INSTITUTE OF MARINE ENGINEERS
INCORPORATED.

SESSION 1895-6.

President—A. J. DURSTON, Esq., C.B., R.N.

THE "THORNYCROFT" WATER-TUBE BOILER FOR TORPEDO BOATS.

Descriptive Lecture by Mr. J. E. Thornycroft at 58, Romford Road, Stratford, on Monday, December 9th, 1895.

Chairman:
A. J. DURSTON, Esq., C.B. *(President)*.

Mr. Thornycroft: Mr. Chairman and gentlemen—It should be understood that this particular type of boiler was designed for torpedo boat work, the locomotive type, which followed the earlier type of marine boilers, having failed to stand the hard forcing necessary to obtain the high speed required in these boats. It must also be clearly pointed out that in describing its merits for the particular use for which it is so successfully employed, it is not intended to argue that it must be superior to the ordinary marine boiler in cases where

none of the properties of an express boiler are required. Nevertheless, there are many cases in which it would be superior to the marine type at present at work in fast passenger services and dispatch boats. When I read a paper, six years ago, at the Institution of Naval Architects, describing the boiler, nearly all the superintendent engineers said that they did not think it suitable for their class of work. Since then, however, so many opportunities have arisen for employing express boilers that boilers of this type, representing some 300,000 indicated horse-power, have been already built. The most prominent feature in this design is the arrangement of generating and down-take tubes, ensuring a systematic circulation of water, by means of which is obtained a maximum transmission of heat, and at the same time preventing any possibility of overheating the tubes. The arrangement of these tubes in long flues and passages, through which the flames must pass before reaching the up-take, ensures a high evaporative duty from the boiler. At the same time, these must be arranged in such a way as to allow of their being cleaned from soot and ashes. These flame passages are of such a size that with continual forcing there is no possibility of their being choked, as is so often the case with the tubes of locomotive and marine boilers. The combustion chamber, formed of tubes, admits of the use of air jets for intimately mixing the gases, and thus ensuring more perfect combustion, making the boiler superior in economy to the ordinary marine boiler. Dry steam is ensured, and priming prevented, by a sufficient volume of steam space in the separate barrel. If this volume is below a certain limit, it necessitates the use of reducing valves between the boiler and engine, to prevent a dangerous amount of water at times being carried over to the engine. In order to allow a free expansion of the tubes, and consequent freedom from leakage at the joints, caused by unequal heating and rapid changes of condition, a curved form of generating tube is essential. It might appear that there would be great advantages in the use of straight generating tubes, which would permit of internal examination ; but it has been

found by experience that they are quite incapable of withstanding the severe treatment to which water-tube boilers are generally subjected. The method employed of simply expanding the tubes into the different barrels has been found most satisfactory, it being quite possible, with a suitable gearing for working the expander, to do the work efficiently in a five-inch barrel. A similar arrangement of gearing can be used for plugging or removing a damaged tube. In a case of this sort, however, it is usually unnecessary to replace the tube, as one or two out of action makes such a small reduction in the total heating surface. Steel has been found to be the most satisfactory material to use for the tubes. It was at first thought that some non-corrosive metal, such as copper or brass, would be superior, but trial has shown that brass will not stand the high temperature, and copper so soon deteriorates under these conditions. At the present time numbers of boilers are having their copper tubes replaced by steel. One great advantage in the working of water-tube boilers lies in their power to raise steam quickly, but it must be remembered that this necessitates an extreme sensitiveness with regard to their feeding. For example—one of the boilers of H.M.S. *Daring* would evaporate the whole of its water in ten minutes if the feed were altogether stopped, while a boiler of the ordinary marine type would take about a hundred minutes, so that it will be seen that it is ten times as sensitive in this respect. This difficulty is got over by the use of an automatic feed regulator, which accurately keeps the water in the boiler at a constant level under different rates of working. The before-mentioned sensitiveness and freedom from priming in this type of boiler have made it possible to increase their output with very great rapidity. On many occasions the speed of the *Boxer* and her sister vessels have been increased from nineteen to twenty-nine knots in fifteen minutes, which means an increase in power from about 800 to 4,500 h.p., a performance quite impossible with the old form of boiler.

