I have to thank Messrs. Anthony Hordern & Sons, Ltd., for their courtesy in allowing me to present these notes, as the investigations have been made on their behalf.

Discussion.

MR. MCEWIN said he had great pleasure in proposing a vote of thanks to the author for his paper that evening.

He had but a few remarks to make upon the paper. He considered that the burner was too close to the heater during the experiments, and in Fig. 5, where the Combustion Chamber was formed by the asbestos, much better results could possibly be obtained by lowering this Chamber. Present heaters were inefficient, and there was certainly room for improvement in their design. In Fig. 6 it is almost impossible to put in so much radiating material and keep it hot; the heat would be dissipated quicker than it could be carried to the water. The author suggested that better results could be obtained with a thick plate, but he considered it would not be economical to use a thick plate in the class of heater, as, owing to the short time that the flow would be in contact with the plate, the difference in tempertaure between the two sides of a plate heated to 180° F. would not be very great. He had known of a case where brass condenser tubes were unobtainable at a certain place on the Continent, so thick tubes had to be installed. The results quite unexpectedly showed no difference over those that would obtain when thin plates were used.

MR. SINCLAIR asked why coils had not been tried in the heater, and said that he considered that in the design of the heater adopted, the walls had no heating value whatever. Perhaps the walls of the tube were covered with smoke during the experiment, although the author said they were quite clear. If a wire gauze had been used instead of asbestos, the experiment might have shown better results. Could the author tell him would there have been any better heating effect from the tube if it had been lengthened some distance below the level of the water?

It might prove interesting to the members present to know that Blessinger adopted a vessel similar to that illustrated in Fig. 7, for carrying on his heat experiments.

He had great pleasure in seconding the vote of thanks proposed by Mr. McEwin.

Mr. Fraser said he would like to ask a question about the burner and flame. Does the flame extend to a great distance? Does it widen out and fill the cylinder, and does the burner produce a large thick flame, or is it a series of jets?

Re the theory of cooling the flame, put forward by the author, perhaps the cool surface smothered the flame by excluding the air on one side, and caused CO_2 to be present. This would make a layer between the flame and plate, and prevent the gases from igniting; it would also prevent the flame from coming in direct contact. The section shown in Fig. 4 might further tend to extinguish the flame. He would quote an example of a flat plate with the flame of candle in contact, in this case quite an appreciable space can be seen between the flame and the plate. On the other hand, vertical tubes would allow the gases to escape up the sides more rapidly, leading to better combustion. He thought the cooler outside walls were an indication that the heat was being retained, not lost.

Mr. Kidd said that Mr. Tournay-Hinde had pointed out that the experiments were made in the workshop to test the relative efficiency of heating water with an ordinary Bunsen burner, when the flame is allowed to come in contact with a comparatively cool plate heating surface, and using an asbestos lining or grating of suitable material, which becomes incandescent or glowing, and prevents the flame from being rapidly cooled, and probably extinguished. I·

am inclined to the view that a core of asbestos or an iron grating placed in the heating chamber would be more efficient than the asbestos lining, as it would ensure the thorough mixing of the gas and air, and transmit at least 50 per cent. of the total available heat by direct radiation to the heating surface. The figures in the lower line of Table A indicate the comparative heating efficiency of the apparatus, with and without the asbestos lining, and also the iron radiating plates. The results computed on the corrected figure for gas consumption are as follows:—

TABLE A.—Gas 2·33 Cub. ft. per Min. at 550 B.T.Us. per Cub. ft. = 2·33 × 550 – 12813 B.T.U.

EXPERIMENT.	No. 1.	No. 2.	No. 3.	No. 5.	No. 4.
Gallons per Minute ...	1·12 ·81 ·75	1·04 ·84 ·75	10·0 ·86 ·62	1·50 1·00 ·79	1·5 1·20 1 00
Average	·8933	·8766	·8266	1·0966	1·233
Temp. of Exit Water ...	105 125 130	110 123 128	133 137 154	100 120 137	108 119 125
Average	120	120·33	141·3	122·3	117·3
Degrees Rise	45 65 70	50 63 68	73 77 94	50 60 77	48 59 65
Average	60	60·3	81·3	62·3	57·3
Per cent. Recovered Heat	39·3 41·1 41·0	40·6 41·3 39·8	57·0 51·6 45·5	58·5 46 5 47·5	56·1 55·2 50·7
Average	40·5	40 56	51·36	50·93	54·4
Mean tempt. differences	$\frac{120 + 60}{2} = 90$	90·16°	100·65°	91·15	88·65
Increased % Efficiency ...	100	·06%	11·86	10·43	9·9%
Rate of Heat transmitted per sq. ft. per hour per 1° tempt. difference.	80·4 B.T.U.	79·2 B.T.U.	116	99·1	92·6
Increased rate of heat transmitted.	1·5%	100	46·7%	25·1%	16·91%

The application of asbestos or iron radiators indicate a saving in gas of 10 to 12 per cent., and an increase in the rate of heating 25 per cent. to 40 per cent. No. 3 test gives the economy of gas and the highest figure for heat transmission, which seems to be due to better circulation of the water in the heater caused by the higher exit temperature of the water.

