Discussion.

MR. W. REEKS: In the absence of our President, which we all regret, his duties have devolved on our senior Vice-President, who would otherwise have proposed this vote of thanks to the lecturer, and so it gravitates through the animal kingdom until it gets me.

I certainly have very great pleasure in submitting to you the motion for a hearty vote of thanks to Mr. Sinclair for his interesting paper. He has purposely, I take it, made it shorter than he otherwise could have done, with the object of affording you gentlemen time and opportunity for discussing it. I have made a few notes on the subject of this particular type of boiler, because I have had some little experience of it, but before reading them I would like to say it seems to me that the Colonial boiler ought to take an entirely different place in the evolution of boiler construction than it does. I use the word "construction" purposely, because in the early days boilers were not designed as we understand the term to-day—to a very large extent, they were just built.

If you go back to the time of the very earliest boiler it was probably a hollow stone. I shall have something to say about that later on, when I come to the workaday common or garden boiler, made of steel or iron, as we know it to-day. Following the hollow stone through the clay pot upright, we come to the oil drum on its side, and a bonfire underneath.

There are a very large number of such oil drums and similar cylindrical vessels in use to-day. They do not provide for steam engines, but they do very useful work.

A man would naturally find the wind blowing the fire about, and so, no doubt, put a few stones around it, making a sort of barrier against the wind—just as we do in out-door cooking. From that, it follows he would, from time to time, make the wall a little better, and still better, until he got to all intents and purposes the casing, as we understand it now.

It is not a big stretch of imagination to suppose that he, not being quite satisfied with the generating power of his oil drum, which he used perhaps for steaming planks, or seasoning timber, put a few tubes through it, thus producing the genesis of Colonial boilers.

I think that the Colonial boiler ought to be about No. 3 on the list in the evolution of boilers, and yet, apparently, this type was evolved for use first in America, and then in Australia. At any rate, that appears to be the written history of it; but I really think if the actual history of boiler construction were known—it may be known—it would be found that the Colonial type boiler is of very much greater antiquity than is generally supposed.

The few notes I have made on the subject are as follows:—

Quite early in his paper, Mr. Sinclair referred to and gave an illustration of the Tangye Colonial boiler, and I felt a little bit aggrieved to find that Tangye had, for ease of construction, made his ashpit the same way as I have had to do from time to time for an entirely different reason, viz., that of getting the boiler reasonably low in a boat, for which purpose I have had to clip the outside corners more or less parallel with the rise of floor of the vessel—this applies more particularly to the sharp-floored ferry boats of comparatively small displacement.

Mr. Sinclair's condemnation of the round-bottom ashpit was rather a dash to my ardour; but in point of fact we have never had any trouble, the large flat ashpit full size, less the outside corners (the jobs being twin type), has provided ample space for ashes.

With regard to the H.P. of these boilers, it is common practice, so far as my experience of them afloat is concerned, to allow the same proportions as one would do in a return tube or straight through boiler, and to expect one I.H.P. for every 4 square feet of heating surface, and eight I.H.P. from every square foot of grate, this, given easy egress for air to the ashpit, and suitable diameter, and length of funnel, works out quite satisfactorily, even with the ordinary small coal in common use.

It is a fact that the Board of Trade turned down this particular class of boiler; I speak from actual experience, having prepared plans, boiler details and specifications suitable for both local and home manufacturers, then let the contract to home makers, and afterwards, upon the Board of Trade declining to certify, changed over to marine return tube type of equal power.

It may be interesting just at this stage to mention that the two types, though differing very much in detail of both dimensions and thickness of plate, finish up by occupying just about the same overall space in the vessel, but differing in weight between 20 and 25 per cent., the Colonial type being, as might be expected, the lighter.

Obviously the reduction in weight arises from the much thinner shell, absence of furnaces and combustion chambers, and less water, against which has to be set casing and brickwork, but the net weights work out pretty much as stated.

I had occasion once to reduce the draft of a small vessel three inches, or, in other words, lift her that amount, and the difference in weight between the original return type boiler and a twin Colonial type of equal power just did it nicely.

For what it is worth, I might mention that on one occasion, building a small cargo boat and fitting a Colonial type boiler, the manager of the company for whom it was being built (himself an engineer), objected to the customary Galloway tube or water leg, so we fitted the blow down through the boiler top, and carried it to the bottom;

whether or not this is a vital point I leave to you; suffice it to say, thousands have been built with the water leg, of course protected by brickwork, and have given no trouble.