At the conclusion of the lecture, which was illustrated by diagrams, specimens of boiler pipes, and other appliances, Mr. Thornycroft exhibited a working model of the Thornycroft Water-tube boiler under steam, and explained its construction and working.

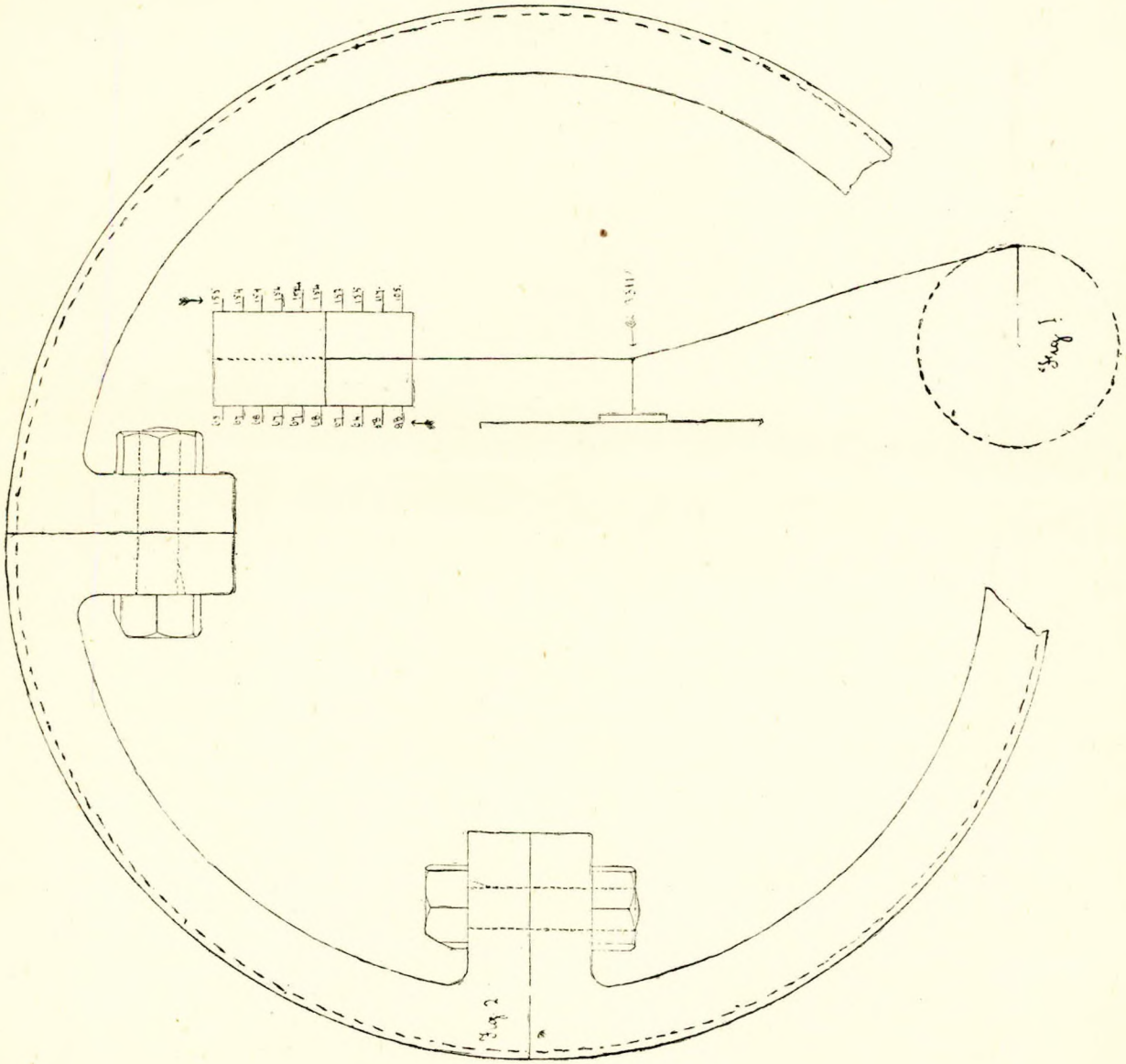
The PRESIDENT then invited questions on the subject of the lecture, and said he was sure they all felt very much obliged to Mr. Thornycroft for the information he had afforded them. This type of boiler had been used in the torpedo-boat destroyers up to something like 5,000 horse power, and it really furnished about the only solution to the problem of getting high speed in a small boat. Mr. Thornycroft had very rightly said that he did not put forward this boiler in competition with the ordinary cylindrical boiler for general purposes, but it was adapted for high speeds where a large amount of power was required in a small space. Mr. Thornycroft had also said that this boiler was intended as an express boiler for torpedo boat destroyers, and for dispatch vessels; but there was something more in it than that, although the further development and more extended use of water-tube boilers must be the result of experience. If they were going to get the full advantage of high-pressure steam they must use cylindrical construction of comparatively small diameter.

