REPORT FROM THE BOILERS AND BOILER PRACTICE COMMITTEE.

(Read by Dr. HEDLEY.)

CHAIRMAN: It is with a great deal of satisfaction that I notice a good sprinkling of Engineers here to-day. It has been stated in the past that this Association was developing a little too much on the Chemical side. That has not been our fault, and I think in the future it is up to the Engineers to make the same success of these meetings that the Chemists undoubtedly have in the past. You now have a Factory Manager as President, an Engineer and a Chemist as Vice-Presidents, so there can be no complaint from the Engineers in future. It is probable that we may have to appoint a sectional chairman. I wish we had a sectional chairman this year; I tried to get our Vice-President to preside to-day over this Engineer's meeting, but I was not successful.

The first paper to-day, from the Boiler Committee, represents a distinct advance, and, with your co-operation and assistance, there is no doubt in the near future you will secure information which will become necessary when the softer varieties of cane come in. I will ask Dr. Hedley to read the paper.

Introduction.

During the past season the Boilers and Boiler Practice Committee has been very actively engaged and has pleasure in presenting to you the following report:—

The obtaining of these figures has involved four months' continuous work in the factories visited.

The work which has been done was made possible by a grant of £250 by the Experiment Station Committee for the purchase of instruments for the testing of the boilers. The history of this grant is recorded in the Proceedings of this Association, beginning with the year 1929. The list of instruments purchased is as follows:—

1. A recording water flo meter.
2. A Leeds water meter.
3. A Dobbie-McInnes steam calorimeter.
4. A high temperature pyrometer.
5. A low temperature pyrometer.
6. Three draught gauges for the furnaces and flues, which are comprised of a vacuum gauge reading to 3 ins., a pressure gauge reading up to 3 ins., and a gauge reading from 2 ins. suction to 2 ins. pressure.
7. A standard boiler pressure gauge.
8. An Orsat apparatus.

No instrument was purchased to record the steam generated by the boilers.

In order to assist in the understanding of the results the method of experimentation adopted is described. The first intention was to record on a chart the feed to the boilers, but the instrument originally designed for this purpose proved unsatisfactory owing to a minor fault and we had to use the Leeds water meter; in the coming season's work we propose to revert to the flo meter. The quality of the steam was examined by the Dobbie-McInnes calorimeter. The temperatures of furnace and flue were recorded every minute by an observer, this was therefore a whole time job. The draught gauges and boiler gauges were read every quarter of an hour and the flue gases were sampled continuously by slowly drawing a sample from the flue at the damper, into an aspirator filled with water, the surface layer being covered with paraffin oil. In this way was obtained a representative sample of flue gas extending over the period of the test.

The obtaining of the weight of bagasse fired was a difficult problem to solve. It will be obvious to everyone that to weigh all the bagasse fired is an impossible task. Where it was a question of testing a range of boilers fed by the total output of a mill it was not so difficult to get at the weight used in the test, but when only one boiler in a range was to be tested the problem seemed insoluble. However, ultimately the following scheme was hit upon. When the bagasse is fed to the furnace down a chute, it is possible by diverting the feed for a definite time (measured on a stop-watch) to collect a portion of the feed on a cleaned floor. This gives the weight of bagasse passing into the furnace for the time measured (in this work one minute's feed was taken). This operation is repeated at very frequent intervals, and while one minute's feed is being collected, that bagasse collected at the previous weighing is fed into the furnace and thus the continuity of feed remains uninterrupted. To carry out this measurement satisfactorily, one white man and three boys are needed.

Another reliable person is required to look after the steam calorimeter, so that at least six people are needed to assist in conducting the test efficiently.

For the steam calculations embodied in the results of the tests "The Revised Callendar Steam Tables (1931)" have been used.

Results.

In Table I. are set forth the results so far obtained from the examination of the boilers in some of the sugar factories. It will be remembered, doubtless, that one of the reasons advanced for the undertaking of this work was the necessity for finding out the efficiency of the boiler plant, in view of the fact that in the near future a considerable drop in fibre is to be expected in our fuel. These results show how uneconomically the fuel is burnt and how greatly the boilers have been neglected. Doubtless, one contributing factor has been the fact that fuel has been obtainable for nothing, but when, in the near future, twenty-five per cent. of that supply is cut off, then those factories which have to purchase supplementary fuel to-day will be seriously affected by the change.

The Type of Boiler.

Under this heading we have several kinds of boilers, Multitubular, Stirling with a flat grate, and one with step grate, several Babcox & Wilcox boilers with flat grates and one with a step grate.

The Moisture in the Steam.

This figure is uniformly high and was very carefully examined experimentally. The steam calorimeter was lagged and the results compared when unlagged. The results were the same in both cases. To see whether the kind of sampling nozzle would affect the result, two different types of sampling nozzle were tried in the same steam main and the results did not differ. It is therefore to be concluded that the steam as used in the sugar factories herein reported is very wet and calls for serious improvement. The losses due to wet steam hardly need to be pointed out. If the steam not only was dried by some form of steam separator, but given 50° to 70° of superheat, there would result a great improvement in the work done by the prime movers—the mill engines, the high-speed engines, besides avoiding the condensation of steam in the steam mains, etc. These are some of the directions in which we have to look for the saving of fuel. Superheated steam should be used in *all* our factories; some are already using superheated steam.

Temperature of the Feed Water.

In most cases this is too low; a temperature above 212° F. can be attained and maintained. It is not too much to ask for 220° F., and in fact in order to avoid corrosion due to oxygen in the boilers it is necessary to heat the feed water to somewhere about this temperature.

Temperature of the Furnaces.

Linked with this figure and having a profound influence on the temperature is the figure for excess air. In most of the recorded tests the temperature of the furnace is too low, and the cause for this can be seen by studying the accompanying curves. No. 1 and No. 2 are the temperatures taken minute by minute for Multitubular and Babcox & Wilcox boilers. It will be observed how widely they fluctuate. This great fluctuation, a rise or fall of 400° to 500° F., is due to irregular feeding. Such bad feeding admits large quantities of excess air, cools down the furnace walls, and greatly lowers the output of the boiler.

This oscillation in temperature naturally is reflected in the excess air figure.

As an example of better feeding consider curves 3 and 4. In the former the variations are only about 150° rise or fall, while in curve 4 there are long periods when the temperature did not vary a degree. Indeed we thought the pyrometer was broken, so steadily did it hold the temperature.

W. Mackesy.
P. Murray.
E. Camden Smith.
J. R. Simpson.
G. Wilson.
E. P. Hedley (*Convenor*).

APPENDIX.

We have thought it worth while to include in our report a copy of efficiency tests carried out on the boilers of two industrial concerns in Durban. Complete figures are given in the case of the Thompson boiler at Hulett's Refinery, and it should be noted that it is possible to take out a test from the daily returns. That this is the case is a tribute to the method of running the plant. All the data are recorded by the controlling instruments, and Fig. 1 shows a sheet which the man in charge of each shift receives daily. He is thereby able to examine his work and compare it with that of his two mates. The system leads to friendly rivalry between the shifts.

The test recorded below shows an efficiency of 80%, but if the 2 to 10 p.m. shift were calculated out it would show that 10·2 lbs. of steam per pound of coal means an efficiency of 82·5%. In any case, both these efficiencies are splendid for an industrial concern.

