are not many such boilers with such a space, I fear; but even if so, what can be done in a 10-inch space? I am not very big, and I could perhaps get into a 10-inch space, I could just manage to squeeze in, but there would be no room to twist round or do anything. There is no reason why the tubes in boilers of this kind should not be drawn at every inspection. The tubes of every locomotive boiler on our railways are drawn after the engine runs a certain number of miles; Colonial or American boilers are practically of the same class, and why should not their tubes be drawn for purposes of internal examination regularly in the same way? Boiler owners may not be able to see this. There is no doubt as to the efficiency of this type of boiler when in good condition, and clean—the trouble is to keep it clean.

With reference to the horse-power question: if you calculate the horse-power according to the heating surface, you may, by using long or crowded tubes, run the nominal horse-power up to an abnormally high figure, but you will not get more power or efficiency probably than with tubes of moderate length and reasonably spaced. The real measure of horse-power is the grate surface—that is chiefly what determines the fuel consumption, and the coal burnt ought to be the gauge of power. If there is not heating surface enough to absorb the heat produced at the grate, then diminish the grate, or, keeping the grate the same, increase the heating surface as by a supplementary boiler or heater, but the grate remains the best measure of the power. McFarlane Gray long ago proposed a very simple rule for nominal horse-power of boilers—it was to allow ten N.H.P. to every foot width of grate. It is not a very good rule, as it takes only one factor in the problem into consideration, and, of course, that is insufficient; but it gives about as good results as any other more complicated one. The horse-power of a boiler is a misnomer; the engine develops the power, and may want anything from 10lbs.

to 100lbs. weight of steam per hour per horse-power to do so. The intending boiler owner should stipulate the amount of steam he wants to make in an hour or given time, and the boilermaker should guarantee that the boiler will do so under ordinary or prescribed conditions of firing.

I am not quite clear as to what Mr. Sinclair meant when he made a distinction between the multi-tubular boiler and the Colonial boiler. I presume he means that the Colonial boiler is one with only a single 9-inch brick casing—whereas a multi-tubular boiler must have brick walls.

MR. SINCLAIR: And side plates as well!

MR. SHIRRA: I have nothing more to say, except that the Colonial boiler can be used with careful treatment, and a very vast number are in use and now at work in America, may be in Australia as well; but I hope in this matter engineers and boiler users will follow the lead of the United Kingdom, and not of the United States.

MR. HASEMER: I have much pleasure in supporting the vote of thanks to Mr. Sinclair for his interesting paper.

With regard to what Mr. Shirra has said, there are some points about the Colonial type boiler which, to my mind, do not make it everything desirable for all purposes, but, for all that, I do not think sufficient reason exists for the Board of Trade to bar the boiler as a marine boiler altogether. We have seen this boiler working in coasters on our coast; we have found it in ferry-boats, and it has given remarkably good results. For small lighters, and handy little tow-boats, this boiler is, to my mind, very much superior to the ordinary marine type boiler; it is a quick steaming boiler, considerably faster to raise steam on than the marine type boiler, and can be used with perfect safety in a wooden boat. It has been tested. If it is safe on a coaster, where the draft is shallow, it is surely safe in an ordinary wooden ship, as far as safety can be considered from the risk of burning the ship.

I lately overhauled a Government vessel that trades year in and year out; it has two Colonial type boilers side by side; it was a shallow draft vessel, and it has now been in commission some 13 years. It has never been found dangerous in respect to risks such as setting fire to the ship, or being silted up to the extent of destroying the bottom of the shell plating of the boiler. I think the Board of Trade might be induced to accept the Colonial type boiler under certain conditions. With regard to the cost of the Colonial type boiler I agree with Mr. Sinclair that the initial cost is a small one. As to the cost of fuel, it compares favourably with any other type at least, and the cost of repairs is, to my mind, very much in favour of the Colonial type boiler as against the marine type boiler. While advocating the Colonial type boiler to the extent I have, I do not for a moment push the idea that it is going to take the place of the marine type boiler in very large vessels; but for the smaller type vessels I think it would show favourable conditions in comparison with the marine type boiler. Talking about the boiler as a land boiler, of course, there again, up to a certain point in horse-power, it would compare very favourably with most boilers; and, touching briefly on the design of the boiler, I think, with the author of the paper, that one of the features of the successful Colonial type boiler is the heating surface of the tubes, large diameter tubes generally showing an advantage.