Numerous questions were then addressed to Mr. Thornycroft by Mr Ruthven, Mr. Leslie, Mr. Sage, Mr. Johnson, Mr. M'Farlane Gray, Mr. Hawthorn, Mr. J. T. Smith, and others. Mr Thornycroft replied to these various questions at length, some of his answers being supplemented by the President, who gave the experience of the Admiralty on several points on which information was desired.

Mr. RUTHVEN proposed a hearty vote of thanks to Mr. Thornycroft for his lecture, and, the motion having been seconded by Mr. SAGE, was carried by acclamation.

The PRESIDENT announced that on Saturday next, the 14th inst., the members of the Institute were invited to attend at the works of Messrs. Maudslay, Son and Field, in the Westminster Bridge Road, at 3 p.m., to witness a demonstration of the "Belleville" water-tube boiler. On the following Monday, the 16th inst., a paper by Mr. Aisbitt would be read on "Water Ballast for Steamers and Sailing Vessels."

Mr. R. LESLIE proposed a vote of thanks to the President for attending and taking the chair on that occasion. The proposition was seconded and carried with cheers, and the President having briefly acknowledged the vote, the proceedings terminated.



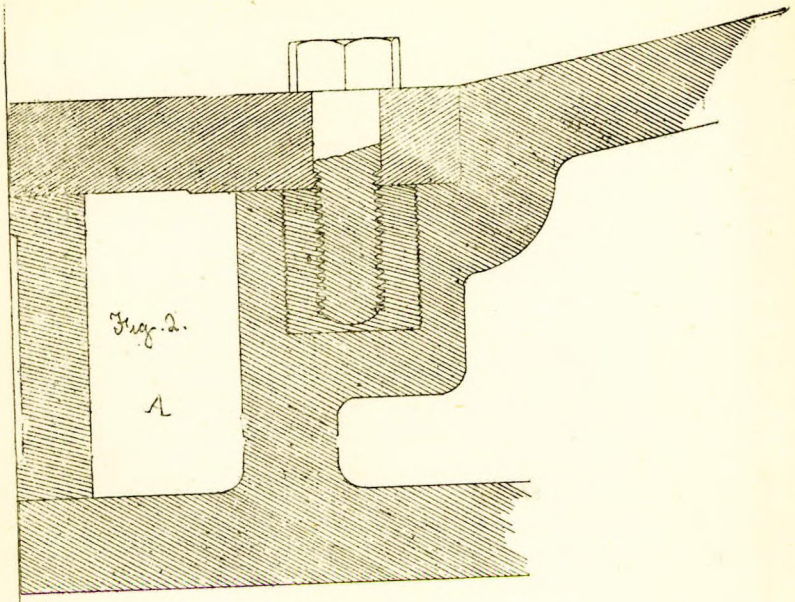


Fig. 2.

