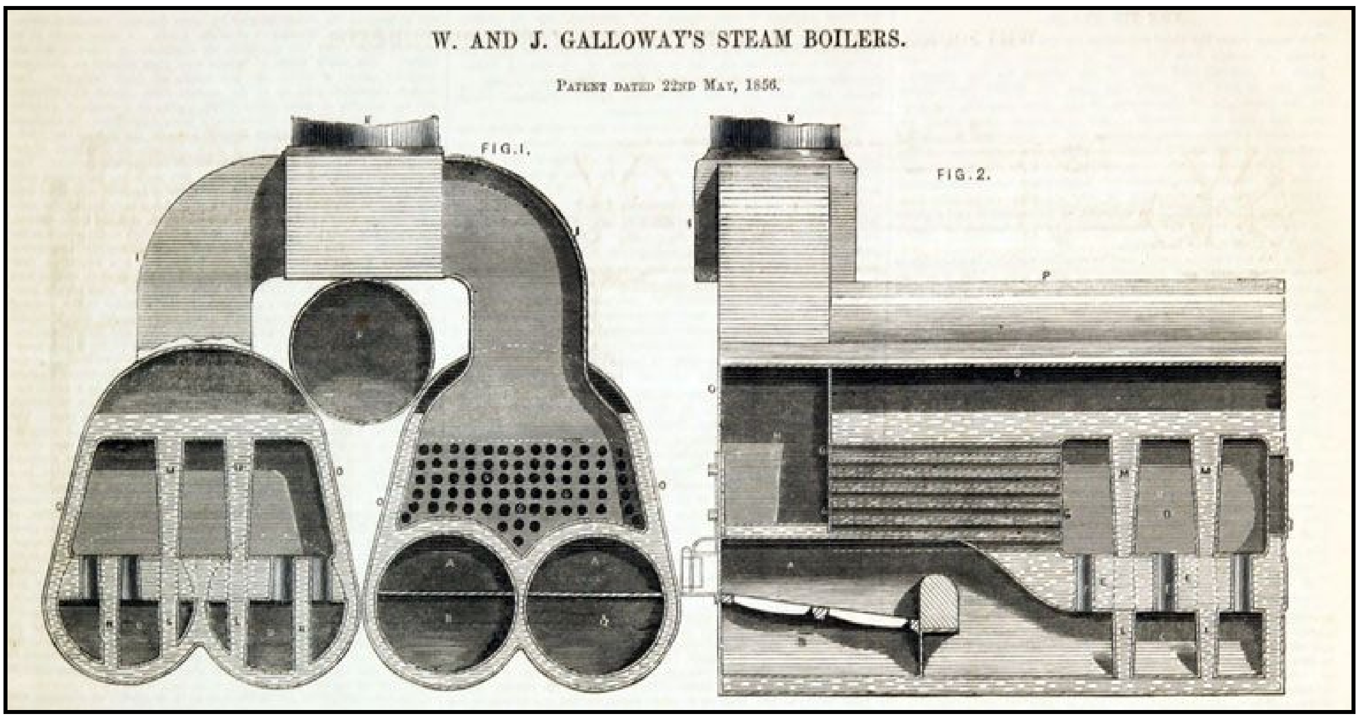
& J Galloway & Sons



TEXTBOOK BOILER ENGINEERING

THE

MODERN PRACTICE

OF

BOILER ENGINEERING,

CONTAINING OBSERVATIONS ON THE

CONSTRUCTION OF STEAM BOILERS;

AND UPON FURNACES USED FOR

SMOKE PREVENTION,

WITH A CHAPTER ON EXPLOSIONS.

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REVISED, WITH THE ADDITION OF NOTES, AND AN INTRODUCTION

BY JOHN BOURNE, ESQ.

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1856.

