

these boilers, those upon which they were designed, and which experience has established to be true, are—

1st. That marine boilers, judiciously made, will last, without material repairs, for ten years. The whole interior parts of these boilers, even those exposed to the greatest heat, having during that period, undergone no repair. A portion of the outer case of the steam chest, and a part of the outside case, at the bottom, where it was exposed to the action of the bilge-water, or was inaccessible to paint, were alone decayed and had been once repaired.

2nd. That it is better to have the greater heat near the top, than at the bottom of the water.

3rd. That it is most important to durability to have higher furnaces, or fire-boxes, than are generally used.

4th. That boilers, properly formed, may be so effectively kept clean by ordinary blowing apparatus, that during ten years constant work no damage will accrue from incrustation.

The Paper is illustrated by a diagram exhibiting the construction of the boilers.

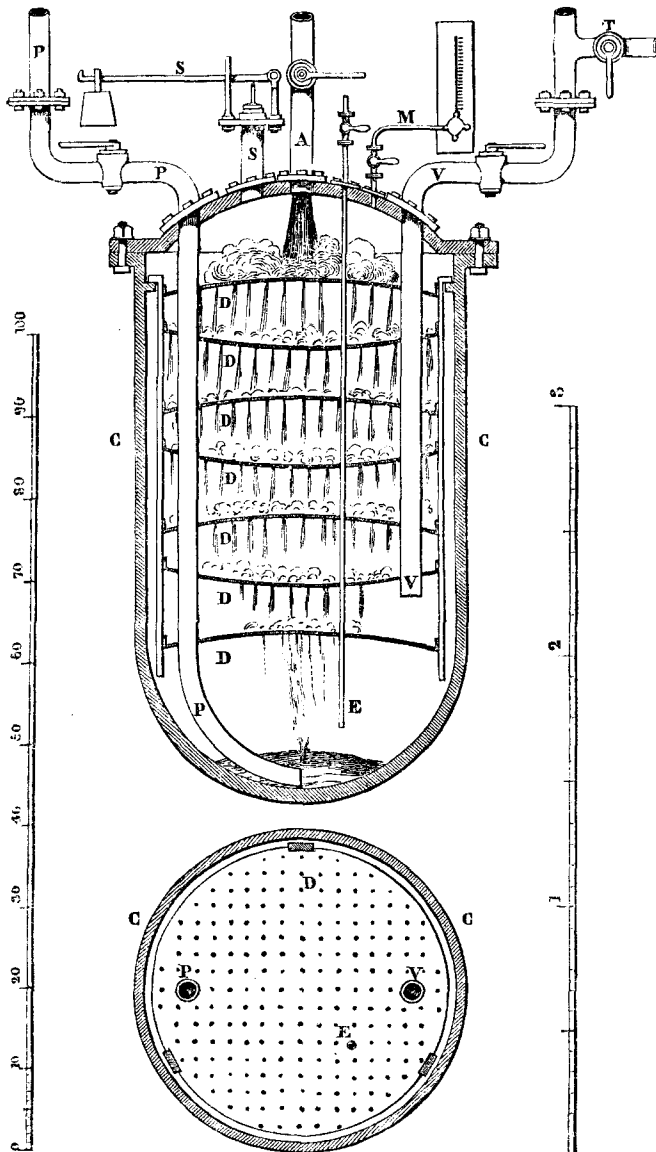
No. 874. "Description of a Diaphragm Steam Generator." By  
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THE Author's well-known researches into the subject of water in a spheroidal state, have established the fact, that bodies evaporate only from their surfaces. This being received as an axiom, the practical result would necessarily be, that, in the construction of steam generators, the evaporating surface should be extended to the utmost limit; this has however certain objections, either of complexity of construction, additional weight of metal, greater cost, &c. The next step then was to consider, whether water could not be brought into contact with metal surfaces, so heated as to obtain the greatest amount of evaporation, with the least expenditure of fuel. An extended series of experiments demonstrated the practicability of this, and a steam generator constructed on this principle, has been for some considerable time in daily use, at the Stearine Works of Messrs. Jaillou, Moinier & C<sup>o</sup>, Paris.