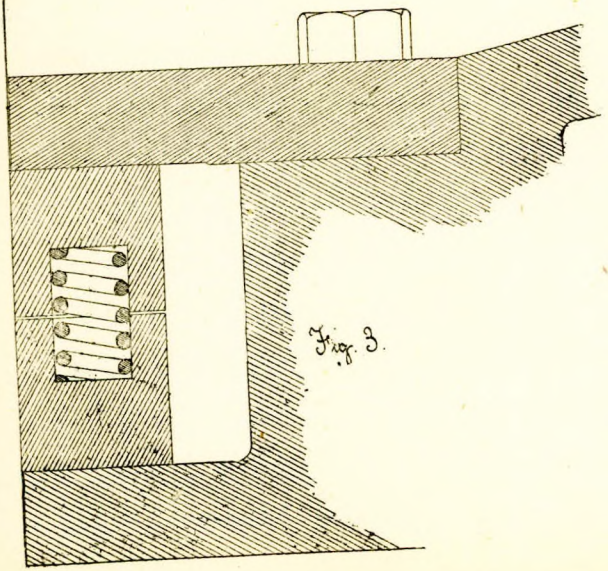


Fig. 3.

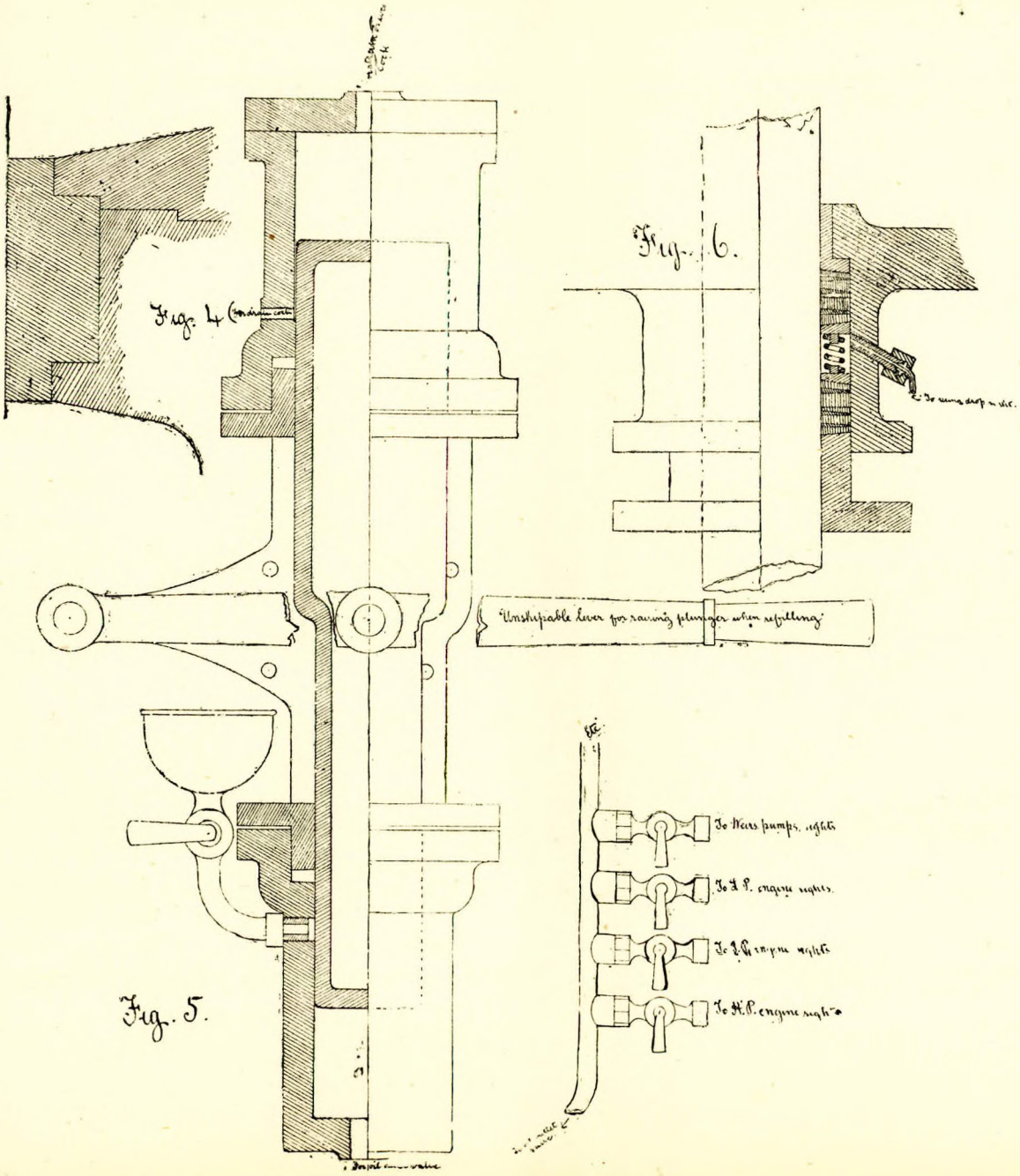

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Fig. 6.
Fig. 5.

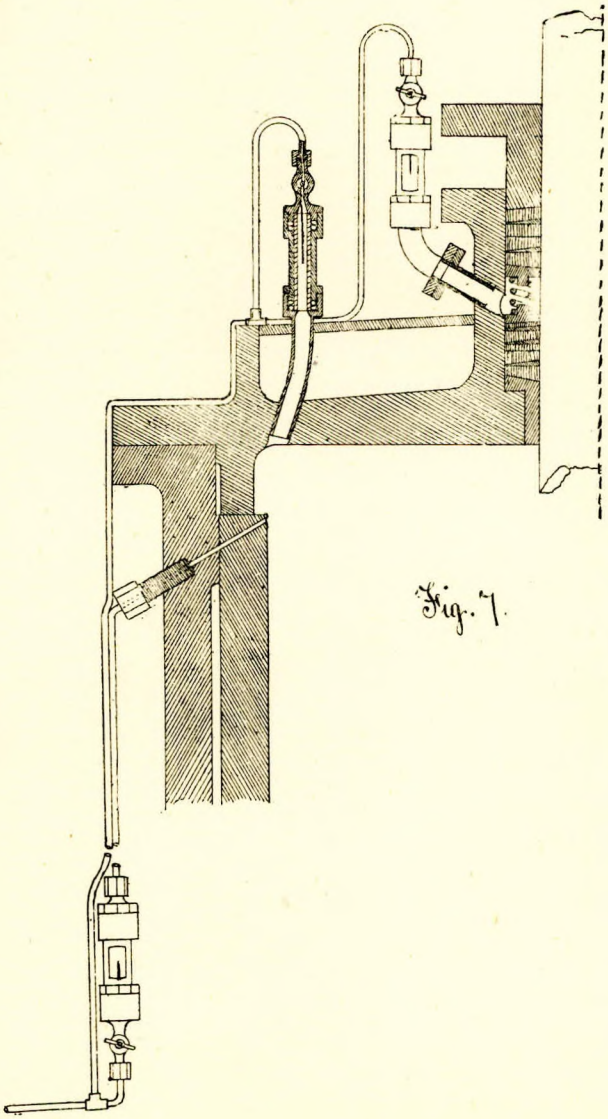

Fig. 7.

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Volume VII.

FIFTY-EIGHTH PAPER

(OF TRANSACTIONS)

INTERNAL FRICTION IN STEAM ENGINES

BY

Mr. W. W. HOUFE

(MEMBER)

READ AT

THE INSTITUTE PREMISES, 58, ROMFORD ROAD, STRATFORD, ON MONDAY, OCTOBER 14th, 1895.

THE UNIVERSITY COLLEGE, CARDIFF, ON WEDNESDAY, NOVEMBER 6th, 1895.

THE ARTS' SOCIETY HALL, SOUTHAMPTON, ON TUESDAY, NOVEMBER 12th, 1895.

