Steam Balance.

Including Boiler House Efficiency.

On resuming at 2.30 p.m., the Chairman called upon Mr. P. Murray to read his paper on "STEAM BALANCE INCLUDING BOILER-HOUSE EFFICIENCY."

Mr. P. Murray prefaced his paper by saying that the Committee were supposed to have prepared a paper on this subject, but, he was sorry to say, owing to various reasons, they had not been able to do so. Some of the Committee had been able to do a certain amount of work in connection with the subject, but, he was afraid, not very much; but he hoped that before next year they would be able to compile a lot of information on the matter. It was rather a big question; one which would involve a great deal of work. So he thought that. by leaving it over for another year, they might be able to produce something interesting next year; but it was thought that as they had already written two papers—one last year and one the year before on this subject, it would be worth while discussing the subject at that meeting. He thought it was a good idea to discuss the whole of the papers read previously in order to see if they could find out anything to help the boiler plant. Since the paper read last year some interesting work had been done with preheaters, especially at Darnall. They would see from the paper the results of the test taken at Darnall. He had got the figures from the agents. Those tests had given them a lot more information than they had last year. All those they had last year were purely theoretical. Now they were getting down to facts and he thought the matter was becoming quite interesting. The main facts brought out regarding the preheaters, were, as follows: The saving in fuel, extra steam raised per lb. of fuel, the increased efficiency and the increased evaporation per square foot of boiler surface. The boilers at Darnall with preheaters were giving over 5 lbs. per sq. foot, a remarkable figure, and this with a flue gas temperature leaving the boilers at 492°F. 492°F. was a fairly low temperature, and still they got about 5 lbs. per sq. foot, which was pretty good. One would have expected the exhaust gases to have had a higher temperature to get this evaporation. It was quite interesting to know how that 5 lbs. had come about. There must be some fact which gave them that increase in evaporation. They said something about the temperature being higher and giving a radiant heat and a bigger transmission. Those were things which they had no actual data or proof of; but they were actually getting a very big figure in evaporation. The main fact brought out was the saving in fuel. He thought at Darnall they were under boiler-powered, and they would not get such a saving in fuel there as they should have got. The preheater would give them the capacity of steam which they wanted and would help them a long way; they would get a big increase in efficiency and an increase in the evaporation per sq. foot of boiler, but whether one should instal a preheater in this country or an extra boiler to get more steam was a different question. In this country they had plenty of fuel, and he did not think it was necessary to instal a preheater unless it was cheaper than installing a boiler. But that was a point they needed to find out for themselves. In Cuba and other countries where they were short of fuel, preheaters must be the thing to instal.

There was another interesting point. Mr. Hutcheson, of Umfolozi, since the last meeting, had written a very interesting paper on Fuel. He thought Mr. Hutcheson was to be congratulated on that paper which had been published in the *International Sugar Journal*. The paper showed the kind of men we have in Natal.

Turning to preheaters, again, he said that they also could give one a saving in fuel. He had a visit from a continental gentleman the other day, who had said that he was supplying locomotives to Java which use bagasse as their sole fuel. It was worth while, said Mr. Murray, for the sugar people to consider starting locomotives here of that kind, and so saving expense in coal. At the present moment, he had not very much information as to how they fired that fuel, but he believed it was pressed and fired in the form of briquettes. It should be cheaper than coal. But that was a point they would have to go into. The Committee would like to have a full discussion on boilers.

The first point that came up was the heating surface required per ton of cane for sugar factories. He knew here that this ran up from 360 to 650 sq. ft. or something like that. He thought that point should be discussed with them all. If they had got less than 500 sq. feet, then they were not burning their fuel efficiently. Last year they calculated that 595 sq. feet of heating surface per ton of cane was required to burn the fuel efficiently.

With regard to this point, he had a letter from Messrs. J. L. Hulett & Sons, Ltd., which might be of interest. He would read it:—

The Secretary,

S.A. Sugar Technologists' Association,

344, Smith Street, Durban.