The figures in Table B, giving the progressive rise of temperature per minute, indicate considerable variation in the rate of transmission of heat through the plate, or the absorption of heat by the water inside of vessel. The supply of heat by the burner would be fairly constant, so that variation in the rate of heating per minute must be due to irregular circulation of the water.

In making experiments of the rate at which water can be heated from 70 degrees Fah. to 180 degrees Fah., with a constant supply of heat (supplied by steam), I have found the rate of absorption to increase in the ratio of 1 at 70 degrees to $2\frac{1}{2}$ at 190 degrees, due to the increase in the movement or circulation of the water. Box shows that the rate of absorption at the boiling point, 212 degrees Fah., is five times greater than at 20 degrees Fah.

For comparison, I have worked out possible maximum efficients on the assumption that the temperature of the flame or the incandescent mass was 1850 degrees Fah., and the exit temperature 450 degrees Fah.

1850 + 461 = 2311° Fah. Absolute Temperature of flame

450 + 461 = 911° „ „ „ „ gas

$$\frac{(2311 - 911) \times 100}{911} = 60{\cdot}5\% \text{ efficiency}$$

as the maximum possible under the assumed conditions of temperature.

If allowance be made for radiation and other losses, the efficiency of the tests Nos. 3, 4 and 5 compare favourably with the maximum possible.

No figures are given of the volume of combustion gases passing through the heater. I estimate they are only a fraction of a second in passing through the heater from the time combustion takes place.

A device having a similar action to the asbestos lining has been used in Cornish steam boiler. It is illustrated and described in D. K. Clark's "Treatise on Steam Engines and Boilers," vol. I., page 195:—"It consists of a cast iron grid laid diagonally within the flue of the boiler, beyond the ordinary fire-bridge, the lower end inclined towards the bridge. This grid is covered with small lumps of asbestos the function of which, being heated to redness, is to interrupt and intermingle the combustion gases and air passing from the furnace, and effect their combustion by imparting heat to the mixture." This apparatus, when tested on a Cornish boiler, gave an increased evaporation per lb. of coal of 21 per cent., as compared with tests without the apparatus.

The President (Mr. D. F. J. Harricks) said he could not agree with the author with regard to the statement that the thickness of the plate forming the heating surface had a good deal to do with the transmission of the heat. He was sure that the point upon which the greatest stress must be laid was in regard to the gas film which retarded the rate of transmission, more than any other factor.

Professor Dalby has shown this very neatly in a temperature gradient diagram. As much as 98 per cent. of the total heat available has been stated to be required to force the heat through the gas film and into the plate, the remaining 2 per cent. being sufficient to pass the heat from the plate into the water.

Members will remember the extensive experiments of Nicholson, who showed how, by high velocity of gases, the scrubbing action so destroyed the gas film, that very high rates of transmission were obtained in ordinary boiler trials.

He desired, in conveying the vote of thanks to Mr. Tournay-Hinde, to remark upon that gentleman's enthusiastic work in the Association. The way in which Mr. Tournay-Hinde responded to every call that had been made, showed his keenness in furthering its welfare. He knew that the Students' Section would have the very pleasantest recollections of the work he had done on their behalf. In these days of stress, one could not but feel the pressing need of activity in any work which might help the country. Our Association provided a means of helping, and members should never forget our principal object was to improve that important arm of the country's service, viz., its industrial and constructive development.

Mr. Tournay-Hinde, in reply, said that he was very pleased that his description of the experiments had met with the approval of those present.

Mr. McEwin, in referring to Fig. 5, asked if the position of the gas combustion chamber had been lowered, would better combustion have been attained. He would say, in reply to that, yes, he had found that to be the case. As to the apparent loss of a quantity of heat which, at the start, was absorbed by the radiator, it is given up again to the water after the gas is turned off. Mr. Sinclair had asked why coils had not been used. It was not a question in this case of high heat recovery, so much as providing an article at a price to suit the buyers, and the form of construction shown was cheaper to produce than a coil.

Several speakers had referred to the position of the asbestos lining. He was afraid that his reference to this lining had been misconstrued. He did not intend to suggest that it would be advisable to use the asbestos lining as indicated in the figure in practice. In the course of the experiment this lining had merely been placed in the position shown for the purpose of ascertaining if the flame was actually extinguished when it came into contact with the cold surface of the plate. Asbestos prevented the contact, and enabled all the gas to be burnt. If a lining of any kind had to be used, there is no question that a metallic one, heavily perforated, would give the best results.

Mr. Fraser had also suggested that the cold surface smothered the flame, and caused CO_2 to be present. This was obviously incorrect, because before CO_2 could be present, complete combustion of the gas must have taken place. In the author's opinion, the film between the gas and the plate consisted principally of "live gas," in other words, the process of combustion of the gas in the flame was arrested, and such of it at the moment that was not burnt formed an insulating film.

In conclusion he would like to thank those gentlemen who had offered criticism for the value of their remarks. He would like to reiterate the fact that, in the paper he had read, he was not putting forward a treatise on the theoretical efficiency relating to the subject. He wished it to be understood that the paper should be considered merely as a description of a few experiments carried out for the purpose of constructing a commercial article, where the object to be obtained was the most efficient apparatus that could be constructed within certain limits as to price. He thanked those present for the generous reception of his paper.