I am very thankful to Mr. Tournay-Hinde for the information he has given us with reference to electrolysis in a boiler. I am quite sure it will be full of interest to many members when it reaches them. You very often find men pitting one substance against another. One man will say: "I don't believe in putting caustic soda in a boiler; it is too severe on the boiler; it is not, to my way of thinking, a bit like lime—give a boiler a good dose of lime." Another man says: "I don't believe in lime; I don't believe in caustic soda; I will give it common washing soda." That

seems to be the ordinary extent of different operations, as far as keeping the inside of the boiler clean is concerned. When Mr. Tournay-Hinde comes along and gives valuable information that he has absolutely tested as a practical man, I think it is certainly worth something to the members of this Association.

The VICE-PRESIDENT (Mr. D. F. J. Harricks): Before asking Mr. Sinclair to reply to the various points raised, I would like to refer to several matters that have struck me whilst perusing his paper. There is no doubt that Mr. Sinclair has put before us a very concise statement of his experience with the class of boilers dealt with. I must say that it came somewhat as a surprise to me to find the words "Colonial type" applied in so general a way to practically all sizes, large and small, of under-fired multi-tubular boilers, whether they be of a portable or of a permanent character. I have always understood the Colonial type boiler to be a small, portable, under-fired, multi-tubular one, with self-contained steel casing enclosing the furnace and external flues. I cannot think that it is right to call large boilers of the multi-tubular type, set permanently in brick work, and with all the improvements that have been applied to this particular form of boiler, Colonial type boilers. As to the origin of the true Colonial type boiler, it is, as Mr. Sinclair has stated, impossible to trace much of its history, and, perhaps, Tangye's were the first suppliers of the type out here; but I have little doubt, judging from conversations I have had with older engineers here and in Great Britain, that the boiler was used to some extent in Great Britain very many years before it was imported into this country. It is, in fact, an off-shoot of the very old portable loco-type boiler mounted on wheels; but evidently in designing the Colonial type boiler, the aim was to devise a cheaper boiler, and at the same time to combine the high efficiency of the tubular type with a large grate area for burning wood and other light fuels. So far

as this country is concerned, Colonial boilers have in the past been largely in demand for small installations, and were often fitted with travelling wheels and horse shafts for inland work, where neither rail nor waterways were available for transport. No skilled labour was required for setting up, and the boiler frequently earned the title of the "bush boiler."

If one examined the catalogues of even the present-day makers of these boilers, it will be found that practically the maximum size made is 4ft. 6in. in diameter by 10ft. long. When a boiler of larger dimensions than these is required, it is generally accepted that it is getting outside the range of portability, and some type of permanent setting is adopted. I think that the title "Colonial type" is a misnomer when applied generally to the boiler installations illustrated in Mr. Sinclair's paper, for all of these, with the exception of the first illustration, show a much improved design as compared with the first, and most of them are evidently permanent installations. I say it is a pity, because I think there is no doubt that the true Colonial type boiler, such as was imported here years ago, earned an unenviable reputation, and it is not difficult to find fault with the design of boiler illustrated in the first figure of the author's paper. Take one instance, that of the blow-off pipe shown in the back of the boiler. The author has already stated that this is a bad feature; and I might say that I happen to have had an actual opportunity of examining such a blow-off pipe in an imported boiler, and the bottom of the blow-off pipe was actually 2½ inches above the bottom of the boiler. Now, when you consider the treatment that many, if not most, of these boilers were subjected to in the way of unskilled care, the class of water frequently supplied to them, and then remember that they are fired directly under the shell, just where deposits of mud or scale are most likely to accumulate, it is easy to imagine the troubles that were met with from this source alone.