The Congella Power Station shows an efficiency of 85·6%, and it is well worth visiting the Power Station to see how this figure is obtained. This plant is a typical modern boiler with water-cooled walls and automatic control of water feed. It is, of course, unique for Durban.

DAILY AVERAGES.	BOILER HOUSE.	Date **6.12.32.**
Shift.		*Copy.*
6 a.m. to 2 p.m.		*9·3* lbs. Steam per lb. of Coal.
	14·4 Tons of Coal Burned, per shift.	*270,000* lbs. of Steam Generated per shift.
2 p.m. to 10 p.m.		*10·2* lbs. Steam per lb. of Coal.
	13·5 Tons of Coal Burned, per shfit.	*276,000* lbs. of Steam Generated. per shift.
10 p.m. to 6 a.m.		*10·03* lbs. Steam per lb. of Coal.
	13·5 Tons of Coal Burned, per shift.	*271,000* lbs. of Steam Generated. per shift.

FIG 1.

SUMMARY OF BOILER TESTS.

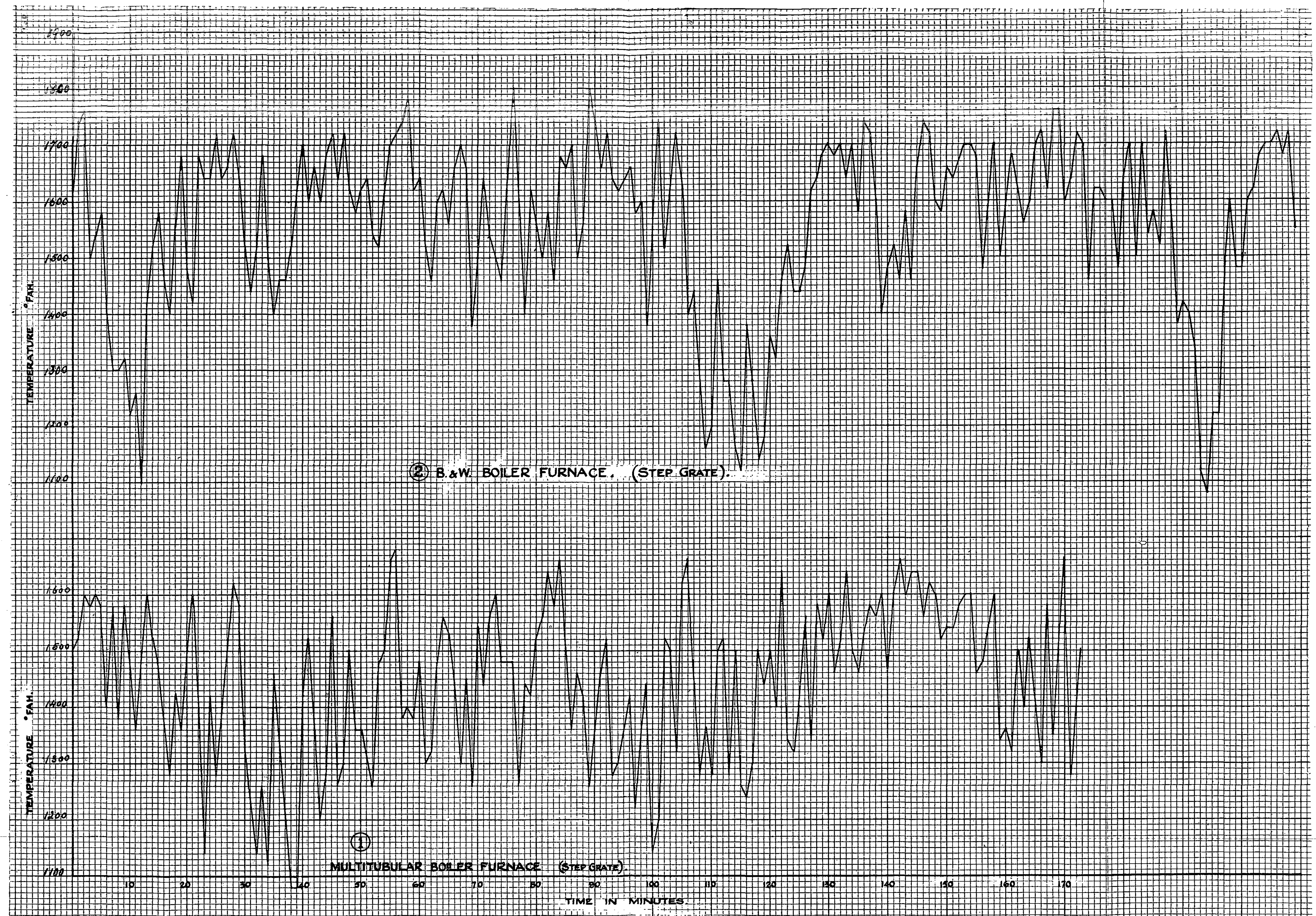
TEST NUMBER	1	2	3	4	5	6	7	8	9	10	11
Duration of test—hours	8	8	8	8	7½	7	8	6½	7	8	7
Type of Boiler	Multi	Multi	Multi	Multi	Stirling	Stirling	B. & W.	B. & W.	B. & W.	B. & W.	B. & W.
Number of Boilers on range for test	7	7	7	7	1	1	2	2	1	4	1
Heating surface, sq. ft. per boiler	2,500	2,500	2,500	2,500	3,660	3,660	2,531	2,531	2,531	14,622*	4,780
Type of Grate	Step grate	Step grate	Step grate	Step grate	Step grate	Flat grate	Flat grate	Flat grate	Flat grate	Flat grate	Step grate
Grate surface, sq. ft. per boiler	35	35	35	35	50	48	36	36	36	210†	66
Ratio of Heating surface/Grate area	71·4/1	71·4/1	71·4/1	71·4/1	72/1	76/1	70/1	70/1	70/1	‡	73/1
Combustion space, cu. ft. per boiler	256	256	464	464	675	955	432	432	432	4,000§	—
Ratio of Combustion space/Heating surface	9·7/1	9·7/1	5·3/1	5·3/1	5·4/1	3·8/1	5·8/1	5·8/1	5·8/1	‖	—
Water apparently evaporated—lbs.	405,043	443,154	496,460	488,483	99,317	76,376	163,254	118,993	64,550	299,301	115,668
Moisture in Steam %	17·8	17·1	16·2	16·0	18·8	16·0	17·6	16·5	16·4	15·7	12·9
Water evaporated—lbs. (corrected for moisture)	332,946	367,375	416,033	410,326	80,646	64,156	134,521	99,359	53,963	252,311	100,747
Feed water temperature—° F.	215	212	200	190	188	191	136	136	136	222	177
Factor of evaporation from and at 212° F. into dry steam	1·038	1·038	1·048	1·059	1·063	1·064	1·128	1·126	1·125	1·031	1·078
Water evaporated from and at 212° F. into dry steam	345,598	381,335	436,002	434,535	85,726	68,262	151,739	111,878	60,708	260,132	108,605
Steam pressure by Gauge	83	84·5	82	84·8	93	90	141	129	122	90	90
Weight of bagasse burnt—lbs.	210,000	200,870	214,600	213,800	65,326	41,701	77,451	51,630	35,120	148,375	63,430
Moisture in bagasse %	46·1	48·3	46·5	46·8	51·8	51·4	51·6	53	53	50·5	49·1
Weight of dry bagasse—lbs.	113,190	103,849	114,811	113,741	31,487	20,267	37,486	24,266	16,506	73,445	32,286
RATE RESULTS.											
Water evaporated from and at 212° F. per sq. ft. heating surface per hour	2·47	2·72	3·11	3·11	3·12	2·66	3·74	3·40	3·42	2·21	3·24
Wet bagasse burnt per sq. ft. of grate surface per hour	107	102	109	109	155	124	134	110	139	¶	137
Water apparently evaporated, lbs. per hour	7,232	7,913	8,865	8,722	13,242	10,910	10,204	9,153	9,221	9,353	16,524
Water apparently evaporated, lbs. per sq. ft. heating surface per hour	2·89	3·16	3·54	3·48	3·61	2·98	4·03	3·61	3·64	2·56	3·45
Water actually evaporated, lbs. per hour	5,945	6,560	7,429	7,327	10,753	9,165	7,643	7,643	7,709	7,884	14,189
Water actually evaporated, lbs. per sq. ft. heating surface per hour	2·37	2·62	2·97	2·93	2·93	2·50	3·02	3·02	3·04	2·16	2·95
EFFICIENCY RESULTS.											
Water evaporated, apparently, per lb. bagasse	1·93	2·21	2·31	2·27	1·52	1·83	2·11	2·30	1·83	2·01	1·82
Water evaporated, from and at 212° F. per lb. **wet** bagasse	1·64	1·89	2·03	2·03	1·31	1·64	1·96	2·17	1·72	1·75	1·71
Water evaporated, from and at 212° F. per lb. **dry** bagasse	3·05	3·67	3·79	3·83	2·72	3·37	4·01	4·61	3·67	3·54	3·36
Thermal efficiency [1]	—	47·0	48·4	48·7	35·6	44·1	53·7	61·0	48·4	—	43·3
								No.1 / *No.2*			
Temperature of flue gases, ° F.	—	500	580	—	469	462	465	435 / 469	550	—	526
Temperature of furnace, ° F.	—	1,600	1,840	—	1,656	1,854	1,584	1,748 / 1,589	1,663	—	1,550
Draught at back of boiler at flue damper—inches	—	0·6	1·1	—	1·2	1·05	0·93	0·8 / 1·0	0·87	0·4	1·2
CO_2 %	—	13·8	14·9	11·0	10·2	11·0	6·8	9·0 / 10·4	13·4	**	7·8
O_2 %	—	3·6	3·3	7·0	7·6	8·1	13·2	10·9 / 9·0	4·6	**	10·8
CO %	—	1·8	1·3	0·8	1·0	0·5	0·2	0·0 / 0·4	0·8	**	0·3
Excess air %	—	26·0	22·1	63·6	74·5	73·6	194·1	121·0 / 86·5	34·3	**	140·0