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On MONDAY, OCTOBER 14th, 1895.

DISCUSSIONS CONTINUED MONDAYS, OCTOBER 28th AND NOVEMBER 11th.

READ AND DISCUSSED

AT THE UNIVERSITY COLLEGE, CARDIFF,

On NOVEMBER 6th AND NOVEMBER 20th, 1895.

READ AND DISCUSSED

AT THE ARTS' SOCIETY HALL, SOUTHAMPTON,

NOVEMBER 6th, 1895.

REPLY TO DISCUSSIONS BY THE AUTHOR OF THE PAPER.

Mr. W. Houfe (Member): Much has been said about Ramsbottom rings, most speakers being in favour of them, not only for H.P. cylinders, but also for I.P. and L.P.; nevertheless, I see no reason for altering my views respecting them. Beyond doubt, by their adoption, a great saving in friction is effected over the

rings of big "effective depth," which they may be said to have displaced, and that saving is almost solely due to the decrease in effective depth of rubbing surface and their small initial outward load. These alterations have been found almost necessary in H.P. cylinders as steam pressures have increased, and no doubt are steps in the right direction for all sizes of cylinders, no matter what the steam pressures may be. I deem it only due to our national characteristic reluctance to change that L.P. cylinders are still hampered with spring loaded rings, having deep rubbing surfaces.

That varying steam pressures behind the split ring must tend to cause unequal wear of the cylinder is beyond a doubt, but at the same time this fact makes it quite possible for a change of rings, or even of cut-off, &c., to so alter results that this tendency may be so disposed that a cylinder with a varying bore may even be trued up, as Mr. R. Davison has evidently experienced.

Mr. P. Smith, no doubt, by providing a ready outlet to the exhaust side of his piston rings, succeeded in decreasing the ring's load an appreciable amount; such ring fitting would, however, if with a very slack piston, tend to increase instead of diminish the load. In advocating four Ramsbottom rings, he appears to me to be somewhat inconsistent, for by so doing he would dam up the pressure behind as well as between the rings, to say nothing of the increase in "effective depth."

I can assure him that I have effected considerable saving in frictional resistance by fitting two rings $\frac{3}{8}$ in. deep, in place of three $\frac{1}{2}$ in. deep, in H.P. twin engines, and by removing the centre ring in the I.P.'s, without any apparent increase in leakage.

Mr. Adamson and others were wrongly impressed respecting my experience being with such rings wrongly applied; he will see by reference to my paper, at the top of page 18, that I advance there for all split rings

what he mentions in respect to Ramsbottom rings. He, with Mr. Kirkwook and Mr. Wilson, is again wrong in imagining that I have been wont to see great compression put on piston ring springs. Generally speaking, I am of Mr. A. Kendrick's view in thinking springs should be abolished from behind piston rings. There is a point, however, regarding the outward initial pressure on a split ring, which no one has mentioned, but still is of very great importance. This point has reference to my reason for stating 3 lbs. as being generally considered the necessary force per square inch with which the ring should press against the cylinder walls. This I intended to apply particularly to split rings, for with so slight a pressure as $\frac{1}{3}$ lb., as alluded to by Mr. Duncan, the danger of collapse would be great in almost all such rings. The extent to which the rings overrun the counterbore, and also the rounding of the edges, as proposed by Mr. Adamson, are points of great importance and must not be lost sight of in fixing the initial load in any given case. I am at one with Mr. Adamson and Mr. Leask in advocating dull edges to all rings.

With reference to the ring sketched by Mr. Ruthven, I am of Mr. Kirkwood's opinion, and, as far as I can judge, if a split ring, I should condemn it for considerations of collapse in any ordinary steam engine. I suspect its designer intended it only for single acting engines, such as gas engines.