Dear Sir,—With reference to your letter of the 2nd. ulto., asking for information with regard to the working of our boilers and preheaters control, we have pleasure in reporting as follows:—

Amatikulu: During last off crop an extra boiler was installed, bringing the number up to nine, each of 2,300 sq. ft. heating surface or a total of 20,700 sq. ft. The cane crushed per hour averaged 52 tons, thus giving practically 400 sq. ft. per ton of cane per hour.

It had been quite evident in the past that we had insufficient boiler power at this mill and the installation of this boiler proved of great benefit, no steam troubles being experienced at any time during the crushing season.

A 96 in. Howden Fan was also installed to deal with the flue gases from five of the boilers, it being our considered opinion that the chimney would be overloaded if dealing with the gases from all nine boilers. The erection of this fan was not completed until some time after crushing operations had commenced, and a very decided improvement in combustion and steaming was immediately evident as soon as the fan was put into operation. So much was this so, that we were able to shut down the Ljungstrom Air Preheater which had previously been operating on one boiler.

Our experience of the fan warrants us making the statement that it is a very much better proposition than a large chimney under natural draught.

With the increased boiler power and the fan we were able to cope with any sudden call for steam, and what was also very important, we were able at any time to shut down a boiler so that fire bars and tubes could be thoroughly cleaned at will.

With regard to the operation of the Preheater, we have to say that no extensive repairs were found necessary after one year's work. Some of the elements were found burned in places, due perhaps to having been clogged with partly consumed fuel, but we understand that the elements now supplied are of larger corrugations and that there is now little danger of choking. We hope at a later date to supply you with more detailed information with respect to the larger preheater in operation at our Darnall Mill. In the meantime we trust that this short report will prove of some little use to your members.

Yours faithfully,

for Sir J. L. Hulett & Sons, Ltd.

Members would notice that they had 400 sq. feet. If they had more heating surface, he thought they would do still better.

Another thing was the grate area. He had just jotted down some rough notes so as to bring the points up for members to say something about them.

The grate area should be 1/100th of the boiler surface. If the boiler surface was small, then less than that, down to say 1/80th and up to 1/120th where there was ample surface. 1/100th gave 100 lbs. of fuel per square foot of grate area, and perhaps it would be better to use that figure when basing on plants with preheaters. The plants with preheaters were totally different from ordinary boilers. They needed to consider them separately. It was a question of burning so much fuel per square foot of grate rather than per square foot of boiler, he thought.

Another important point was the capacity of the furnace. They put down last year a certain capacity; he thought it was 3 cubic feet per 12 sq. ft. of the boiler. Well, that was a fairly big size; but he thought most of the furnaces in this country were far too small. He thought that was a point that those present might say something about, because most of them had had experience of those things. They could increase the capacity of a furnace by pushing the furnace further back, or lowering it down a bit or widening it. In pushing it further back, they might contract the cross-section of that furnace and make it too small by contracting the area. He thought that had been done in some cases here. The same thing with the areas of the flues; and he thought in a lot of cases here the boilers were put down for a certain capacity of plant. Those plants had been pushed up, increasing their capacity enormously, without increasing the flues. The flues in those boilers were far too small; and, he thought in a lot of cases they should go into the size of the flues and see if they were the right size. The figures they gave last year were for that purpose. He did not think there had been any comments regarding the figures they put down, and they would like something said about them, telling them whether they were right or wrong, or something of that kind.

The other matter was whether one should have natural draught or mechanical draught. That was a question which it was not so easy to settle. Mechanical draught gave complete control over a boiler; but a big enough chimney, gave the same control. In most of the cases where they had put in mechanical draught, the chimney had been too small. When they put in the fans, they found a great improvement. If they had put in bigger chimneys at first, there would not have been so much call for mechanical draught.