[1] Calculated on Prinsen Geerlig's formula.

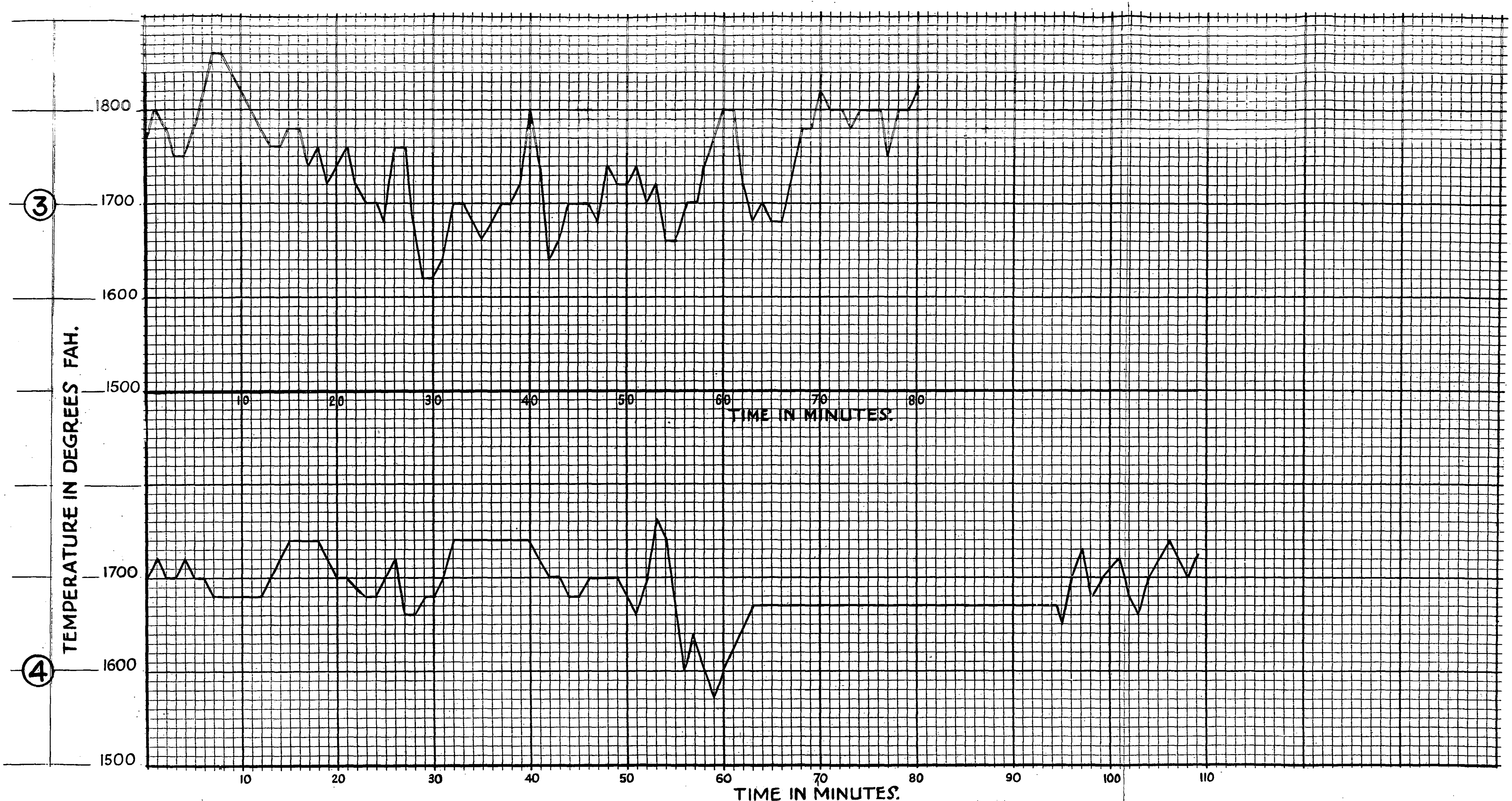
* 2 at 4,780 and 2 at 2,531.
† 2 at 63 sq. ft., 2 at 42 sq. ft.
‡ 76·0/1 and 60/1.
§ 2 at 1,250 and 2 at 750.
‖ 3·8/1 and 3·3/1.

¶ 91 lbs. Boiler No. 1.
99 lbs. Boiler No. 2.
87·8lbs. Boiler No. 3.
89 lbs. Boiler No. 4.

**	*No. 1*	*No. 2*	*No. 3*	*No. 4*
CO_2	8·6	7·0	6·2	7·6
O_2	10·2	8·0	12·0	11·4
CO	0·3	—	—	—
Excess air	118·6	114·3	193·5	150·0



FLUCTUATION OF TEMPERATURE IN FURNACES. (STEP GRATE).



