)

To link to this article: <http://dx.doi.org/10.1080/03071849709416018>

Published online: 11 Sep 2009.

Submit your article to this journal [↗](#)

Article views: 4

View related articles [↗](#)

THE CONSTRUCTION AND WORKING OF BELLEVILLE BOILERS.

By A. E. TOMPKINS, Engineer, R.N.

Belleville Boiler.—This boiler is built up of many tubes of about $4\frac{1}{2}$ inches in diameter, and about 7 feet long. The tubes are arranged in groups called the *elements*, each boiler is composed of seven or eight elements, and each element contains eighteen or twenty tubes. From the sketch (Fig. 1) it will be seen that, commencing from the lowest junction box *Z*, the tubes are inclined upwards by raising opposite ends alternately. The junctions are formed at the ends of each two tubes, one of which is inclined downwards to the junction box below, and the other upwards to the junction box above. The lowest tube in each element is connected to the *feed collector G*, and the uppermost to the steam chest *V* by a pipe *P*.

After filling the boiler to the working level shown, fires may be lighted. The steam and water then rise through the generating tubes until finally ejected into the steam chest *V*. From here the steam escapes through the steam valve or safety valves, and the water falls into the bottom of the chamber and mixes with the feed water pumped in by the feed pumps. This water then flows downwards by the downcomers *U* to the sediment chamber. The upper part of the sediment chamber is connected to the feed collector *G*, so that a continuous flow of water is supplied to the generating tubes. The boiler is surrounded by a casing of thin sheet-iron and asbestos. At the front of the boiler there are two large doors which, when open, expose all the front junction boxes and fittings; these doors correspond to the smoke-box doors of the ordinary shell, or marine, boiler. Immediately below these doors are the furnace doors, generally four in number, and below these again are the draught doors leading to the ash-pits. The fires are forced to a small extent by introducing jets of air from just above the furnace doors on to the top of the fire. Special air compressing pumps are supplied for this purpose; the pressure in the jets is about 30 lbs. per square inch.

The Belleville boiler differs from nearly all other water-tube boilers in four important respects. 1. It has straight tubes of equal length and

diameter. 2. Each tube can expand or contract almost independently of any other part of the boiler. 3. The flames strike the heating surfaces almost at right angles, and this should give the best results, as it is most favourable to the generation of steam. 4. Each tube can be examined internally by removing the small door in the junction box opposite the end of the tube.

In addition to these advantages, there are others of a practical character which affect its working in a satisfactory manner. The "circulation" of the water in the boiler is continuous, and constant in direction, this leaves the least deposit of scale; any loose scale or mud will generally find its way into the sediment chambers, and from there can be blown out by the valve *S*. Nearly the whole of the floor space occupied by the boiler can be used as grate surface. Its weight is not much below that of the ordinary marine boiler, but the advantage is greater than would otherwise appear, if it be noted that in the Belleville only natural draught ($\frac{1}{2}$ inch air pressure) is required to produce greater power per unit of weight, compared to the forced draught (2 inches air pressure) of the ordinary boiler.

The weight of an eight-element boiler without mountings or water is about $14\frac{1}{2}$ tons, the weight of water at working height is about $1\frac{1}{2}$ tons, giving a total of $15\frac{3}{4}$ tons when working. From 550 to 600 I.H.P. may be obtained from this boiler when burning 20 lbs. of coal per square foot of grate: a very low rate of combustion, and which can be easily obtained by good stoking without forced draught.

Automatic Feed Regulator.—This is probably the most important factor in the successful practical working of the boiler. In Fig. 1, a sectional elevation of the apparatus is shown in connection with a side view or elevation of the boiler, thus showing the relative position of the various parts.