In defining what he understood to be the difference between a Colonial boiler and a return multi-tubular, the author stated that the former was that type which was fired from the front directly under the shell, the hot gases then passing through the combustion chamber at the back of the boiler, and then through the tubes to the stack, and that the latter was that type in which the gases before being passed through the tubes were returned along side flues, and then through the tubes to the back of the boiler.

I cannot see that a comparatively small difference in the brick setting of a boiler, which was practically identical in all other respects, should establish a line of demarcation between two types.

Mr. Sinclair's statement that it is well worth knowing that in almost every case where it has been possible to do away with the side flues in return multi-tubular boilers economy has resulted, is interesting; but probably the whole reason for any such improvement lies in the fact that in the first instance the fire grate has been obviously too narrow, and consequently the area too small, for the fuel burnt. In the instance he quotes it is difficult to understand why the taking away of the narrow partition in the centre of the furnace should have resulted in such a marked increase of economy, for apparently the division in the furnace had very little influence on the total area of the grate available, and it would almost seem to indicate a reversal of a generally accepted principle of providing, if possible, for a means of firing each half of the fire alternately. I presume, from the figures, coal was the fuel.

The return multi-tubular boiler, set somewhat as illustrated in Fig. 4 of the author's paper, is practically the standard industrial boiler in America to-day and, depending largely on the size of the unit, and the class of fuel used, just as efficient results are being obtained from the boiler with side flues as those in which the gases passing from the furnace return directly through the tubes, as

shown in the illustration above referred to. There is no doubt about the efficiency of the return multi-tubular boiler; it is highly efficient, and has many well known advantages over many of the other types; but it certainly can be stated as probably the most important consideration that, with under-firing, good water is a necessity; in fact, this remark applies to any form of under-fired boiler. For use in many industries, such as that of sugar manufacture, where megass is the principal fuel, and special furnaces external to the main boiler setting—but, of course, attached direct thereto—are necessary, I think it might safely be said that the return multi-tubular boiler, with the gases passing first under, and then round the sides, and finally through the tubes to the chimney, is one of the most efficient in use. As a matter of interest it might be worth mentioning that the C.S.R. Co. have practically adopted this type of boiler as the standard one for their mills in Australia. Of course, for the refineries situated in the cities, where coal is the fuel, a different set of circumstances is set up, and Cornish low-pressure boilers and Babcock and Stirling boilers for high pressure, all mechanically stoked, are used.

Referring to the author's remarks with regard to the Board of Trade not granting certificates for what is termed the marine Colonial boiler, this statement in itself seems to support my contention that the old Colonial type boiler has not a good reputation. I can quite believe, as the author states, that the installation shown in his Fig. 5 has, however, many points to recommend it. The placing of the two shells of the boilers practically plate to plate strikes me as a bad feature, especially considering that, on the underside, some 18 inches down on each shell is inaccessible, being covered by brickwork. The supporting of the boilers also seems open to improvement, and the unprotected mud drum directly behind the furnace might easily be a source of trouble if bad water was used for the feed. This remark applies to all of the unprotected blow-

off collectors. Could Mr. Sinclair give us some information as to the reason given by the Board of Trade for not granting certificates for this type of boiler?

With regard to the diameter and length of tubes, the 3½ inch diameter (which the author recommends for ordinary work) certainly appears to be a most suitable size; but when the author states that he would favour a 10ft. long boiler as compared with a 12ft. long boiler, for the reason that he considers that the longer boiler would not evaporate much more steam than the shorter, he cannot surely be considering the question of economy. In America the size of return multi-tubular boiler, now practically accepted as a standard, is 7ft. in diameter by 20ft. long. The tubes are 3½in. to 4in. bore, and they consider that with this length of tube, and with one of the many means now available for easily keeping them clean, it is more economical to have the extra length of boiler and reduce the temperature of the gases therein rather than to instal economisers with the same object in view. The C.S.R. Co.'s standard multi-tubular boiler for sugar mills is 8ft. in diameter by 18ft. long, and containing practically 2500 square feet H.S., the tubes being 3½in. in diameter.