B. & W. BOILER FURNACE TEMPERATURES.
FLAT GRATE TYPE.

HULETT'S S.A. REFINERIES, LIMITED, ROSSBURGH.

Test on Thompson Boiler, 25th October, 1932.

Duration of Test 7½ hours—9 a.m. to 4.30 p.m.

Weight of water evaporated.. ..	266,000 lbs.
Average weight of water per hour..	35,466 lbs.
Evaporation factor..	1·05
Equivalent Evaporation from and at 212° F.	279,300 lbs.
Equivalent Evaporation per hour .	37,240 lbs.
Calorific value of Coal	13,500 B.T.U.
Average Boiler Pressure, absolute .	211 lbs. per sq. in.
Average temperature of Boiler feed tank	190° F.
Average temperature of Boiler feed water	236·5° F. entering Boiler.
Weight of Coal burned	28,620 lbs.
Weight of Coal burned per hour ..	3,816 lbs.
Area of Grate in square feet.. ..	168 sq. ft.
Lbs. of Coal burned per sq. ft. per hour	22·71 lbs.
Heating surface of Boiler in sq. ft.	7,560 sq. ft.
Lbs. of water evaporated per sq. ft. heating surface	4·93 lbs.
Heating surface of Economiser ..	3,410 sq. ft.
Average temperature of Flue Gases	471° F.
Average temperature of Steam ..	578° F.
Average CO_2	12%.

Lbs. of Steam generated per lb. of Coal $\frac{37,240}{3,819}$

= 9·75 lbs. of Steam per lb. of Coal.

Total heat per lb. of Steam at 211 lbs. per sq. in. absolute and 578° F. Specific Heat 0·5

$= 1,199 + 0·5\ (578-387)$
$= 1,199 + 95·5$
$= 1,294·5$ B.T.U.

Heat transferred to Water per lb. of Coal—

$= 9·76\ (1,294·5-236·5+32)$
$= 9·76 \times 1,090$
$= 10,800$ B.T.U.

Thermal Efficiency $\frac{10,800 \times 100}{13,500}$

= 80% Efficiency.

Heat Balance.

	B.T.U.	Per cent.
Thermal Heat in Coal	13,500	100%
Heat transferred to Water (Thermal)	10,800	80%
Heat carried away by products of combustion	780	5·78%
Heat carried away by excess air ..	546	4·1%
Unaccounted for (Ash loss, Hydrogen and H_2O loss, Radiation, etc.) ..	1,374	10·12%
Total..	13,500	100%

Water tube boiler fitted with compartment type chain grate stoker, forced and induced draught. Integral economiser, but no preheater.

ELECTRICITY SUPPLY COMMISSION.

Test Figures from Congella Power Station.

(No. 4 Boiler.)

Calorific value of Coal	12,700 B.T.U. (as fired).
Weight of water evaporated	60,000 lbs.
Per cent. CO_2 in flue gas..	13·9
Steam pressure	267 sq. in.
Temperature of Steam	704° F.
Degrees superheat	292° F.
Feed water temperature	198° F.
Temperature of flue gas to stack	362° F.
Temperature of flue gas to heater.. ..	605° F.
Per cent. combustible in ash	10·9%
Steaming hours since last cleaning ..	547 hours.
Fineness of Coal	91% through 100 mesh.

Losses.

Ash loss	1·38%
Hydrogen and H_2O losses	4·32%
Dry flue gas loss	7·17%
Radiation and unaccounted	1·50%
Total	14·37%

Efficiency $= 100-14·37$
$= 85·63\%$.

COMMITTEE ON BOILERS AND BOILER PRACTICE.

Mr. POLLOCK: In November last we had the pleasure of a visit from Dr. Hedley to our Mill. I must say that under very trying conditions he carried out the tests very well and we are thankful as a Company for the interesting report he gave us, inasmuch as my Company has committed itself to an expenditure running into four figures for further improvements to our boiler plant, and I hope we will have the pleasure of another visit from Dr. Hedley through the season. What struck me forcibly in his recommendations was that he advocated superheaters for a low pressure multitubular boiler, and there are two or three schools of thought on that matter: My own opinion is that I do not think it an economic proposition to instal superheaters for such a boiler in commission on sugar estates, but I would appreciate the remarks of members of the Boiler Committee to enlighten me otherwise.

Mr. HESLOP: I would like to thank Dr. Hedley for pointing out the fact that 15 to 17% moisture is the figure obtained from steam generated in conjunction with water. I thought it was pretty well more than that. I thought it was in the region of

25%. Wherever steam is generated in the presence of water you get steam which is critical, which means that with any slight reduction in temperature it will immediately throw back and deposit the water. In fact it is hardly a medium to use at all. Obviously it would be better to superheat. Of course superheating then removes the steam from the critical condition in which it is, and gives it more temperature, more B.T.U.s. before it can ever reach that critical point again. This to my mind is what should be done in every plant, and I think you will go a long way in this world to find such a collection of boilers *without superheaters* as you have in the sugar world to-day. Standard practice is generally to supply a superheater with the boiler, which removes the steam from its critical state and makes it a unit which can be used properly. Therefore I should say that *all* boilers should in the first place be fitted with superheaters. Of course there is no form of separation which will take water out of steam except by superheating, simply because the steam is critical and the slightest drop in pressure will again form water, so the conclusion to be drawn is to supply superheaters. Dr. Hedley mentions that he used water meters with his test; I would like to know how they were tested and how the guarantees were made that they were correct. There is any amount of room for further development in steam use. I think that the boilers without superheaters are about the crudest form of boiler which can be used.

Dr. HEDLEY: When we first got our flo meter we got a tested instrument and we expected to get records of the feed water accurately. The flo meter after half an hour gave in, and we had some trouble with it trying to get it right and it has gone Home for a long rest. We had started on boiler tests at Sezela and so we had to do something,—the instruments were installed and the only thing we could lay our hands on was a Leeds water meter. A Leeds water meter has a large temperature deduction, it also has a vane slip. We have made the deduction for temperature, and we have slipped the slip! I know, and we all know, that these tests are not of cast iron accuracy. One thing is the difficulty in the bagasse weighing. The other thing is this water measuring. If you wished to do a dead accurate test it would be practically an impossibility at any of the sugar mills because the lay-out does not allow for the type of test which is done on a great industrial plant. The boilers are very crowded round about their feeding ports, and such tests cost a lot of money. Each test done by a Consulting Engineer costs a couple of hundred pounds, and the Sugar Industry has had these tests from the Experiment Station for exceedingly little. I was told at one mill that I went to, that they had had a consulting engineer and paid him £500 for his work. I was told he did less than I did! So you get some idea, I trust, of the value the Experiment Station is to the Sugar Industry. In the coming year, we hope to have a tested water meter. We will have to try in any case and get the Leeds water meter tested at the Assize Department. At present, many boilers are not suited for accurate testing. We have comparative results which have showed a great deal, and have opened the eyes of the Engineers and the owners to the necessity for improvements. There are only one or two boilers that are really worthy of the time and sweat that one would put into doing an accurate test. I should like to get that this year. Talking about sweat, this is an excellent job; I lost fourteen pounds in weight, and if any one of you know any young ladies who want slimming, just send them along! (Laughter).