Standing out a little from the front, and generally a little to the right or left, is the *automatic feed regulator*, which consists of a cast steel chamber, in which a float *M* can move either up or down. The upper part of this chamber is connected by a pipe *J*, led up to the height shown and down to a junction box of the nearest element; the junction box generally selected for the connection is the fourth from the top of the element. The bottom of the chamber is connected by the pipe *R* generally to the lowest junction box *Z*, but sometimes to the *feed collector G* or to the upper part of the sediment chamber. By these two pipe connections *R* and *J* a water level is obtained in the float chamber corresponding with that in the boiler. Consequently any alteration in this water level will operate on the float *M*. This float is fitted with a guide rod which works in a bracket *T*. The float is also connected by a vertical rod *EM* to the lever *EFH*, which has its fulcrum at *F*; consequently any movement of the float operates on the rod *BH*, and by it on another lever *ABCDX* exterior to the chamber. The lever *ABCDX* has its fulcrum at *C*. A rod *DK* works the feed valve *K*. At *A* a small adjusting spring *a* and weights *W* and *A* are placed; these are used for any small adjustment of the proper working equilibrium of the float and

levers. By adding weights it will be seen that the float may be allowed to rise more easily; while by removing them there is a greater tendency for it to fall.

Suppose the water level to be falling in the boiler, then the float *M* will fall with it; by means of the interior lever *EFH* the rod *BH* will rise and produce a fall in the rod *DK*, thus opening the valve *K*; this will admit the feed water from the pipe *N* into the pipe *O* and through this and the non-return valve *P* into the steam chest *V*.

A pressure considerably in excess of the working boiler pressure (nearly double) is maintained in the pipe *N* by the feed-pumps. The quantity of feed water can be regulated by the valve *L*, which for convenience is usually fixed to the sediment chamber, but has no internal connection with it. From the lower part of the steam chest the water finds its way by the downcomers *U* (one of which is fitted at each end of the steam chest) to the sediment chamber; the upper part of which is connected to the feed collector *G*.

A water-gauge glass *QQ* and test cocks are generally fitted on the float chamber, which acts as a steady pipe for this purpose. Another gauge glass is fitted to a steady pipe at the other side of the boiler, the upper and lower parts being connected by pipes in a similar way to that in which the float chamber is connected to the boiler.

The lever *EFH* is pivoted on knife edges at *F* and is fitted with a roller bearing at *H*. All the packing glands of the lever rods are of special construction and are generally packed with graphite packing. The valve *K* can be examined by removing the screwed cap at the bottom of the valve box. At *X* a rod is fitted so that the valve and lever can be worked by hand from the stokehold platform.

Steam Chest or Separator.—The extremely small amount of water contained in water-tube boilers, compared with the enormous rate of evaporation, necessitates special means for separating the steam from the water from which it is formed, so as to prevent the latter finding its way with the steam into the engines. It might be mentioned here that the great gain in power per unit of weight of water-tube over the ordinary flame-tube boilers, is in a great degree due to this comparatively small weight of water contained at working height. In the Belleville boiler this gain is not so great as in some others, the Thornycroft for example; but, on the other hand, the power is obtained with a lower rate of combustion per square foot of grate surface. In Fig. 2, *P* is the junction of an element to the steam chest *V*. When the boiler is at work, steam and water are ejected upwards from the generating tubes (or elements) and impinge on a series of dash plates with serrated edges, following the course of the arrow heads through slits or small holes in the plates, until finally the steam passes through small holes (one of nine-sixteenths of an inch in diameter for each element) into a steam-tight chamber. The steam pipe leading to the reducing valve, and from thence to the engines, is connected by the usual steam valve to this chamber. The water separated from the steam by the *dash plates* flows down into the bottom of the steam chest, and

mixes with the feed water from the automatic feed regulator on its way through the downcomers at each end of the steam chest to the sediment chamber and feed collector. From the sediment chamber and feed collector it circulates again through the generating tubes.