They would notice from the paper that he had drawn a comparison between Hutcheson's figures and the figures they prepared for last year's paper. He had merely put them down for the purpose of comparison. They would notice that Hutcheson gave 539 sq. feet per ton of cane; their figure, was 595. With regard to volume of gas per lb. of fuel. Hutcheson had worked out 169 cub. ft. at 500°F.; they had worked out 184 cub. ft. at 600°F., up to 418 cub. ft. at 1900°F. He thought the whole of the figures worked out pretty well, as shown by the following table:—

Item.	Hutcheson 1926 Paper
Moisture in bagasse . .	48%
Exhaust gas temperature	500°F.
Heat available from wet bagasse	3609 B.T.Us.
Excess air	100%
Amount of air required per lb. wet bagasse	5.8 lbs.
Volume at 80°F. of -do- in cubic feet	78.8
Volume of gases per lb. fuel	169 cub. ft. at 500°F.
1 lb. bagasse (wet) evaporates lbs. water	2.3
Wt. of gases per lb of fuel	6.726 lbs.
1 sq. ft. heating surf. of boiler evapor. per hour	2.9 lbs.
H.P. per ton of cane per hour	45.3
Sq. ft. H.S. per ton of cane per hour	539

Item.	Paper
Moisture in bagasse . .	49%
Exhaust gas temperature	550°F.
Heat available from wet bagasse	3600 B.T.Us.
Excess air	100%
Amount of air required per lb. wet bagasse	5.76 lbs.
Volume at 80°F. of -do- in cubic feet	—
Volume of gases per lb. fuel	184 cub. ft. at 600°F. 418 cub. ft. at 1900°F.
1 lb. bagasse (wet) evaporates lbs. water	2.23
Wt. of gases per lb of fuel	6.755 lbs.
1 sq. ft. heating surf. of boiler evapor. per hour	2.5 lbs. Nor.
H.P. per ton of cane per hour	49.5
Sq. ft. H.S. per ton of cane per hour	595.

The Technologists' Association had received a letter from the representative of the Howden-Ljungstrom Air Preheaters (Land) Limited, which he would read:—

The Acting Secretary,
The Natal Sugar Millers' Ass'n.,
344 Smith Street, Durban.

S.A. SUGAR TECHNOLOGISTS' ASSOCIATION
COMMITTEE ON STEAM BALANCE INCLUDING BOILER HOUSE EFFICIENCY.

Dear Sir,

Re Sugar Congress 1927.

We have to thank you for your letter of the 2nd. inst., with reference to the operation of Howden-Ljunstrom Air Preheater, and in reply have much pleasure in enclosing a report and results which have been obtained.

We trust that these will be in time to be used in this year's report.—Yours faithfully,

G. H. Langler & Co., (Natal) Ltd.,
B. K. WARD, Managing Director.

9th February, 1927.

Howden-Ljungstrom Preheaters, Results for 1926.

Within recent years rapid progress has been made in the combustion field and particularly has this been the case with regard to the use of highly preheated air.

The result has been that the Howden-Ljungstrom Air Preheater has come to the fore and marks the greatest single advance yet made in economical power production.

Recently the Howden-Ljungstrom Air Preheater has been installed in South Africa on boilers burning bagasse as fuel and excellent results have beeen obtained.

At Sir J. L. Hulett's Mill, Darnall, a preheater is running in conjunction with six multitubular boilers, and the test results shew that with the preheater in operation a boiler efficiency of approximately 83% was obtained, whereas without the preheater the boiler efficiency was in the region of 64%. This shews that with highly preheated air the improvement in combustion is very marked indeed. The following are the various temperatures taken on the preheater during the test and shew the high heat recovery effected by the preheater:—

Temperature of air entering preheater . . °F . . 75
,, of gas entering preheater . . °F . . 550
,, of gas leaving preheater . . °F . . 220
Heat recovered by the preheater . . . . . % . . 69.5