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I use the term "conical," rather than "patent," in the designation of this boiler, because the patentees have other patent boilers, also with vertical tubes, which tubes are not all conical, being partly "fire tubes" or, strictly speaking, small tubular flues, on the principle of the locomotive; and also to distinguish it in its most prominent feature, in relation to strength and durability, from the boilers of the American steamers "Pacific" and "Baltic," Collins's line. The great and most important point of difference between the American and English boiler is, that in the former, the large internal fire-flue, or flame-chamber is occupied by a great number of *parallel* tubes, about 2 inches diameter, and 5 feet long, placed vertically, and connecting the upper and lower portions of the water chamber. Through these tubes the water, of course, circulates very rapidly, and there can be no doubt this arrangement forms a most effectual means of warming a large quantity of water in a short time, and with great economy. Whereas in the Galloway boiler, the space behind the furnace is occupied by a smaller number of *taper*, or conical tubes of 5 or 6 inches in diameter at the lower, and nearly double that diameter at their upper ends; consequently requiring more space in length of boiler, though less in depth, than the American plan, for the same quantity of heating surface.

In a pamphlet written by Captain Ramsay, R.N., published in 1851, entitled, "Remarks on some of the causes that retard the progress of our Steam Navy," several good observations are made in illustration of the necessity of using much higher steam than previously, in ships of war, and the difficulty in attaining that object with the ordinary construction of marine boiler, as well as on the ill-adaptation of that boiler with small tubes to the proper combustion of bituminous coal or other flaming fuel. In discussing this subject, Page 58, Captain Ramsay remarks,—

"The strongest form of boiler which we are acquainted with is one invented by Messrs. J. and W.

Galloway of Manchester, and which, we believe, might, with modifications, be adapted to marine purposes. The peculiar principle of this boiler is the series of short vertical tubes which act as stays. The only objection to which these boilers are liable, as marine boilers, would be, that using *water* tubes, there is a liability to prime; but we would meet that objection by making the upper part of the tubes very large in proportion to the lower parts."

Now this last suggestion is a very important one, and had been previously made by the present writer, not with a view to prevent priming, solely, but also for insuring a more effective action of the flame against the sides of the tubes, as well as to prevent their being injured by overheating and burning out at their upper ends. In fact, I professionally advised the inventors, on being consulted by them, previously to taking out their patent for this water-tube boiler, in 1850, to adopt that course. This advice they followed, and have continued to pursue, with very great success ever since. Messrs. Galloway having supplied several 50 horse boilers, for the Gutta Percha Company's Works, City Road, and to several other factories in London, during that and the following year.

One of those boilers, erected under my superintendence, at the City Road Works is described and figured in my "Rudimentary Treatise on Steam Boilers." In that work it was stated that this boiler was capable of evaporating a cubic foot of water per minute, with only about 6 lbs. of bituminous coal per hour, not of the best quality, while driving a 30-horse non-condensing engine indicating 50-H.P., besides supplying steam for other purposes. This great, if not unprecedented, degree of economy has been doubted by some persons who have in vain tried to evaporate a cubic foot of water by less than 8 or 9 lbs. under the same circumstances: that is, *while driving an engine at full work*, which is a very different thing to the kind of evaporating experiments some time ago carried on by order of Government, and published in sundry Reports to Parliament on coals suited to the steam navy. These Reports are merely an account of the results of certain laboratory experiments, and, however valuable as scientific facts such investigations may be, it must be said that the labours of the eminent men engaged have been of little use in improving or illustrating the actual practice of engineers. The highest result obtained in these experiments was, 10·21 lbs. of water evaporated from 212° for each lb. of the best Welsh coal. (Ebbw Vale.) This result was obtained with a Cornish boiler. With a Galloway boiler, however, when new, with thinner tubes, that is, ¼ inch instead of five-sixteenths, and welded up the side instead of being rivetted, I have, occasionally, obtained a larger performance than that given in the statement referred to. The result of the experiment in question was, that eleven and one-tenth pounds of water was evaporated by each lb. of coal consumed of an inferior kind called *East Adair's main*. The pressure of the steam was carefully kept up during the experiment, (nearly 2 hours,) at exactly 40 lbs. per square inch, the engine doing its ordinary work, except that the feed pump was stopped off, and, consequently, no feed-water was going into the boiler, which enabled me to measure very accurately the fall of the water-level in the glass water-gauge; and, knowing the exact internal dimensions of the boiler, the quantity of water boiled away was thus clearly ascertained with sufficient exactness for a short experiment: at any rate, the result was as near the truth as the quantity of coal used could be measured, considering that the quantity of fuel on the bars had to be *estimated*, to be equal at the beginning and the end of that the Exhibition was open. And, although only one of *nine* boilers of about equal power used for the purpose, it supplied as nearly as could be estimated, about one *third* of the whole of the steam used in that building. To young engineers, who usually take theory before practice, it may be as well to state that my reasons, when consulted on the subject, for fixing on 6 feet as the most fitting diameter for this Exhibition Boiler, were, in the first place, that with that diameter, according to the rules already given by me, a $\frac{3}{8}$ inch plate is of ample strength for a working pressure of 40 lbs. per square inch; that being the steam pressure recommended by Sir W. Cubitt, and the other Commissioners, not to be exceeded, and from whom I obtained at last, with some little perseverance, their consent to *exhibit* this boiler, a difficulty created through some mistake, by which four boilers of a different kind had been previously ordered. It was then erroneously supposed that those 4 boilers which were of the multitubular class, though without fire boxes, blast pipes, or large chimney for draught, would have furnished an ample supply of steam for all the purposes of the exhibition; but in this power, as the event proved, they were utterly deficient, not producing even half the quantity of steam required, so that this