Mr. P. MURRAY: I think we ought to thank Dr. Hedley for the painstaking job he did last year. On behalf of the Committee I personally would like to thank him very much. With regard to water and steam it was a bit of a shock to me to get the figure of 17% water. Now with regard to water in steam, is superheating steam the right thing? Have you not got to remove the water first and then superheat? What is going to happen to your superheaters with dirty water—they are going to be blocked with dirt. With regard to the water in steam, would increasing the boiler pressure not help? I think in one place Dr. Hedley went to he got less moisture in the steam with a higher pressure. The boiler temperatures are far too low. If they had a higher boiler temperature we would have a higher temperature right through and it would help to dry the steam. The low temperature in furnaces is having an effect on the steam. With regard to efficiency of the boilers, 47 or 48%, we have some boilers with Cook furnaces and their efficiency is 67.7% and there are no preheaters or economisers. I think some of the boilers being fitted with Cook furnaces will show even better efficiency than this.

Mr. HESLOP: I cannot see that any water can reach the superheater if there is no priming, and again the point I made was that steam is at a critical point, that is just a vapour, not a gas, therefore on its path through any steam range or anywhere where it gets slight compression, it must immediately revert to water, therefore any form of separation cannot apply where you have critical steam.

Mr. MURRAY: I agree with Mr. Heslop about critical steam, but the 17% water in the steam must be got rid of. I agree with superheating, I think every factory should have them, but I think we are taking a slight risk. I would like to have other people's opinion.

Mr. CAMDEN SMITH: With regard to moisture in the steam, our factory was the first on which any test was run, and when Dr. Hedley and I discovered the figure we refused to believe it as first.

I for one was very much shocked and subsequent tests proved we were quite within the average figure. It is not a matter that can be easily dismissed. It is a very important matter indeed. The presence of this moisture in the steam reflects very heavily on the efficiency. That being the case I think it is a subject we ought to have an enquiry into. As regards the use of superheaters, their use is certainly very desirable in that it recovers heat from the flue gases and puts that into the moisture of the steam, turning the whole into a gas which is of course the ultimate object of a boiler, to convert water into a working gas which can be used in the various engines and other plant. But to my mind the thing is not going to be easily solved. A Superheater is not designed to be used as an evaporator, It is intended primarily to be used as an apparatus for superheating steam, that is taking steam which has already been converted into a wet vapour and superheating it by adding the higher temperature without adding any pressure. Now the steam which is delivered from any boiler contains a great deal of moisture, ranging from 10 to 25%. This moisture is not only caused by ordinary priming but, as Mr. Heslop has pointed out, owing to the critical state of such steam there is no hard and fast line of demarkation between wet and dry steam. There is a certain belt in which it is partially one and partially the other. Unless the feed water is specially prepared, as it is in very high class power stations, that is to say distilled or otherwise carefully purified, you will certainly get trouble in superheaters owing to the presence of water which passes into the superheater and there evaporated. That is a point on which I agree with Mr. Murray. In sugar factories the water is very seldom previously purified. Of course in the present stage of the Industry we are more or less in the happy position of being able to carry on with the fuel we have without being put to extra expense in buying additional fuel, but as has been pointed out in the report these happy times will soon come to an end. Mr. Heslop is surprised that superheaters are conspicuous by their absence in the Industry, but that is explained by the fact that it has not been necessary to spend any more money! we do not want to pile up the bagasse heap in the yard. The fact of our boiler efficiency only being between 40 and 50 does not worry us very much, but at the same time we have to realise that these times will not last much longer, and we have to set to and improve our boilers and methods of raising steam. If we get the new canes supplied in the near future with low fibre content, even those factories which now manage to pile up a bagasse heap will find themselves compelled to buy extra fuel. Probably after Mr. Mackesy reads his paper there will be a discussion on the more detailed methods. Some of our methods may be open to criticism. As a general report I think this covers very well the work that has already been done this year. As Dr. Hedley pointed out some of the instruments were rather deficient and we were late in starting the work. It was early October before we got a proper start, but we hope this season and in future seasons we will be able to do work which is of far greater value and possibly very much more accurate in regard to methods of measurement and so forth. (Applause).

Mr. B. E. D. PEARCE: With regard to separating water from steam—four boilers were put in in a certain factory in Hawaii of 850 h.p. each. These were equipped with flat grates not the Cook furnace, and each boiler was equipped with a steam purifier and with a superheater. They do not state the reason why they put the two in but I take it the idea was to take the water out of the steam, and I understand the Steam Purifier people guarantee 99% dry steam before it goes to the superheater. Consequently the heating surface of the superheater I should imagine would be lower. On the question of combustion chamber, the practice of Cuba was to put two multi-tubular boilers side by side with one furnace. These were 8ft. 6in. diameter by 22 feet long. The idea was to get a bigger combustion volume. Then in Hawaii they put boilers in tandems. They had boilers 16 to 18 feet long and they put one in front of the other. The idea was to increase the combustion volume. But I certainly think that some means are worth while to take the water out of the steam before superheating.

Mr. HESLOP: The superheater *is* the separator, there is no doubt about that. Getting back to the point of the bagasse supply, the installation of a superheater only means that your square feet heating surface is increased, and the increase of the B.T.U.s. required by the superheater is reflected in the gas so whatever argument there may be about not putting superheaters in I fail to see it.

Mr. SUTHERLAND: I was concerned with Dr. Hedley in the tests on the two Stirling boilers. There has been some doubt regarding the accuracy of the water meter. I should like to point out one thing I discovered after the tests, which I communicated to Dr. Hedley, which no doubt had some influence on the accuracy of the meter. We found the strainer we had on our feed supply had broken and that shreds of grass and reeds had come through and interfered with the propeller which actuated the reading on the meter. On the face of it then these figures seemed so much out that I was looking for some cause. If you look at the Summary you will see in the case of No. 6 we attained there a furnace temperature of 1,854, we have an excess air of 73.6(we exhausted that furnace gas to a flue gas with a temperature of 462! that is particularly low. Now out of interest I took out the actual bagasse firing rate and found it to be for 1,000 sq. feet of heating surface 708 lb. of bagasse per hour. If you look at No. 2 they only managed to get 1,600 for the furnace, they exhausted to 500 in flue gas! their burning rate was 742lb. which was very close, yet the efficiency comes out in the end to 47 as against 44. If the flue gas analysis has been taken accurately we should be able to get a fairly rough check back from our flue gas, etc. If we do that we find that those efficiencies—I speak of the percentage of heat in the furnace taken out by the boiler—No. 6 gives something like 65 whereas the other gives us 56. That shows there has been something wrong somewhere or other; whether there has been more excess air in the one case than the other I cannot say. I merely mention this out of interest because the figures taken as they stand I do not think can be looked upon as truly accurate or a true reflection of the one boiler to the other. In this case I put the discrepancy down to the fact that grass and such things were going through which had hung over the guide vanes. I understand this report was brought about primarily to try and improve conditions in various factories. In the past we have worked in rather a slipshod way because the cost of the fuel has been nil so far. A very easy method perhaps of obtaining higher efficiency would be to concentrate more on getting as high CO2 content as possible and elimination of the carbon monoxide which we see in most of these, and also as high furnace temperature as we can. That particular boiler No. 6 was given a very big combustion space in relation to the pounds of bagasse burnt, much more so than any of the others. You can see that from the chart. There are two boilers side by side, 5 and 6, one having 675 and the other 955 cubic feet combustion space. That seems to give a much higher furnace temperature. It is on lines like that that we might be able to achieve some improvement. Certainly we need a lot of improvement in moisture in steam. We say we have 16% moisture in steam, that means 16% of the apparent weight of steam goes down the drains and through the steam traps. If we were to try and concentrate on higher furnace temperature as high as CO2 as possible, we would probably make a cheap start towards improvement in our boiler efficiency in the Sugar Industry.