This steam generator (woodcut, Fig. 1,) consists of a vertical wrought iron cylinder, terminated at its base by a hemispherical end, and closed at the top by a curved lid, to which are attached the usual steam, safety, and vacuum valves, steam and feed pipes, waste pipe,

<sup>1</sup> The Author was elected Assoc. Inst. C.E., December 7th, 1852.

Fig. 1.



and other appendages. Within this cylinder are a number of wrought iron diaphragms, having their edges turned upwards, their surfaces being alternately convex and concave, and being pierced throughout with small holes countersunk from the underside. They are suspended on three vertical rods, and fixed at given distances apart, in such a manner that they shall not be in contact with the heated cylinder, or shell of the boiler. The orifice of the steam pipe is between the two lowest diaphragms, within a few inches of the bottom of the generator, so that the steam is at a high and equable temperature and in the fittest state of elasticity.

The orifice of the feed pipe being at the centre of the cover of the boiler, when the feed is turned on, the water falls upon the middle of the upper diaphragm, which, having a convex surface, has a tendency to direct towards the periphery, all the fluid which does not pass immediately through the perforations, thence it falls upon the second diaphragm, which being concave, causes the water to flow in the contrary direction, from the circumference to the centre, and thus through the entire series, dividing the water into the most minute particles, or in other words obtaining the greatest amount of evaporative surface of fluid. The whole of the water is not only kept in a state of motion, so as continually to expose new surfaces to the heat, but it must evidently be divided by the perforated diaphragms into minute columns and globules, like a shower of rain, and thus be in the best state for absorbing caloric. In fact the process of the formation of steam within this generator, must be that of the injection of a small quantity of water, into a highly heated chamber, where it is minutely subdivided, and immediately converted into highly elastic steam, without the necessity for the absolute contact of the fluid with a heated metallic surface.

The setting of the boiler is very simple; it resembles that of a common domestic brewing copper, the fire grate being beneath the hemispherical end; but in order to obtain a large surface, the flame is made to traverse a series of vertical flues, extending in spaces of 8 inches each around the entire circumference, alternately ascending and descending, until it reaches the chimney, by which time it has expended the greater part of its caloric.

The ordinary pressure, under which this boiler has been worked, is ten atmospheres, or 140 lbs. per square inch, which in round numbers is equivalent to  $181^{\circ}$  Centigrade or  $358^{\circ}$  Faht. Now as according to the experiments of Baudrimont and others, iron possesses its greatest amount of tenacity at a temperature of  $200^{\circ}$  Centigrade, it will be perceived, that although the pressure may at

first appear great, the iron is just in that state at which it can best support that degree of tension.

When the boiler is first set at work, a few pints of water are injected by a hand pump ; the fire is urged, and in about twenty-five minutes there is steam to work the engine, and the ordinary feed cock is opened as the engine commences working.

It will be noted, that there should generally be a small quantity of water in the bottom of the boiler, to prevent injurious effects on the metal directly in contact with the flame, and to raise steam for starting the engine, after a temporary stoppage. Provision is also made for blowing out any deposit that may occur, by means of a pipe which descends to the bottom of the boiler.

	m.	c.
The extreme height of the boiler is	0·64	= 25 inches.
Ditto, of the cylindrical sides	0·54	= 21½ "
Diameter	0·32	= 12½ "

After deducting the surface covered by the brickwork of the setting there remains 0·55 square metre = 473 square inches of heating surface.

The actual results obtained were ; that in 9 hours, there were consumed 81 kilos. = 182½ lbs. of coal, the quality of which was not good, as it scarcely gave out 6000 units of caloric per kilogramme ; the quantity of water evaporated from a primary temperature of 39° Cent. = 102° Faht. was 351 kilos. = 789½ lbs. under a pressure of 10 atmospheres = 140 lbs. per square inch.

According to Morin's experiments 0·60 is the limit of useful effect to be reckoned upon, even in the best furnaces, but engineers are generally content to take 0·50. Adopting that figure as the basis of calculation, the result obtained from this steam generator would be

$$81 \times 6000 \times 0\cdot50 = 243000.$$

Examining then the amount of caloric contained in 351 kilos. of water evaporated under a pressure of 10 atmospheres.

$$351 (550 + t - t') = 242892 \text{ caloric.}$$

$$\text{In the above formula } t = + 181^{\circ} \text{ Cent.}$$

$$t' = + 39^{\circ} \text{ Cent.}$$

$$\text{Therefore caloric produced} = 243000$$

$$\text{Ditto absorbed} = 242892$$

$$\text{Ditto lost} = 108$$

This result is not given as the limit of what may be obtained, as the Author is well aware of many defects of construction in the generator; but he submits, that enough has been done to point out certain advantages, which Engineers will not be slow in availing themselves of, if on examination the system be found practically advantageous.