While on the subject of that brick guard, I notice it is usual to protect it on the front, or front and two sides only. I venture to think this is wrong, for while it prevents the direct impingement of the fire on the plates, the leg frequently having foreign matter in the water, as well as being pretty full of stuff of a non-conducting nature within it, the eddy of the fire must, I take it, have much the same effect on the back of the tube as water has on the plates of a badly-designed steamer, where, due to the eddying, heavy and irregular pitting often takes place.

The next time I have to instal a boiler of this kind, I shall take counsel as to the advisability of bricking the leg in all round.

On the question of bad feed, I can say little, having had no experience, but I have heard some most extraordinary statements as to the treatment of boilers of this class. One stands out conspicuously in that, upon examination, it was found to contain a very large number of clay balls almost as hard as beach shingle; but apparently they rolled with the circulation, and so permitted the heat to pass without burning. Another case, it is said, showed the boiler to be half full of clay, but fortunately moist; presumably the water leg was solid. Instances are on record of the fire being got away without any water in the boiler, and no harm resulting.

I am not quite sure what size Colonial type boilers have been made to, but the largest I have had to do with was 7ft. 6in. diameter and 7ft. long, containing 144 three-inch tubes, or 844 square feet in tubes and shell, not counting end plate. It might be added that this boiler had the usual 10 inch space between nests of tubes, and was therefore accessible.

I should like to add my thanks to Mr. Sinclair for his paper, and to endorse his remarks that Colonial type boilers are like the proverbial poor—always with us, so that there seems nothing to say about them that is not already common knowledge.

I beg to propose a very hearty vote of thanks to Mr. Sinclair for his paper.

Mr. A. W. Tournay-Hinde: It affords me very much pleasure indeed to second Mr. Reeks' motion for a vote of thanks to Mr. Sinclair for the extremely interesting paper he has read to us to-night. It is one of those papers which deals with the author's personal experience in connection with the class of boiler that he has brought before us, and which give us a good deal of data that he himself must have been at considerable trouble to collect, tabulate, and prepare for us. His contention is quite correct, in the early part of the paper, that there is very little data indeed relating to the efficiency and general design of the return smoke-tube, or Colonial type of boiler, and therefore we are all the more indebted to him for placing the figures before us that he has done this evening. Generally speaking, I feel quite inclined to agree with Mr. Sinclair that this boiler is one which deserves a very much better estimate of its value than is generally assigned to it. It is certainly capable of doing all that any other boiler will do, and will also stand a good deal of ill-treatment that many other boilers will not. So far as the efficiency of the Colonial type of boiler goes, personally I am rather inclined to agree with Bryan Donkin that, within limits, the design of a boiler has very little to do with the efficiency—for the latter all depends on the design of the firing arrangements and the fireman.

The question of feed-water referred to by Mr. Sinclair is one with which all engineers are very intimately concerned when designing a type of boiler. The Colonial type of boiler perhaps does not give quite the freedom from boiler troubles where the feed-water is bad, and of such a nature that it will cause incrustation and deposits, as the Cornish or the Lancashire may do; but still I have seen (as mentioned by the author and Mr. Reeks) Colonial boilers which have received extremely rough treatment in the way of incrustation, and have successfully withstood it. I have seen Colonial boilers very heavily covered on the tubes, and also on the bottom, with deposit, and, comparatively speaking (except in one instance), very little trouble resulted. In this case the boiler had a rather large blister over the fire, about 15 inches by 10 or 12 inches. Every time that boiler was started up (prior to means being taken to combat the trouble), leakage also always occurred at the back end of the tubes, which was due to the incrustation on the tubes being sufficient to prevent them transmitting heat rapidly enough through the water, and they therefore became somewhat over-heated, and consequently expanded, and moved slightly through the back tube plate.

In the Newcastle district of N.S.W. the water supply is taken from the Hunter River, and the water is fairly heavily impregnated with the carbonates and sulphates of lime and magnesia. As is generally known, the carbonates produce a comparatively soft, friable incrustation, which can be got rid of by blowing off frequently, provided that the boiler pressure does not exceed 60 or 70 lbs. The sulphates, on the other hand, produced a dense, hard, crystalline deposit, that cannot be blown down, and which can only be removed by chipping. As a matter of fact, incrustations of the latter kind partake of an incipient form of marble, and are, under certain circumstances of high pressure and temperature, nearly as hard.