Galloway Boiler was considered only as a supernumerary one—a circumstance which gave a very instructive lesson to the railway and other engineers who had the principal share in managing the preparations for working the machinery on that occasion; and the result was that *four additional boilers* had to be supplied in great haste by the same contractor, making in all eight of the multitubular variety, and one Galloway Boiler, before an adequate supply of steam was obtained. Although had the architectural and decorative portion of the Commissioners consented to the erection of a brick chimney, which would have been quite in keeping with the engineering and scientific object of the Exhibition, instead of *nine* boilers, any *three* of them would have been sufficient, besides giving an excellent opportunity of exhibiting a variety of smoke-burning inventions which were thereby virtually ignored. As it was, there was a petty exhibition of locomotive chimneys, a few feet in height—with one exception, the funnel of a marine boiler, only 20 feet high, which in spite of some opposition I succeeded in having erected to the Galloway Boiler we are now describing.

The pressure of the steam being limited to 40 lbs. per square inch, a $\frac{3}{8}$-inch plate will only have a tensile strain upon it of something less than 4000 lbs. per square inch, sectional area of the iron. The formula for the strength of boilers which I usually employ is, $p=\frac{2\,st}{d}$ where s is the strain which, in this case=4000 lbs., t=the thickness of the metal in inches,=·375 or $\frac{3}{8}$, and d=the diameter of the boiler, 72 inches, or,

$$p=\frac{2\times 4000\times {\cdot}375}{72}=41{\cdot}6 \text{ lbs.}$$

will be the pressure of the steam allowable with these dimensions; and I have no doubt whatever that double that pressure might have been put on with perfect safety, so far as the tensile strain on the circular portion of the boiler is concerned.

Another reason for the particular dimensions of this boiler was, that, besides knowing well what a $\frac{3}{8}$ plate will bear, it is so very much used that the proper thickness for securing the best workmanship can readily be obtained.

There needs, perhaps, no excuse for having made this boiler "stronger than strong enough," seeing that it was to be erected in the close vicinity of so many thousands of persons, daily assembled in the Exhibition building, which was, of itself, a matter of no little responsibility, for it was considered good policy not only to be perfectly safe, but also to enable the general public to feel themselves safe, by an assurance of a surplus of strength so far beyond any possible requirements.

For ordinary commercial purposes, however, where people generally know what they are about, as well as for warlike and other government purposes, where they *ought* to know, if any where, this very inordinate precaution is out of place. And although I have, both by precept and example, recommended, in common with many other engineers, 4000 lbs. for "best" Staffordshire, and 5000 lbs. per square inch strain for Yorkshire iron, as a safe rule to be adhered to by boiler-makers; I am now inclined to modify that opinion. By fixing too low a standard for strength of iron structures generally, the result has been to induce the manufacture of very inferior and low-priced qualities of iron, which are substituted for the best in many situations where detection of the inferior quality is difficult; and, so long as such inferior qualities reached the low standard required for the best, at a much higher price, an inducement is gradually being created among boiler-makers to believe that, in many instances it is only "the *name* water, besides using the ordinary surface "blow off," and other similar appliances,* we would make all the plates one-sixteenth inch thicker throughout. If required to work nearly or quite up to the maximum pressure of 100 lbs., then all the parts admitting of it should be double riveted, and the rest *welded.*

THE EXHIBITION BOILER OF 1851.