At the Mount Edgecombe Mill of Natal Estates, Ltd., two experimental preheaters were installed by the manufacturers to work in conjunction with the two B. & W. boilers. Preliminary tests on these resulted in an efficiency being shewn of approximately 87% whereas with the boiler and economiser only 69% was obtained. These preheaters which were of a different type to that installed at Darnall had, however, certain mechanical parts of a more or less experimental nature and these in practice gave trouble which resulted in the preheaters having to be shut down on many occasions. As a result this type of preheater has been taken out and a preheater of the same pattern as installed at Darnall has been ordered. This is now being manufactured and will be installed for next runing season. That the preheater is satisfactory for use in bagasse fired boilers is evidenced by the fact that the Natal Estates even after the mechanical trouble they experienced last season have decided to instal one of the same high efficiency pattern as supplied to Darnall. A further preheater of the same pattern as this latter has been ordered for the Umfolosi Mill. This is now on the water and will be erected and in operation in a short time.

With regard to the Howden-Ljungstrom Air Preheater running on coal-fired boilers we have a preheater installed on a 60,000lbs., per hour boiler at the Sugar Refinery at South Coast Junction. Up to date no test figures have been obtained but the improvement in the combustion of the fuel when the preheater is running is apparent. Experiments will shortly be carried out with the low-grade coal of an anthracitic nature found at Somkele. This coal is extremely difficult to burn under ordinary conditions, in fact experiments in the past with this fuel have been most unsatisfactory. With the advent of highly preheated air, however, fuels of a much more unpromising nature than this have been burned with excellent results, and it is confidently anticipated that the tests will shew that the Somkele coal will be no exception to the rule.

The advantages of a large quantity of low priced coal at a short distance from the mills are too apparent to need enlarging upon.

At present our works in Scotland and America are working at full capacity and numerous orders have been placed for big industrial and municipal concerns, amongst these being the Super Power Station at Brimsdown, London, where the whole of the pulverised fuel fired boilers will be equipped with Howden-Ljungstrom Air Preheaters.

We enclose results of tests at Darnall, Mount Edgecombe, and Dalmarnock Power Station, Glasgow.

G. H. Langler & Co., (Natal), Ltd.,
B. K. WARD, Managing Director.

Howden-Ljungstrom Air Preheater (Land) Limited.

PARTICULARS OF BOILER TEST WITH HOWDEN-LJUNGSTROM AIR PREHEATER.

SIR J. L. HULETT & SONS, LTD., DARNALL.

Date of test	15th November, 1926.
Duration of test	7 a.m. to 9 a.m.
BOILERS:	
Number of boilers	Six
Type of boilers	Multitubular
Heating surface per boiler	2,098 sq. ft.
FURNACE:	
Class of fuel	Bagasse
Calorific value of fuel as fired	3,720 BTU per lb.
Moisture in fuel	49%
Fuel consumption per boiler	3,340 lbs. per hour.
Fuel consumption per sq. ft. grate area	95.5 lbs. per hour.
GAS & AIR:	
Temperature of gas entering preheater	492°F.
Temperature of gas leaving preheater	202°F.
CO_2 content of gas at boiler damper	14.47%
Temperature of air entering preheater	75°F.
Temperature of air leaving preheater	414°F.
FEED WATER:	
Temperature of feed water entering boiler	167°F.
STEAM:	
Average steam pressure	90 lbs. per sq. ft.
Average steam temperature	Saturated
Evaporation per boiler	9,920 lbs. per hour
Evaporation per sq. ft. heating surface from and at 212°F	5.15 lbs. per hour
Evaporation per lb. fuel	2.97 lbs. per hour
Evaporation per lb. fuel from and at 212°F.	3.24 lbs. per hour.
Boiler efficiency without preheater	64%
Boiler efficiency with preheater	83.6%
Increased efficiency due to preheater	19.6%
Fuel saving due to preheater	23.4%
Increased steam per lb. fuel	30.6%

HEAT BALANCE:

			BTU/lb.	
Calorific value of 1lb fuel as fired	BTU 3720	Boiler efficiency	3,110	83.6%
		Flue gas loss	213	5.72
		Heat losses unaccounted for due to radiation, etc.	397	10.68
	BTUs 3720		3,720	100.00

The quantity of water evaporated was that required by the Mill.
This could have been considerably increased had it been necessary.