Mr. DAMANT: I would like to thank you for your invitation to be present to-day. I have studied this report very carefully and I find there is an enormous amount of very valuable information contained in it. I would like to congratulate you on the progressive movement you have made in appointing this Committee, and I am very glad to hear that it is your intention to proceed with this work in future. It is not only the question of efficiency of the boiler which one has to take into consideration in matters of this nature, because as some of your members have pointed out bagasse costs you nothing so why worry. There are other and many indirect infiuences, benefits which you would get by developing this progressive efficiency propaganda, namely, the psychological effect on your staff, saving in materials, less use in machinery and so on. There are many advantages that will immediately arise out of any policy such as you are now pursuing. It is not my intention to discuss this report in any technical detail, but I would like to say that although the report contains very much valuable information I very much regret to see that the Committee have not gone so far as to draw conclusions from the figures which they have obtained. As Dr. Hedley points out it was their deliberate intention not to do so in the report, but I think the value of a report of this nature would be considerably enchanced if the Committee had done so. Studying these figures, the most important figures of course are the overall themal efficiency, and as has been generally acknowledged these figures are extremely poor. It must be recognised that the efficiency which you can possibly obtain with bagasse firing cannot reach those figures which we are able to show for coal firing. I have roughly estimated, assuming a bagasse of 50% moisture and a temperature of 500° that your maximum possible overall efficiency is only about 67%, so that this boiler No. 8 which is showing a figure of 61% is a comparatively good boiler; there is only another 6 or 7% assuming the fuel they are using is a fuel similar to that which I have assumed. With regard to No. 6 I entertained some doubt myself when I read those results as to the accuracy of the test. It seemed you should have got a better result. Mr. Sutherland has pointed out certain points in regard to that, and it would appear from those figures that the efficiency should be considerably better than 44% The only doubt in my mind was as to the amount of smuts or unburnt fuel sent up by the stack. Mr. Sutherland has assured me that his combustion volume is considerably greater than other boilers. It would seem that his loss there is no more than the average, so one wold expect from those figures, a better efficiency than 44%. If you study those figures a little further, you will see that Nos. 2 and 3 are running very high CO_2, thus they have very little excess air. In addition, their CO is comparatively large. All indicates that there is incomplete combustion in those two boilers, and that they could with advantage increase the quantity of excess air.

You can argue right through that list. You will see that the best boilers 7 and 8 show a very low CO_2 content in the offtake gas and low CO_2 indicates the excess air is considerably over 100%. The indication or lesson to be learnt is that generally speaking the boilers are being starved of air and that they could with advantage increase the amount of excess air and reduce the amount of unburnt fuel in the gas. I should have liked to have seen an analysis of the bagasse or average analysis. I do not know to what extent these various bagasses vary. If one has an analysis of the fuel, one can determine fairly accurately what loss to expect, and so you can theoretically work out exactly what losses are due to be found and ultimately discover what losses are being found, and then determine what savings can be made and what steps should be taken to effect those savings. I think every

Engineer should be provided with such apparatus and instruments—the cost is trivial compared with the amount of saving that can be effected. Every Engineer should be given those instruments so that he can keep a daily check on the losses that are going on in his place so that he can check up his affairs exactly as an auditor or accountant would check up his own affairs. (Hear, hear and applause).

11.10 adjourned for tea. Resumed 11.25 a.m.

Mr. Damant left the Congress before the resumption

Dr. HEDLEY: I am sorry that Mr. Damant has gone. It was very good of him to come and speak. He says he is sorry we did not draw conclusions. Well we did; after every test a report was made to the factory concerned and the coonclusions from those figures sent to them, and as a result of that work, I think every factory has done something to improve its boiler plant. Mr. Damant referred to the carbon dioxide and carbon monoxide. Well every Engineer knows that you want the highest carbon dioxide possible. Here is a sheet which has not been published, giving calculations on the efficiency from a heat basis, and the CO loss in one of the factories he referred to, which was 1.8%, meant an actual loss in efficienc in heat loss of 7.8%.That is a very big loss and shows what a low percentage of carbon monoxide can effect.

Mr. Damant asked for an average analysis of bagasse. I am not going to give it now—you can find it, it is in "Noel Derr," who gives an average analysis. I am very glad to hear Mr. Damant say that every Engineer should have these instruments. One factory knows the value of them—Mount Edgecombe. They have spent hundreds of pounds on these instruments and have brought their boiler installation up to a high pitch of efficiency because they are able to control and find out where losses are, in a way that is utterly impossible without having these instrumens. Mount Edgecombe have also got a preheater, superheater and economiser. That will be referred to in the next paper. I do not know whether you know the way the power station is run at Congella; it is run by these instruments. An instrument is set at a definite carbon dioxide—I think it is 13.9%—and in automatic control with that is the feed water heat, the excess air, and the fuel. All these things are integrated and from that percentage of carbon dioxide, these other things which bring and make that carbon dioxide are controlled, and that is the highest pitch of boiler control that is possible. It is not a thing that you can introduce into the Sugar Industry probably straight away, but when the fuel question becomes pressing it is a thing which might be looked into, and it should be quite possible with bagasse, but you will have to do some experiments to reach that condition.

There are one or two other things which I should like to draw attention to. There is the question of the saving on feed water heating. If you look at this summary, you will see in some cases the very low temperature of the feed water. In a certain factory, the feed water is 136°. You can calculate that out quite simply to show that if that 136° was fed at 212°, which is perfectly possible, these would be a saving of 7% fuel. You do not want it perhaps, with bagasse in its present condition, nevertheless, there is a point where you can save fuel when the question comes to save it. But it, nevertheless, leads to efficiency to heat your feed water in this particular way. Another thing, the present wells from which feed water comes, the hot wells, are mostly open to the air, and that is utterly wrong. They should be closed to avoid introducing oxygen into your feed water. By introducing oxygen, the boilers become pitted and bring about the troubles of corrosion. It is a very easy matter to enclose these and pump from them; that is the water from the callandrias, steam traps and so on, pumping them through a feed water heater and thence to your boilers That is an efficiency stunt which may not increase the efficiency of the boiler plant as shown by the figures, but it will undoubtedly increase the life of your boilers. There is a great deal of advice like that, that we could have given, but we are leaving it to you people to raise the questions and we could answer them as they were brought up.

Mr. P. MURRAY: With reference to Mr. Damant's remarks, he said the maximum efficiency possible with bagasse was 67%. I do not think he has enough knowledge of bagasse to know the true value. I quite appreciate his remarks about putting in instruments and so on. With regard to Mr. Sutherland's remarks, he talks about the volume of furnaces. He gets better work with the second furnace. It depends where that volume is. A furnace consists of the combustion chamber proper and the expansion chamber behind it. If he has the first combustion chamber very small it would be a good producer. If he does not admit air into the second chamber, I do not think that furnace is going to be very efficient, although it has plenty of volume. Care must be taken that the first chamber is big enough; you cannot have them too small. The actual cubic capacity of furnaces is not in itself right; you must know the actual facts where the volume is.