In recommending that the diameter of a high pressure Galloway Boiler should be about 6 feet, it is not without due consideration, and considerable experience of various precedents that I offer this recommendation. One such boiler may now be referred to, belonging to the West-Ham Gutta Percha Co. of West Street, Smithfield, by whom it was bought of the Commissioners of the Hyde Park Exhibition of 1851, where it had been worked during the 6 months

STEAM-BOILERS

THEIR THEORY AND DESIGN

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separating surface and to prevent priming. The tubes should be always arranged in vertical and horizontal rows, and not be

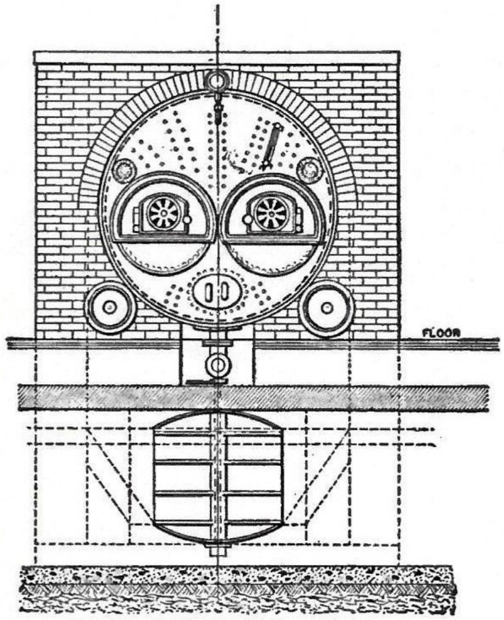

FIG. 19*a*.—Section of Galloway Boiler, Fig. 19.

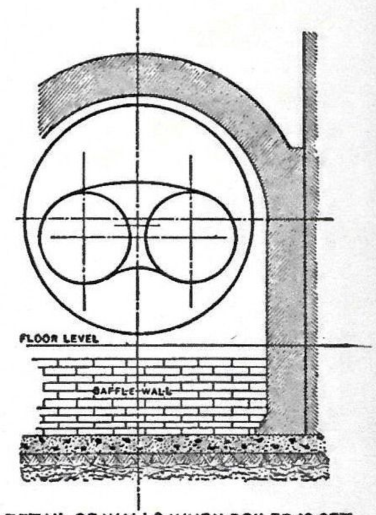

FIG. 19*b*.—Section of Galloway Boiler, Fig. 19.

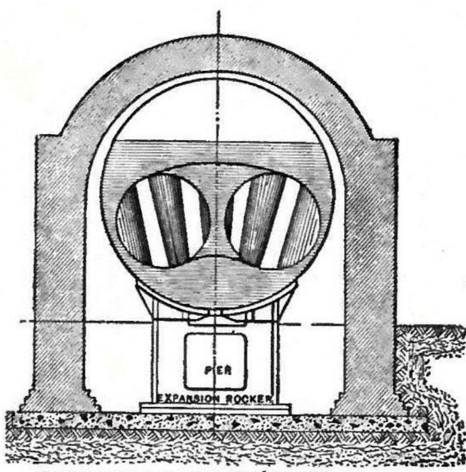

FIG. 19*c*.—Section of Galloway Boiler, Fig. 19.

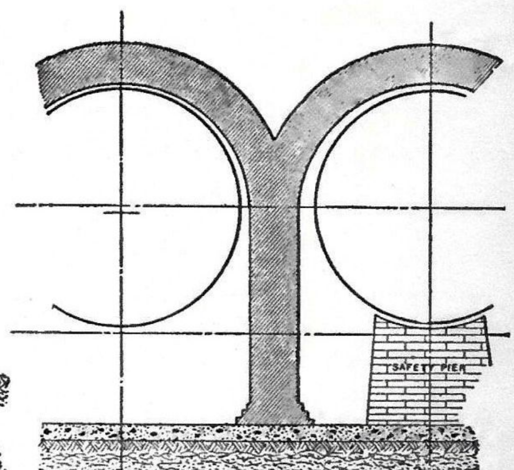

FIG. 19*d*.—Section of Galloway Boiler, Fig. 19.