Cast steel for packing rings seems to be disapproved of generally. Mr. Brock, however, said he has seen good results attend the use of steel mixtures, and I wish it to be borne in mind that cast iron mixtures of days gone by did not run as well as most mixtures of to-day do. Most engine makers have to-day certain *mixtures* of cast iron for the frictional parts in which it is employed. Steel castings may vary enormously in their properties, and it must not be forgotten that our knowledge of it is not anything like as advanced as is the case with cast iron. As a matter of fact, when I suggested cast steel for rings I was thinking of the class

of ring which I was advocating, and my reasons for so doing were :—That dissimilar bodies excite a less degree of friction than similar ones do; that, if pressures are light the hardest bodies excite least friction (see Haswell); that cast steel has a less co-efficient of expansion than cast iron, consequently, when a floating solid ring of cast steel becomes heated by frictional work to a temperature in excess of its containing cylinder, their difference in expansion will compensate to a large extent for their difference in temperature.

Although I advocated a practically solid adjustable ring, my ideas for piston rings of fair size extended to combining with such, the principles of limited expansion (an example of limited expansion may be seen in *Cassier's Magazine* for last November). Such a ring properly fitted would correct the smallest defects due to tool dulling, etc., during boring out a cylinder, a point which was hinted by Mr. Brock. It would also save the tendency to burst the cylinder should the adjustment be bad, and thus our President's fears on this score would be totally removed. I might add, that I have more advanced ideas for this class of ring and am hopeful that it will displace the ordinary split type which, I consider, in all its forms, causes unnecessary friction and stands in the way of the superheated steam engine.

Mr. H. C. Wilson and Mr. Pillans Scarth will find a simple way of measuring the initial pressure of a piston packing illustrated in a paper by Mr. J. Butterworth, which he read before the Manchester Association of Engineers, November 9th, 1895. He stated he considered that objections to piston valves had been chiefly owing to bad workmanship, and that with regard to solid rings he had seen thousands in large yards for vessels of the *Campania* class, so that he considered them the latest practice. Mr. A. C. Mitchell's recital of "a well-known Australian trader's" difficulties with new piston valve rings is very amusing. I guess those rings were not of cast steel, and that it did not strike her engineers to contract the rings by the abstraction of

heat from them, so that they might have been drawn for proper fitting without breaking chains and chain screws, to say nothing of the lessening of detention.

To Mr. P. Smith's answer to his own question I would add want of homogeneousness in the rods, and that their rubbing is in direction of their fibre. He surely agrees with me, that to prevent the slight leakage through metallic packing by the use of textile at the gland end of stuffing box, is to dam up the pressure, which with most, if not all metallic packings will force the rings into the rod and thereby cause unnecessary friction. Textile packing at the neck bush end cannot dam up pressure behind the rings but will serve to prevent leakage to the metallic packing's back. I am pleased to see that most speakers agree with me respecting the advisability of internal lubrication. Mr. W. C. Wilson is evidently quite correct in stating that present practice is a compromise between engine and boiler. Feed-water filters I know are far from perfection, but I have no doubt but that the result of this discussion may stimulate inventors to persevere in this direction.

That the presence of oil in boilers will be much more liable to give trouble where the circulation is rapid, than where the circulation or rate of evaporation per lb. of water contained in the boiler is slow, such as is the case with the old natural draught cylindrical boilers, seems to me self evident. With such boilers it is very uncommon to see oil otherwhere than around the shell at the water line, sometimes, however, it will be found in small quantities adhering to the bottoms of furnaces. With such, boilers have come to grief through oil deposit on furnace crowns; I have always attributed its presence there to some such cause as freshening the water in coaling ports, etc., which practice was at its height when furnace collapse was common. As the rapidity of circulation is increased so will the tendency for the oil to be carried down with the water be increased, but I believe in all cases its tendency will be towards the cooler surfaces, such as furnace bottoms.

a drawing of mine which I sent nearly fifteen months ago to Mr. Mudd, of the Central Marine Engine Works, West Hartlepool, the acknowledgment of which I am still waiting for.

I do not agree with our President's views respecting the distribution of oil when admitted internally in steam engines. Mr. Leask's views I judge are more in accordance with my own, which I have formed from rough experiments, and are, that the oil gets dashed against the surfaces almost as it enters and is there spread by the sweeping effect of the steam along all the inner surfaces of the engine, remaining mostly in contact with these surfaces throughout its course through the engine, or to some stagnant corner in the engine.