HEAT RECOVERED BY HOWDEN-LJUNGSTROM AIR PREHEATER

AT SIR J. L. HULETT & SONS' MILL, DARNALL.

Temperature of air entering preheater	°F	75
,, of air leaving preheater	°F	490
,, of gas entering preheater	°F	550
,, of gas leaving preheater	°F	220
HEAT RECOVERED BY PREHEATER	%	69.5
APPARENT EFFICIENCY OF APPARATUS	%	87.5

Natal Sugar Estates.

Mouut Edgecombe.

PARTICULARS OF BOILER TEST WITH AND WITHOUT HOWDEN-LJUNGSTROM AIR PREHEATER.

		Without Preh.	*With Preh.*
Date of Test		24-8-26	24-8-26
Duration of Test	hrs.	1.42	1.47
BOILERS:			
No. of boilers		two	two
Type		Babcock	and Wilcox.
Heat. surface per boiler	sq. ft.	2780	
FURNACE:			
Type of grate		Step	
Grate area per boiler	sq. ft.	64	
FUEL:			
Class of fuel		Bagasse	
Calorific value as fired	BTUs/lb.	3,720	3,720
Moisture in fuel	per cent.	49	49
Fuel consumption, total	lb.	16,600	19,050
Fuel consumption per boiler	lbs./hr.	5,900	6,450
Fuel burned per sq. ft. heating surface	lbs./hr.	92.2	101.0
GAS AND AIR:			
Temperature of flue gas entering preheater	°F	.....	460
,, of flue gas leaving preheater	°F	.....	230
,, of air entering preheater	°F	.....	85
,, of air leaving preheater	°F	.....	370
FEED WATER:			
Temperature of feed water entering economizer	°F	186	....
,, of feed water leaving economizer	°F	240	....
,, of feed water entering boiler	°F	240	220
STEAM:			
Average steam pressure	lbs/sq in. gauge	137	139.3
Average steam temperature	°F	459	494
Evaporation, total	lbs.	38,760	56,900
,, per boiler	lbs/hr.	13,650	19,400
,, per sq. ft. heat. sfc. from & at 212°F.	lbs./hr.	3.25	4.56
,, per lb. fuel	lbs.	2.3	3.0
,, per lb. fuel from and at 212°F	lbs.	2.615	3.36
Boiler efficiency	per cent.	64.8	....
Increase in efficiency due to economiser	per cent.	3.34	....
Boiler efficiency with preheater	per cent.	.....	87.9
Increase in efficiency due to preheater	per cent.	.....	19.76
Fuel saving due to preheater	per cent.	.....	22.8
Increased steam per lb. fuel	per cent.	.....	29.0

Glasgow Corporation Electricity Department.

Dalmarnock Power Station.

PARTICULARS OF TEST ON No. 4 BOILER, WITH & WITHOUT PREHEATED AIR.