staggered. The horizontal spacing is generally made wider than the vertical, to facilitate the rising currents carrying the steam-

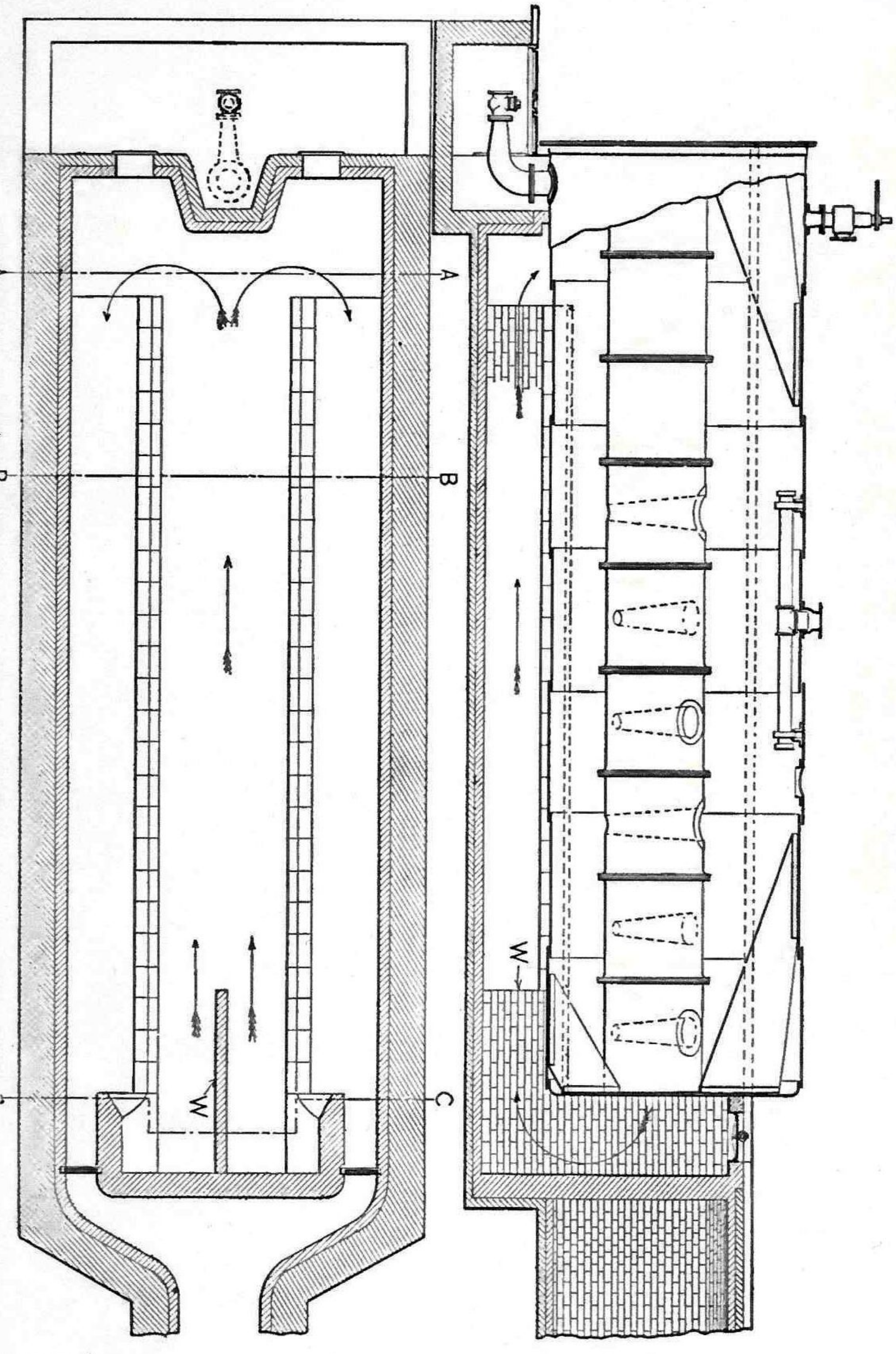

Fig. 20.—Lancashire Boiler with Galloway Tubes, seated in the type of brick setting most used. For Galloway and Cornish boilers the division wall "W" is omitted.