Mr. SUTHERLAND: My remarks regarding combustion chambers were more or less general. As a matter of fact, air is admitted, and I found that when admitted, the temperature definitely went up, showing that the air improved the combustion. The flue gas analyses were not taken before and after, so I have not a definite check whether it was a more complete combustion or more fuel burnt in a given time. Apart from that, the comparison I made from those two boilers was just in a rough practical way, to state, that with more excess air a higher furnace temperature results and a lower flue gas temperature; that your smut loss is not greater, that your radiation is not appreciably different; also with regard to those flue gas analyses, that calculation has not been upset due to introduction of air, so it shows that the one must be the better boiler or the boiler with the highest efficiency. This was a "Stirling" Boiler, which as we all know, is a good one.

Mr. WATSON: I wish to object to a statement made by our Technical Secretary, Dr. Hedley; he said it was very unfortunate that the delegates who went to Puerto Rico, were not in a position to supply anything in the way of Engineering knowledge. I myself, regretted very much the impossibility of my going there, but I delegated to Mr. Dymond, a certain duty, which he carried out very faithfully, and if you care to refer to the copy of the report of the proceedings overseas, you will find that he has got a whole lot of very useful information which he brought back from overseas, including Trinidad and Puerto Rico. All members have received a copy of this report, I believe. Looking over the figures here, I see that the ratios with regard to grate and combustion chamber and everything, compare closely with our own figures. At the same time, I am of opinion that our combustion area is too small. You will find in Dr. Hedley's paper, that generally speaking, the boilers with the biggest combustion area are the best steam producers. Mr. Sutherland mentioned No. 6 with a ratio of 3.8/1 as beig one off the best boilers under test. That seems to indicate that our combustion volume is too small. At Sezela, I understand they made rather a big change. I wonder if Mr. Camden Smith found, that increasing the combustion volume increases the efficiency to any extent.

Mr. CAMDEN SMITH: Undoubtedly! With what we call the old set of boilers, we have their furnaces very close up, with comparatively no combustion space, we found the combustion was always incomplete and we are altering them to the newer setting, providing a larger combustion chamber.

Mr. WATSON: I think there are two factors to be taken into account with regard to dry steam. First, the quality of feed water and second, the capacity of your boiler plant. In the first case, the purer the feed water the less chance of entrainment I take it. At Amatikulu, we are drawing the whole of the feed water from the condensate of the factory, and practically nothing from the river. With proper chemical control of the condensate, we find no reason to draw any water from other sources, we have far more than necessary. So if we take care of all the condensate from the factory, we have a supply of distilled water to go into the boilers which should be very much better than anything you can get from a river or anywhere else.

Then there is some talk about oxidation. At one time, we had cast iron feed tanks, and pitting in the boilers was brought to my attention; the cast iron tank was not big enough and we put in a steel one, and straight away the corrosion in the boilers was reduced. On top of that we had hung steel plates in the tank, and apparently if you have a steel feed water tank with sufficient surface in it, you will practically absorb all the oxygen in the feed water and instead of the corrosion taking place in the boilers, it takes place in the feed water tank. Well we would rather have it there than in the boilers.

In view of the particulars which I have got here, we are under-boiler powered. Practically every factory is. That is to say, we have to force our boilers, and if you do that you are bound to get entrainment and wet steam. At least that is my opinion. But we have not come down to a definite figure for boiler power per ton of cane per hour. I would like very much, if some of the engineers would give us their opinions as to how many pounds of steam are required to treat a ton of cane in this country. I am definitely certain every factory in the country is under-boiler powered.

Mr. W. A. CAMPBELL: As a layman, I am very glad to hear Mr. Watson say that most of our boilers in this country have not sufficient combustion space. I regret very much that Mr. Townsend is not here. I have had a considerable amount of experience with furnaces ever since I started work. It might interest some of you here, that Mr. Townsend, at Sea Cow Lake, was the first miller to work the green bagasse furnace. Other mills in the country were drying their bagasse, but Mr. Townsend started the green bagasse furnace at Sea Cow Lake, many, many years ago and he stopped getting extraneous fuel and he had wonderful steam. We had no instruments in those days. I was then managing Prospect Hall, and had the devil's own job to get sufficient steam. I had four trash carts bringing fuel. In the course of conversation in the train, one day, I mentioned this. Mr. Townsend said he would come along one day and take the measurements of the furnaces. He came along and said, "you have no room, no combustion." I remember Mr. Townsend's furnaces. He fired 30 feet from the boilers, his step grate and his arch ran parallel. That was his secret, and by the time the flames got to the boilers they were white. I pitched those furnaces out at Prospect Hall, and in one place I was able to fire 30 feet from the boiler and the other was 28 feet, owing to some machinery being in the way. Prior to the alteration of these furnaces, we had an enormous amount of smut coming up the chimney, the factory was always belching forth black smoke. When these furnaces were altered we hardly had any smut coming out of the chimney, and I think Mr. Townsend would tell you that at his own factory, he did not know what smut was. I took away the four trash carts we had, and I had to put a cart on daily, to take away the surplus bagasse. When Prospect Hall was dismantled there was an enormous heap of bagasse.

I remember afterwards, Mount Edgecombe following suit, in putting in furnaces. Unfortunately, they put furnaces with very little combustion space and we had an awful job for years to try and put this right. There was not the room, and we did our best to step the arch down, but even now certain of the boilers there, have not sufficient room to enable us to bring the furnaces out to give more combustion area. It is very noticeable in one particular boiler. I just wanted to tell you of practical experience, following out what Mr. Watson says, and I am certain that if some of those factories could go back to the old West Indian idea, and bring the furnace 30 feet out with your multitubular boilers and step grate, and run the arch parallel to your step grate, you will find a difference. (Applause).

CHAIRMAN: Mr. Watson has referred to certain data which I was enabled to bring back from Puerto Rico. I am very much indebted to to some of the Engineers in Trinidad and Puerto Rico for that information. Mr. Watson gave me an Engineering questionnaire, which the Chief Engineer at St. Madeleine, Trinidad, and the Central Organisation in Puerto Rico, which handles all engineering problems in Puerto Rico, kindly filled up for me. That data is included in the Puerto Rican Report. There is a matter from the chemical side that I would like to bring up in connection with boilers. In Puerto Rico, the fibre ranges in 43 central from 11, sometimes 10.5 up as high as 20. There is a certain amount of doubt in my mind as to the accuracy of some of the fibre figures that we see published. Some time ago, I remember reading a report on the estimation of fibre in Cuba, and it was contended that the formulas used, gave too low a figure, and while in Puerto Rico, I had that impression confirmed, because in very few places do they have water meters or scales for weighing water, and they have various formulas for arriving at the water and the fibre. There are one or two points that struck me as regards the practice in Puerto Rico. One was the intense regard they have for condensates. They utilise every available condensate for bolier feed water. The second point was the general use of pre-evaporators. In a few factories, they use excess fuel, usually in the form of crude oil, and the last point I noted was that they have no pre-heaters in Puerto Rico at all.

Mr. CAMDEN SMITH: In regard to the use of condensate water in a boiler, I presume Mr. Watson refers to the water from the first three vessels of the evaporators.