Referring to the question of evaporation, I think there is no doubt that the author was on safe ground in claiming that the multi-tubular boiler is very efficient in this respect. The figures quoted from Bryan Donkin's tests confirm this, although it might here be remarked that these figures apply to boilers varying from 16ft. to 24ft. in length, and it is not clear from Bryan Donkin's book what path the gases follow.

Evaporation efficiency has not made the strides one would expect with the knowledge now available. Perhaps the oldest evaporative result on record is that stated by Alan Payne in describing his steam boiler to the Royal Society of England in 1747, when he announced that he had rarefied,

or turned into steam, some 90 gallons of water with 112lbs. of coal, equal to a thermal efficiency of very nearly 70 per cent. If we take Bryan Donkin's record of trials made from many tests 20 to 30 years ago, we see that the average thermal efficiency for land boilers was as follows:—

Water Tube	77.4%
Locomotive	72.5%
Multi-tubular	68.7%
Cornish	68.0%
Lancashire	63.0%

If we come down to the present day, it is interesting to notice some figures recently published in the Engineering Journals from a paper read by Messrs. Brownlie and Green on "The Running of Boilers and National Economy." The average thermal efficiency of 100 typical industrial boiler plants in Gt. Britain at the present time was found to be only 55.65 per cent, and including economisers and superheaters, etc., only 62 per cent. The typical British industrial installation, i.e., not including power houses, consists of Lancashire boilers. The authors compared the results obtained from the 100 plants tested, with another average plant run on ordinary scientific lines, and which gave an over-all efficiency of 78.68 per cent., and they went on to show that if the 100 boiler plants were taken as an average for all such industrial plants, and they and all others in Great Britain could be brought up to the same efficiency as the typical plant run on scientific lines, a saving of no less than 18 per cent. of coal could be obtained, and that this would mean a saving of £3,000,000 per annum. They emphasised the fact that this enormous loss was caused entirely by out-of-date methods of running boiler plants. Their statement is a moderate one, for we know that an efficiency of anything up to 80 per cent. can be obtained from Cornish and Lancashire boilers in every-day practice if some of the many means of keeping a reasonably scientific control over their working are made us of. The article above referred to, and which appeared

in "The Engineer" and "Engineering," is well worth reading, as it has a peculiar significance to the engineers of the Empire at the present time. I think we should be very thankful to Mr. Sinclair for so frankly giving us the benefit of his actual experience, which is at all times useful; but, at the same time, I think, for the sake of manufacturers of multi-tubular boilers here, that a mistake is being made in adopting the title of "Colonial Type" boilers as applied generally to a much improved article, and one which, in my estimation, does not come within the limits of the original designers of this type. If I may say it, I think there is no doubt that the original boilers of the Colonial type were designed to meet a call for a cheap boiler and for temporary uses mostly, and it is unfair to boilers such as those illustrated in the author's paper to have the odium of a poor design brought up against them. Why not adopt the true title of "Return Multi-tubular" for all such improved boilers?

Mr. Sinclair asks the question why the different countries seem to have adopted a fairly definite type as their standard for industrial plants; and certainly when one considers the relative advantages and disadvantages of each, it is difficult to shut out the conclusion that these standards have been adopted, not so much as the result of proved efficiency, but rather as the outcome of tradition and sentiment. Perhaps, as an instance of this, I might quote the fact that, in certain factories in the vicinity of the Clyde, there are land installations consisting of boilers of practically the Scotch return-tube marine type, some of which are 15/16ft. in diameter, and with three furnaces. Surely this is a case where the atmosphere surrounding one of the homes of marine work has led to the adoption of a boiler peculiarly suitable in its own domain, but which would surely find few supporters to recommend its installation in stationary plant.