Getting now to the question of zinc plates and corrosion, I notice that the author says in his paper that if the pressure does not exceed 60 lbs. there would be less incrustation, and such as does result, can be blown off. I do not altogether agree with him; for as I have just mentioned, I think it depends entirely on the nature of the material in the water, that produces incrustation.

The use of zinc in boilers to prevent corrosion is a question I am considerably interested in, and its main function, as far as I have been able to determine it from such experience or such opportunities as I have had, seems to me to be merely a question of assuring that there is some metal in the boiler of a greater positive value electrically than the iron of the shell, or of any other metal, or the brass fittings connected with the boiler. The presence of any contamination, either alkaline or acid, in the water sets up an electrical couple, that will eat away whichever element of the boiler's construction is positive in the solution. As most of the fittings in connection with a boiler are of copper or similar metals, the iron, being electrically positive to the latter, usually suffers. If zinc be present, it is still more positive than the iron; and the zinc is then eroded in place of the iron. Why trouble should occur if zinc is in contact with the shell, as mentioned by Mr. Sinclair, I cannot understand, except that in the case mentioned, where the zinc plate lay on the bottom of the shell, where the fire would be immediately under the shell, it may be that possibly the zinc plate would prevent the transmission of heat to some extent, or accelerate the accumulation of any deposit in that particular place. I am not quite clear either, how zinc, if it is enclosed in an iron box, in the boiler, can be as efficacious as if it is hanging free from some part of the boiler in the water space. I would very much like a little further information on that. If the feed-water itself be rendered neutral by treatment, or by the addition of suitable ingredients, there is generally no necessity for zinc, and there are preparations produced by reliable makers for this purpose. I do not refer to the ordinary so-called "boiler fluids," because most of them are comparatively valueless; but if, in the case of water containing carbonates or sulphates of lime, magnesia, or similar salts, caustic soda is added in suitable proportion, it will neutralise the electric action; but, unfortunately, owing very often to it not being correctly used, or used in excess, it sets up an action in a contrary direction, and does cause trouble by the brass fittings, valves, and so on becoming eroded and leaking. If, however, together with the caustic soda, sufficient ordinary grey arsenic is added, the whole trouble disappears.

Some time ago, in order to ascertain why this was, I undertook some experiments. I filled a small beaker with a 33 per cent. solution of caustic soda, and into it I inserted a steel and gun metal plate; I measured the voltage across the couple, while the solution was hot, although it was not quite so hot as the water in a boiler at 150lbs. pressure would be—but still hot enough to materially affect the electrical results. In the solution of caustic soda the brass or gunmetal plate showed positive in the solution—that is, negative outside; therefore such erosion due to electrical action as might take place would destroy the brass element of the couple. I then added, gramme by gramme, a 33 per cent. solution of ordinary white arsenic, and as each gramme of arsenic solution was added the voltage fell, until, when there were equal quantities of arsenic and caustic soda present, the conditions were neutral, the voltmeter was at zero, and no action was taking place. I proceeded, still further, to add arsenic in excess. The polarity then reversed, and the steel element of the couple became positive in the solution, and the gunmetal negative. Following up the information so obtained, we ourselves used to prepare the solution for the boilers. What was done was simply to dissolve, as nearly as we could, equal quantities of the materials. After the solution was complete we used to test electrically to see whether we had a completely equal and neutral mixture. If not, sufficient of the other component was added until it was so. During an experience of some three or four years with the solution so prepared, we had no trouble either from erosion in the shell or fittings, from the formation of hard crystalline deposits. I thought possibly this information might be of some interest to the meeting, though I am afraid I have perhaps rather gone outside the scope of the subject matter of the paper.

Mr. Sinclair refers to the choking of the feed pipe. I have myself seen a feed pipe originally of 2 inches or 3 inches in diameter closed up by deposit until the opening was not more than a quarter of an inch in diameter. The reason that a feed pipe often shows signs of trouble by choking up is that, as the feed-water enters the boiler by this means, it is here where the water first encounters the heat in the boiler. Pretty well all the carbonates of lime, etc., will start to deposit when the temperature of the water reaches about 150 deg. F., and they deposit fairly rapidly at about 200 deg. F. So immediately the feed-water starts to get into that portion of the feed pipe which is in the boiler, the carbonates come down and gradually choke up the pipe. If you examine such a deposit you will always find the characteristic friable structure in it due to carbonates.