Mr. WATSON: To-day, we do not worry where it comes from. The pH of the water from the last vessel of the evaporator is round about 7.4 to 7.6 and we take in water from anywhere. I see Mr. Stoddard here from Felixton; he uses practically no steam in the boiling house whatsoever, it is practically all vapour from his pre-evaporator, and I think he takes back everything, whether from first, second or third bodies. It is all distilled water, and provided we get complete chemical control over it, there is no reason why we should not use it. We have the opinion of the Boiler Inspector or Inspector of Machinery to say that he is satisfied that is the best source of boiler water. Thus it does not matter which vessel it comes from. Under our conditions of clarification, we get condensate from the last vessel about 7.4, 7.6, which is quite good for boiler water, although I read in the "International Sugar Journal," that they reckon 8.2 as being the optimum pH for boiler feed water. I think that is too much on the alkaline side.

Dr. HEDLEY: I should like to tell you in this connection that I think it was a little argument that Mr. Bihl and I had three years ago, that converted Mr. Rae. I noticed that in a Beet factory, in England, they were returning the quad water to the boilers, and we tested our quad water and I suggested that Mr. Bihl should do it. He preferred not to do so as he thought the water was acid. Ultimately, we got down to the fact that in the days gone by, when white sugar was made, the water was dangerous, but to-day, when cargo sugar is made, the water is perfectly all right and I think it was three years ago, they started using it as a result of that discussion. Mr. Rae was rather nervous at first. I asked him about it and said "which would you rather have, a dam water or distilled water." He said he would prefer distilled water every time and I told him distilled water is always acid. The water that is distilled through the quad is alkaline because of the decomposition of various ammonia compounds. It is really ammonia that is responsible for the alkalinity. Even if you had 8.2, I do not think it would be very dangerous, because it is ammonia. If it was caustic soda, then it might be toublesome in time, but of course that is impossible in the Sugar Industry.

Mr. BIHL: About four years ago, we had difficulty with steam and we decided to go into the question of using condensate. I was prepared to use the water on condition that I could get a guarantee that that water was suitable. I was not going to take a chance of getting acid water. That assurance was given by the Chief Chemist, and for three years we have used nothing but condensate from the evaporator, with excellent results. Mr. Rae is quite satisfied, and we have not had any trouble. We put up a big boad on the wall and the pH of the water is put up every hour. We have had no difficulty at all, since using it. In regard to wet steam, I fully agree with a superheater in a decent boiler, but I cannot see where it will help us to-day, with our multitubular boilers, the way they are installed in some of the older factories, where there is no room to alter the boilers. Coming to the question of boiler power; for years we have referred to the square feet of heating surface. Looking at the chart of Dr. Hedley's paper, we see a figure of 3 pounds for multitubular boiler and 4 pounds for a water tube boiler. It is necessary to go into the alteration of boilers before we can overcome the difficulty of moisture.

Mr. WATSON: We have Mr. Campbell and Mr. Simpson here from Mount Edgecombe. The methods of clarification there, are on the lines of making white sugar. I would like to know whether the evaporator water from the last vessel condensate from Mount Edgecombe is acid or alkaline.

Mr. RAULT: It was a surprise to me to find the composition of those waters three years ago. In sugar literature, generally the waters from the evaporator are called acid waters, even in defecation mills, where no sulphur is used. In Java, they are called acid waters, and most Engineers and Chemists are afraid of them. We too, were very much afraid of these waters for boiler purposes, and we were speaking from experience, because at one time we had to run the water on to the floor and a piece of sheet iron left by the drain would be corroded in no time. Further, this water was also used as masceration water and we found all the meters were worn out and the links on the bagasse carriers. So that after a time we decided to add lime to these waters to make them more alkaline. Accidentally one day I found the water was alkaline although no lime had been added. I did some tests n the laborartory, taking a glass vessel I imitated as closely as I could factory conditions of boiling and regulating the distillation to 5, 15, 25 inches of vacuum. What happened was the first distillate, say 10% only, was acid in the case where we had an acid juice, but that did not last very long. After having distilled the first 10% the rest of the water became alkaline and to a fairly strong alkalinity, pH 8.0; so that when everything was mixed together, if you were to take a test of the mixture you would have an alkaline reaction, but that alkaline reaction would probably be the result of a mixture of an excess of nitrogenous bases with oxy-acids of sulphur. There is still some danger no doubt in using that with the high temperature of the boilers. We are still rather afraid to use it, and are very pleased to hear that Messrs. Huletts have had experience of this and have had no trouble.

Mr. CAMDEN SMITH: In the first place I brought up this point because our experience is that we cannot get an ordinary discharge tube to last more than a season, the corrosion is very definite indeed. Of course it must be remembered that our process of filtration is designed for the manufacture of white sugar.

Mr. RAULT: Mr. Watson made the statement that we are generally short in boiler capacity and when we force our boilers we entrain. A way to trace entrainment would be to put foreign matter in the boiler and find whether the added material goes all over the steam pipes. We have noticed that as soon as we get any sugar from the pan or in any other way into the boiler it is immediately drawn all over the factory. If you were simply using your boiler to produce steam and not water, and distilling steam only it would be impossible to find sugar all over the factory in the steam mains. Therefore it will be found that your boilers are really producing a lot of liquid and carrying sugar that has found its way into the boiler and through the steam pipes. We know when you get sugar in the boiler you get foaming, but it is quickly over.

Mr. WATSON: That is what I stated, that if we get pure condensate water we will have no foaming and no waste of any kind whatever. We will get clean steam and therefore less carry-over as Mr. Heslop said, of moisture in the steam. As Dr. Hedley has pointed out, one of our biggest troubles is the moisture in the steam; one of the most important recommendations the Boiler Committee make is to see whether we cannot get drier steam. If we get clean water to make our steam and do not force our boilers then we should get drier steam.

Mr. HESLOP: It is definitely laid down the density of the water should not exceed a certain figure, otherwise you will get priming and it is very critical. You must keep that right. The other point I would like to make is, when you talk about increasing your combustion space, do you mean increasing your grate areas or your cubic area of your chamber?

Mr. WATSON: In looking through the report I find that the Committee have put down figures which are almost comparable until we come to No. 10 which is a combination of 4 boilers. Unfortunately they have not worked it out in square feet per ton of cane per hour. Looking through the report on factories in Trinidad and Porto Rico it is almost exactly the same, that is grate area per ton of cane per hour. You should have the combustion area outside the furnace itself, on the other side of the brick wall is definite.

Mr. HESLOP: I want that definitely fixed because if you increase your grate area you must throttle down your combustion space until you obtain the highest furnace temperature, and then you must get the full output of your boiler with the greatest furnace temperature.

Mr. WATSON: Would you infer that we should confine our actual grate area?

Mr. HESLOP: You should make two separate units, you should have an area for your grate and an area for the mixture of your gas. Those should be two separate things.

Mr. WATSON: I find the average for Natal, the ratio of grate area to heating surface, is 1 to 17, and in the West Indies practically the same, but it seems to be a question of where that volume is allowed; whether it should be actually in the grate itself or in the combustion chamber.

Mr. HESLOP: If your grate is burning a certain amount of fuel you must throttle that grate or the area confining that grate until the highest furnace temperature is obtained, and then regardless of what your boiler takes if your back end temperature is down to say 300 you know that that grate area and combustion area of the grate is too small, it must be increased and it also controls your excess air. That is the point I want to bring out.