Mr. William Sinclair, in reply, said: I thank you very much for your vote of thanks. Candid criticism is the best kind of thanks that one can get for reading a paper. The time is late, and does not permit of me going very closely into all the points that have been raised, and I may say, fortunately, most of the gentlemen who have referred to the paper have really replied to one another.

Mr. Reeks has reviewed the early history of boilers, and I thought of the patchwork quilt that some boilers look like, especially on the ends. There is one old boiler down at a mill near Dapto, and if any members are passing close by it is well worth seeing. It lies out in a paddock outside the mill. It is an old egg-ended boiler, and the plates all come together, none being more than about 8in. wide at one end, tapering down to a point at the centre.

The question of ash-pit raised by Mr. Reeks is hardly the same as I have shown. His is a good wide one, which will carry a lot of ashes, whereas with the one shown on the photograph the space was greatly confined.

The different weights Mr. Reeks goes into are very important, especially dealing with it the way he has done.

Mr. Tournay-Hinde has contributed some very interesting facts in connection with the corrosion, encrustation, and so on.

I have always thought myself that zinc was put into a boiler, irrespective of the condition of the feed-water, with the sole purpose of counteracting the corrosion which is set up in all metal structures where different metals are employed. For instance, even in one plate, according to the best authorities, electrolysis occurs, due to the different proportions of carbon and so on in the plate. Of course, this condition is accentuated by different kinds of feed-water.

Mr. Shirra asked a very pertinent question as to whether I could give him the reasons why the Board of Trade would

not sanction boilers of this type. Mr. Shirra, however, himself has practically touched on all the points, such as the thickness of the shell, the style of riveting, accessibility of the boiler, and the fact that the bottom of the boiler forms a receptacle for dirt. In connection with this, however, one thing that has often struck me is that the Board of Trade allow locomotive boilers without any question, and veto the Colonial boiler; and I think I am free to say that most of us would sooner have a Colonial boiler than a locomotive boiler after it had run several years, emphasised by the fact that marine boilers depend more on impure water than others. The Colonial boiler is tabooed on account of having a bad name—why, I do not know; it is the first I have ever heard of it having a bad name.

The VICE-PRESIDENT: There is no doubt about that!

MR. W. SINCLAIR: Mr. Shirra remarked a good deal on the question of imitating America, but I do not think there is any fear of us doing that. I quite recollect seeing boilers going up to the Klondyke at the time the rush was there, when they were used for thawing out the ground, and so on. They were of the locomotive type and smoke tube type; and quite often in these boilers I have seen the cheapest of riveting—in fact, I have seen the plates cracked from the rivet holes out to the edge of the plate, and still going up on the job; so in whatever way we may follow America with the type of boiler, certainly we will not do so with the construction.

With regard to the Galloway tube forming a water leg, it has often occurred to me that if another pipe was inserted in this, something like a "Field" tube, it will get over a good deal of the sediment occurring in this one place.

Mr. Shirra raised a point also about the length of pipes needed for water gauges, and this is a thing that always requires careful thought. There is in Sydney a boiler that I have viewed in which the pipes to the water column came

through the smoke-box, and the water at certain times when the boiler was forced would boil violently in the glass; but by encasing the pipe in another one, and thus insulating it, this trouble disappeared.

The point has been raised by several gentlemen who have taken part in this discussion as to the difference between a multi-tubular and a Colonial boiler, and I have always taken it as a hard and fast rule, irrespective of size and anything else, exactly as I mentioned early in the paper.

I was very glad to have Mr. Hasemer's practical points and his experience about the life of this type of boiler.

There are a good many other points which have been raised by members, but, I think, on account of the lateness of the hour, it would take too much time to go into them. I thank you very much for your attention.

The VICE-PRESIDENT: In my anxiety to sit down, I am afraid I omitted to ask you to carry, by acclamation, the vote of thanks to Mr. Sinclair.

The motion was carried accordingly.

The proceedings terminated.