As the author has very clearly explained, nearly all of the material forming such deposits can be removed from the feed-water before it enters the boiler, by the simple expedient of pre-heating the water to a suitable temperature, in an apparatus as described by him. This heat treatment, however, will have no effecting in removing the sulphates.

I do not think I have anything further to add except to say that I consider we are very much indebted to Mr. Sinclair for his very excellent paper, and I regret that, to some extent, there are not more members present to have heard it read.

Mr. James Shirra said: I have not prepared any notes on Mr. Sinclair's paper, but I would like to submit a few questions and remarks. I am sure we are much indebted to Mr. Sinclair for bringing the subject forward. He says in his paper:

"A good deal of unfavourable comment has been made on the marine Colonial boiler; I believe that the Board of Trade will not grant certificates for them, but those who have intimate knowledge of them make sure of certain constructional details, and fit them with every confidence."

If Mr. Sinclair could enlighten us a little more as to what the constructional details are, we should, I think, receive his paper with more confidence, because there must be some reason for the Board of Trade adopting that attitude, and for the want of popularity of this type in Great Britain. I think the proper name for the type is the "American"; the "Colonial" boiler is the little portable boiler that Tangye's make. Boilers made somewhat after that pattern are really the Standard boilers used in the United States of America; which is also the land of boiler explosions, in spite of the enormous number of Government boiler inspections. In about two million such inspections which had been made up to 1896, according to Professor Thurston, nearly one and a half million boilers were found defective, and 180,000 of the defects were considered dangerous (v. Thurston's Manual of Steam Boilers, New York, 1901). Still, boiler explosions go on, and it is a good deal due to the careless way they have of looking at such matters in America. I read in "Engineering" lately about a type of steel ship construction there, not good enough for Colonials or British, but good enough, apparently, for Americans (v. Report of Meeting of Inst. Naval Architects, March, 1915, paper on "Ore-carrying Steamers," by John Reid).

Mr. Sinclair himself, I think, states quite enough to justify suspicions about the boilers. The bottom of the boiler, the principal heating surface, being convex to the fire, and right down in the hottest part of it, how are we to ensure keeping this part free from internal deposit? Then, if it gets overheated, down it comes in a pocket. What are you to do with the pocket? Draw the tubes, cut out the pocket, and rivet a patch of plate over it, which leaves a recess for the accumulation of more deposit? The only thing is to lift out the boiler and put a new bottom in.

A Voice: Turn it round!

Mr. James Shirra: You cannot do that because of the mountings and the dome. Another point is: most of the boilers are built in two or three rings, even the little Tangye boiler shown is in three rings of plates; that means two transverse riveted joints in the fire. Besides forming recesses in the bottom for the accumulation of scale, those landings are apt to crack at the rivet holes, especially if the plates are fairly thick. Of course, thirty years ago and more, boilers had to be built up of small plates with joints in the fire; but now that we can build the "Navy" type of marine boiler used in our ferry boats seventeen or eighteen feet long, with the bottom plate in one length without a transverse joint in it, there is no excuse for not building Colonial boilers likewise.

I was once told that the Board of Trade would not pass such a boiler with plates over 7/16th of an inch thick, owing to trouble with thick plates and landings in the fire. I do not know what the authority of my informant was. Now we are told the Board of Trade will not pass them at all. In America they build such boilers of comparatively large diameter, and necessarily of somewhat thick plates; but in one such boiler I saw described in "Engineering" about three years ago (v. "Engineering," February 7th, 1913), of 7 feet diameter and of $\frac{3}{4}$-inch plates, in three rings, the landings were reduced to 7/16ths inch thick at the bottom seams of the boiler. This is a refinement in the right direction, but one that most of our boilermakers have not yet reached. In American practice they often go farther in taking risks, and instead of taking the heated gases right up a smoke-stack from the smoke-box, they take them back over the top of the boiler to a flue at the back, thus superheating the steam. That looks all right at first blush, but if you have flaming coal you will make the boiler top very hot. The Board of Trade does not even allow a steam-drum to be put in the uptake of a marine boiler. Thirty years ago it was a common practice; now, it must be put outside of the uptake, owing to the danger of steel plates not in contact with water being overheated.