The chief merits of this steam generator would appear to be simplicity of construction and of setting; the limited dimensions; the rapid production of steam at a high degree of elasticity and dryness; the economy of fuel; and the almost entire absence of danger of explosion.

It has been generally admitted, that the most fertile cause of explosion has been the sudden formation of a large quantity of highly elastic steam, from the injection of water upon intensely heated parts of a boiler. Now in this generator it would be impossible to heat the diaphragms beyond a given degree, because they are not in contact with the exterior shell of the generator; and any water introduced, must come first into contact with the diaphragms, and before any of it could reach the bottom of the boiler, even supposing that part to be red hot, the whole would be converted into steam, the equilibrium would be restored, and thus all danger would be obviated. This will be more readily appreciated, by remembering the vast amount of latent heat in steam, and how feeble is the property of iron for retaining caloric.

Supposing, however, that the hemispherical end of the generator should become red hot, and the temperature =  $500^{\circ}$  Cent.; the mass of metal heated being presumed to weigh 10 kilos., it is easy with these simple data to determine, by the following expression, the amount of caloric contained in that part of the generator.

$$\begin{array}{rcl}
 m c t & = & \text{Caloric} \\
 \text{Let } m \text{ represent the mass} & = & 10 \text{ kilos.} \\
 c \text{ the capacity of the iron} & = & 0.12 \\
 \text{and } t \text{ the temperature} & = & 500^{\circ} \text{ Cent.}
 \end{array}$$

then  $500 \times 0.12 \times 10 = 600$  units of caloric, which is the precise quantity required to convert a kilogramme of water into steam, supposing the primary temperature of the water to have been =  $50^{\circ}$  Cent. Therefore one kilogramme of water would suffice to restore the boiler to its normal state of temperature.

The Author is aware, that there may be many practical objections urged against the application of this system to large boilers, and in fact, up to the present time, it has only been tried on a small scale and with the intention of providing for the peculiar

wants of those who require a motive power, but whose premises are generally ill adapted to afford the necessary space for a steam boiler of the ordinary construction. The boiler which has been described, supplies steam for an engine of 2 H. P. and occupies a space of 3 feet 3 inches diameter by about 4 feet in height, including the brickwork.

Numerous modifications will assuredly be suggested, by the practical engineers to whom this boiler is submitted, and to whose candid consideration the Author commits a system, which he trusts may eventually be found as useful in practice, as he feels certain it is correct in theory.

The paper is illustrated by a diagram from which the wood-cut, Fig. 1, (presented by the Author,) is compiled.

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MR. A. MURRAY said Lord Dundonald had scarcely done justice to the principle he advocated, as demonstrated by the results of the comparative experiments on the evaporative power of some tubular boilers, made at Woolwich, and the vertical tubular boiler of the 'Janus,' the statement of which had been published and was appended to the paper before the Institution.<sup>1</sup> As far as the absolute evaporative power went, the boilers of the 'Janus' gave better results than any other marine boilers, although not so good as long Cornish boilers. Still it was necessary to consider the practical advantages and disadvantages of the horizontal and vertical tubular boilers as compared with those on the old flue system, and whether any great economy of fuel resulted from very slow combustion. Some experiments made at the dockyards showed, that as good evaporative effect was produced by burning the same quantity of fuel, in the same time, in three furnaces of a boiler, as had been previously obtained with four furnaces. In marine boilers there were many points to be considered besides the mere evaporative power and economical working.

The durability, alluded to in Mr. Scott Russell's paper was an important feature; in the case of the boiler on board the West India Royal Mail Packets, their duration might be attributed to the large heating surface,—1 foot of grate to 3 feet of water surface; this was more than could be allowed for boilers on board steamers in the Royal Navy.

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<sup>1</sup> Vide Appendix to Lord Dundonald's Paper, No. 871—a printed document, containing "Result of Experiments made on the Evaporating power of Marine Boilers."