I wish to say to Mr. Pillans Scarth and Mr. J. L. O'Flynn that because steam of one pressure be higher than steam of another, it does not follow that the one is drier than the other.

I was astonished to see Professor Elliott's statement that the idea of increasing the efficiency by using superheated steam was a fallacy, and I think I cannot do better than to request him and all others who have not seen it, to read the address itself or a report on it in the "Steamship" of August, 1895, page 64, which Professor Ripper delivered at the Sheffield Technical School, on the 3rd of July, 1895.* It is there stated that practical experience showed that the chief difficulties which stood in the way of the success of the superheated steam engine in the past was due to internal friction. With the engine he referred to and had to work, a steam consumption of 10·17 lbs. had been obtained and this I feel sure can be still much reduced. In Professor Ripper's opinion the secret of steam engine economy is dry steam in the cylinder, and although many devices

* I wish it to be understood that I had not the advantage of this address when writing my paper, for although delivered three months before my paper was read, it left my hands during the end of April, 1895, nearly three months before Professor Ripper delivered his lecture.

had been adopted to accomplish this desideratum, superheating is by far the most effective. Professor Elliott will also see he is in error in stating that a temperature of melting glass would be necessary, which is, I believe, 2,377° F. Professor Ripper believes that superheating is the next step in steam engine economy, and commences a chapter in steam engineering which will have similar results in points of economy to those introduced with double and triple expansion engines. From this address Mr. Adamson will see that superheating is carried on with pressures exceeding 100 lbs. The idea of stage superheating has evidently not occurred to Professor Elliott. I do not consider it extravagant to look forward to seeing successful stage superheated quadruple expansion steam engines working at pressures of 200 lbs., having a steam consumption of about half that of to-day's practice, with the B.H.P. approximating much more closely to the I.H.P. than is the case at present.

My remarks respecting our method of estimating steam consumption, although referred to by one or two members, did not elicit the discussion I expected. Mr. Leask, I judge from his remarks, thoroughly understood what I wish to convey, and to emphasize this part of my paper I would add, that an engine may be easily conceived or even designed, such that it will absorb, say, 75% of its power I.H.P. internally and in consequence the lbs. of steam per I.H.P. per hour would be far superior to any commercial saturated steam engine, but at the same time its useful effect would be only 25% less than that absorbed in external friction. Professor Elliott draws attention to the fact that I have not drawn any distinction between liquefaction due to wall action and liquefaction which attends the performance of work. Apart from considerations of the paper's length I did not think any distinction necessary, being firmly of opinion that the former is almost wholly a consequence of the latter.

I regret not being able to state positively how the difficulties in the *Magellan* and *Patagonia* were overcome, but believe by abandoning superheating.

I would advise Mr. Sage to give up all hopes of ever seeing anything perfect, even the human factor, during his sojourn here upon earth.

With reference to the objections and suppression of the employment made by me of certain "makers' names," Mr. Auckland and Mr. J. T. Smith were perfectly correct in their opinions. I used such purely as finger posts. I was prompted to write the paper solely from a desire to try to make some slight return to the Institute for the benefit I have received from its transactions; its other benefits, I regret to say, I have not the opportunity of participating in, owing to our respective geographical positions. I leave Mr. Brock and Mr. Mitchell to glean from what has been said and from Professor Ripper's address that the trouble with superheaters was not at any rate the primary cause for the abandonment of the superheated steam engine, that cause being internal friction, as advanced by me.

I was pleased to hear from my brother-in-law, in the *St. Louis*, that having tried the sight feed arrangement on their H.P. glands, they find it to give satisfaction.

I regret the "Discussion" forwarded to me did not include Mr. Durston's remarks sent in in writing.

In closing, I wish to express my hearty thanks for the reception given to my humble efforts, and especially to Mr. Ruthven for having performed the task of reader.