Another point, to which Mr. Reeks referred, is the Galloway tube or water-leg on the bottom. The Galloway tube is only a makeshift; what is wanted is quite a big dome or sediment collector. With every under-fired boiler you want a receptacle for mud. In the Babcock W.T. boiler large mud-drums are provided, and you want them still more in this type. American practice with this boiler seems to ignore this; all that is done seems to be to rivet on a patch of plate and screw into it a two-inch iron pipe for a blow-down. There is a good deal about these boilers in Professor Thurston's ''Manual,'' referred to above, which gives specifications for their construction. They are not the things which commend themselves to the British engineer at all, but there are thousands of the boilers working, and, as Mr. Reeks said, it is astonishing what some boilers will stand.

There is one point about these American land boilers—I have never heard of them being used there on board ships—they have always a good casing of brickwork; a large boiler would have two 9-inch brick walls with an air spacing between. In all of those pictures of boilers shown on the screen, I think the brickwork, the heat insulation, is dangerously thin, which not only wastes heat, but is dangerous to the surroundings. An insufficiently insulated boiler in the open simply wastes heat, but does no farther damage. In a wooden ship it may seriously endanger the timbers. We have had a few fires in our ferry steamers of late. I should like to know whether it is due to the increasing use of the "Colonial" boiler? Mr. Reeks says there is always 9 inches of brickwork round them. There is hardly that on the figures shown on the screen.

The point which Mr. Sinclair made about mountings is one which applies to all types of boilers. Asbestos packed gauge-cocks are not common, he says—I think it is a pity—I am sure they are fairly common in marine work. Then there is the problem of where to put the gauge-glass. With a long series of pipes between the boiler and the glass it is difficult to get the true water-level, as the water in the pipes cools down and shows in the glass much below the true level, so that if you pump up to show half-glass, the boiler may be dangerously full. If the engineer blows the glass through it is not so bad; but they do not do this, I am afraid, so often as they ought to. Then there is the position of the safety-valves. In the small twin marine boiler of this type shown, the author shows, as an alternative position, the valves on a connecting pipe. I think this is contrary to reason and to requirements—the valve should be directly on the boiler, and not on a pipe. The alternative in the drawing is to put one safety-valve on each drum of the boiler, which is not so bad.

The author stated that one of the things to avoid is the use of lap joints on the shell. The danger of lap joints was well pointed out in Professor Barraclough's paper read to us in 1911. The trouble is met with by using double butt-straps; the American boiler illustrated in "Engineering" referred to above, has quadruple riveted double butt-strapped longitudinal joints; the writer of the accompanying article states that no such boiler with butt-straps has ever exploded, while there have been many explosions with lap joints, and they are still exploding. There is no doubt a lap joint, on a boiler of small diameter especially, is a source of danger. I remember some twenty years ago or more, there were several explosions of locomotive boilers in Queensland; they were comparatively cheap boilers, with lap-jointed longitudinal seams in the barrels; I believe none had butt joints. In New South Wales butt joints are, and have been, always used in low-pressure boiler barrels. With lap joints in a small high-pressure boiler the plate at the joint is always straining and working with variations of pressure, and cracks are set up. If you look at the old reports of boiler explosions which occurred thirty or forty years ago, one is rather alarmed to see the number of lap joints in the plating, and the number of small plates the shells are built up of, and consequent opportunities of disaster. The plating looked like a piece of brickwork, or like an opossum rug made of small patches tacked together. There is no occasion now, with large steel plates at our disposal, for so many joints, certainly not in the heating surfaces exposed to fire. In Cornish and Lancashire boilers we cannot very well avoid transverse riveted joints in the furnace crown, but in good practice the plates are flanged up, and an "Adamson" joint made which keeps the rivets out of the fire and strengthens the furnace tubes. You cannot do that, however, with the fire seams of these Colonial boiler shells.

Another trouble is that, in the desire to get all the possible heating surface, the brickwork is often made too high at the sides, and the fire can play on the plate at or above the water line, which may be a source of disaster. This often prevents inspection of the longitudinal joints, which should be so arranged as to be easily visible above the brickwork.

With the Colonial boiler the great difficulty is with regard to cleaning and inspection. Mr. Reeks mentioned a 10-inch space left between the tubes in the middle. There