Where the junction of the element to the steam chest is fitted, a doubling plate is riveted inside the steam chest. Near the bottom of the steam chest towards the front are two or three small oval doors, which can be easily removed for cleaning and temporary examination of the interior. At each end in some instances, and at only one in others, a flanged joint is fitted, so that by removing the steam chest from its position on the boiler, and taking off the cover, a thorough examination or refit of the interior parts can be made. The connection for the downcomer is generally cast on this cover. If there is only one cover, a small oval door is fitted at the opposite end above the downcomer (see Fig. 1).

Junction Box.—Fig. 3 shows a horizontal section and front elevation of the ordinary junction box at the front end of the tubes. In the Belleville boiler it will be noticed that the usual English practice, of expanding the tube ends by rollers to make the joints steam-tight, is not carried out, but that screwed joints are generally employed. The junction box varies slightly in form and shape as made by different firms, but the principle is the same in all. There are two spigot pieces cast on it, which are screwed internally with a slightly different pitch of thread to that on the ferrules and sleeve pieces; the slight difference of pitch secures a tight joint. The sleeve pieces are made tight at each end by graphite joints and a nut at the outer end. A blunt chisel or set is used for hardening up the nuts and sleeve pieces where space does not allow of gas-tongs being used. Opposite the end of each tube is a small clearing hole fitted with an oval door secured by a single bolt and nut through a bridge piece. This door is surface jointed.

The junction box at the back end is very similar as regards the securing of the tubes, but the sleeve piece and ferrule are omitted and the tube is screwed directly into the junction box. No clearing holes are fitted at the back end. Lugs are cast top and bottom of each junction box to carry the weight of the tubes above. The lugs are side-slotted from front to back so that each junction box can move in the direction of the expansion of the tubes, independently of those next it. The front junction boxes in one row, generally the second from the top, are fitted with a fusible plug, so that warning may be given and fires put out in case of any stagnation in the circulation and consequent overheating of an element.

Special junction boxes are required for the top and bottom connections at the front end. The top box is secured to the vertical tube *V*, leading to the steam chest by a square flanged joint with four bolts and nuts.

The bottom connection shown in Fig. 4 is a sectional side elevation of the connection with the feed collector. A horizontal section of the bottom junction box is very similar to that shown in Fig. 3, one of the differences being that one clearing door is omitted and a screwed

plug substituted opposite the part where no tube is connected, there being only one tube connected to each *front* bottom junction box. The lower water connections of the steady pipe and float chamber are generally made at this point. The lower part of the junction box has a conical hole drilled in it vertically which fits over a corresponding steel plug with a nickel ferrule facing for making the joint. This plug is screwed into the top of the feed collector, and forms the connection between it and the generating tubes. In front of the bottom junction box a lug is cast, so that it is secured by means of a T-headed bolt to an angle iron bolted on to the front of the feed collectors.

The feed collector has three or five clearing holes and doors fitted of a similar size and shape as those fitted to the junction boxes. At each end the feed collector is connected by a cast steel pipe to the upper part of the sediment chamber.

When two downcomers are fitted, there is a possibility of the water circulating unevenly; and to assist in dividing the circulation evenly, a flap valve is fitted in the top of each sedimental chamber to control the flow of water into the feed collector.

Reducing Valve.—To reduce priming and the chances of its occurring, it is found advisable to fit a reducing valve in conjunction with Belleville boilers. The valve may be fitted at any place in the steam pipe, either at the boiler or at the engine. The latter has been adopted generally for naval boilers and a large reducing valve is now found in each engine-room. The effect of reducing the pressure of the steam is to produce a better quality of steam, as by lowering the pressure (and temperature), a certain amount of heat is set free which converts some of the particles of water in suspension into steam. It also partly counteracts any condensation which may take place through imperfectly lagged steam pipes. If the steam generated by the boiler were dry *saturated* steam, the effect of reducing the pressure would be to *superheat* the steam; within moderate limits this is not a probable effect, as nearly all *common* steam contains some priming water or particles of water in suspension.

A sectional elevation of a reducing valve is shown in Fig. 5. There is a cylindrical gridiron valve *A*, which has ports cut in planes at right angles to the axis and extending about two-thirds of the circumference. This valve is open at the bottom end and partially closed at the top, a few holes only being drilled to allow the reduced pressure access to the space above the valve. These holes are $\frac{5}{8}$ inch in diameter. The valve *A* is connected by two loose pin joints to a spindle *B*, which is connected to the lever *CDE* at *C*; this lever has its fulcrum at *E*. Similar ports are cut in a cylindrical valve face *G* which surrounds the valve, and which is secured into the valve chest *V* in a similar manner to that of the liner of a cylindrical slide valve into the slide casing. The lever *CDE* has a cross beam at *D*, poised on knife-edges, to which are attached frames containing several springs; the lower part of the frame is attached by a similar cross beam *H* to a square threaded adjusting screw *L* which passes through the boss of a wheel *M* working in a bracket on the bottom cover *N* of the valve chest. By means of the wheel *M* the tension of

the springs can be adjusted. The end *E* of the lever *CDE* is connected to a support on the valve chest by a rod *EF*.

In the figure the valve is shown *open*, the ports of the valve being opposite those in the valve face. Steam enters from the steam pipe as indicated, and finds its way through the ports into the interior of the valve, impinging on the cast-iron *dash column* as it does so.

The valve is in equilibrium when the tension on the springs is balanced by the upward pressure on the valve. The difference in the area acted on by the reduced steam pressure, above and below the valve, is the area of the spindle *B*, the upper part of which is open to the atmosphere. From this it will be seen that if the pressure exceeds that for which the springs are adjusted, the valve will rise, and consequently tend to close itself. By careful adjustment, when the flow of steam is fairly constant through the valve there is very slight movement or oscillation. As there are no packing rings round the valve, there is a small leakage at all times, and particularly when the engines are stopped; consequently, it is convenient to have a small safety valve on the *reduced* steam pipe to take away any excess of pressure over that required. A small drain pipe connected to an automatic steam drain trap is also generally fitted to take away any water from the lower part of the steam chest.

By adding more springs to the frame, or by using the adjusting screw to put on more tension in the springs, the reduced pressure would be increased; and *vice versa*.

Economisers.—In conjunction with new naval boilers, economisers, a type of feed heater, are to be fitted. They consist of sets of tubes, placed in the uptakes to the funnel, through which the feed water passes on its way to the boiler. This is a method of utilising some of the heat which would otherwise be wasted up the funnel. They are still in their infancy, but their utility is so evident that an economy of 20 per cent gained by their application would not be astonishing. The uptake is the natural position for a feed heater theoretically, and any practical or mechanical objections should soon be overcome. The arrangement of the tubes and junction boxes of the Belleville economiser is very similar to the boiler, but, of course, smaller.

The Belleville boiler (without economiser) has up to the present shown no particular economy of coal over the ordinary boiler; this is due principally to inexperienced stoking. After the stokers have become accustomed to the large furnaces, enormous economy is gained. I have been constantly reminded of this during the past two years in training stokers with Thornycroft boilers, the facilities for stoking which are very similar to those in the Belleville. After a few days' practice, the same men have been able to obtain nearly double the H.P. with the same speed of fan and air pressure; this is, of course, more noticeable at moderate powers; at very high powers for short periods it is not so remarkable, but is still evident. The Belleville boiler is a very easy boiler to fire indifferently, but experience is absolutely necessary for economy.

Apart from all considerations of space, weight, and economy, it is in all its essential points an engineer's boiler, as it meets his requirement for facility of examination of all parts, both internally and externally. The comparatively moderate rate of combustion also appeals to the seagoing engineer, as he knows that he can get within reasonable limits of the maximum power for as long as required, and also with safety. As further experience is gained, better results will be obtained, and further improvements will be made, and eventually economy must follow.