		With Preheater.		*Without Preheater.*	
		Normal Load.	Overload.	Normal Load.	Overload.
Test No.		1	2	3	4
Date of test		19/5/26	20/5/26	27/5/26	28/5/26
Duration of test in hours		5	5	5	4
BOILER:					
Type		Babcock & Wilcox Water Tube.			
Size		50,000/lbs./hr. Normal rating			
Heating surface	sq. ft.	6,948			
FURNACE:					
Type		3 – B. & W. Chain grate stokers.			
Grate area (Total)	sq. ft.	273			
FUEL:					
Class of Fuel		Mixed coal.			
Calorific value as fired	BTUs	10,852	10,776	10,995	10,991
Moisture in Fuel	per cent.	14.6	14.5	13.1	13.6
Fuel consumption (total)	lbs.	34,375	41,564	34,212	36,518
Fuel consumption	lbs./hr.	6,914	8,313	6,842	9,129
Fuel burned per sq. ft. grate area	lbs./hr.	25.3	30.5	25.0	33.4
FLUE GAS AND AIR:					
Temp. of flue gas leaving boiler	°F	559	585	557	577
CO_2 content flue gas leaving ,,	per cent.	11.6	12.5	11.4	12.3
Temp. of flue gas leaving econ.	°F	362	375	378	394
CO_2 content flue gas leaving ,,	per cent.	....	....	9.4	9.3
Temp. flue gas leaving preheater	°F	185	204	....	....
CO_2 content flue gas leaving ,,	per cent.	8.4	8.4	....	....
Temp atmosphere in b'lr.-house	°F	259	278	....	....
FEED WATER:					
Temp. feedwater entering econ.	°F	175	175	153	150
Temp. feedwater leaving econ.	°F	281	274	271	268
STEAM:					
Average steam pressure	lbs./sq. in.	275	278	277	280
Average steam temperature	°F	641	644	660	666
Evaporation total	lbs.	277,178	330,787	254,382	270,033
Evaporation total	lbs./hr.	55,435	66,157	50,876	67,509
Evaporation sq. ft. heating sfce.	lbs./hr.	7.9	9.5	7.3	9.7
Evaporation per lb. fuel	lbs.	8.01	7.96	7.43	7.39
EFFICIENCY	per cent.	88.9	88.9	83.4	83.4

Proceeding, the speaker said the Committee especially would like to have the views of those present on some of those points which were put in the paper there. He thought the first thing to tackle was the heating surface per ton of cane: he thought they ought to have some views on that. Also, he thought, that some of the Darnall men might tell them something more about the preheater.

Mr. J. Murray said he would like to bring forward the question of the sizes of boilers in sugar mills. The ordinary 8 x 16 he thought was something like 2,200 sq. feet. The biggest ones were at Umfolozi; they were 2,880 sq. feet. A boiler of that size was very small, according to present day practice, for he thought they were 10,000 sq. ft. and more now. He thought instead of having 10 boilers in a sugar factory, they should only have two. They would take less looking after and give better efficiency. There was no reason at all why they should stick to boilers of that size.

There had been great developments in the powdered-fuel firing of boilers throughout the world; some 40 million tons of coal were being burnt annually now in that manner. He understood those boilers were very clean. He did not know whether it was possible to adapt those furnaces to hot air, so as to be able to use them in a sugar mill. If it could be done that way it would be a very much better way of firing the bagasse than that at present in vogue.

Mr. Pullar said he had only received the paper yesterday. There were one or two matters that he could not let go without a few remarks.

To start off with: the test figures that were mentioned there were certainly remarkable; they were so remarkable that they had got to investigate them and see if they were true, or whether it was just the apparent result. He thought the best way to look upon it was this. Probably the most efficient boilers in South Africa to-day, were very large indeed, operating under very high pressure, high temperature feed water, chain-grate stokers, and everything possible to increase the efficiency of the boilers. The efficiency obtained was 84 per cent.; and yet at Darnall, with a little multitubular boiler, by the mere addition of a preheater, the efficiency we are told, was dashed up to 83.6 per cent. Well, there was something radically wrong. He had been trying to analyse where that could be. This is where he thought it might be. At Darnall, to his knowledge, they had suffered very considerably from priming, this year; and in the test results, no figure had been given that took into account the quality of the steam. The method of measuring the water was not stated; it might have been weighed, or it might have been by water meter; but the fact remained if the quality of the steam was bad, they were not only generating steam, but also pushing water out of the boiler too. That was what they could expect with 5 lbs. of steam per square foot from that boiler. It might not be apparent to some of his friends who were present, but he had taken out the B.T.U. content for 75% quality steam, which was possible, judging from conditions he had also seen at Darnall, he having taken a small test there himself; he thought 75% was about what they were getting, which was only 950 B.T.U's, against 1,180 B.T.U. for dry steam a difference of 20 per cent., this made some difference in the efficiency figures given in the paper. He thought that ought to soak in, and they should take a proper test of the condition of the steam. At Mt. Edgecombe he knew nothing about mechanical troubles of preheaters on tests. Mr. Simpson was present, and he could bear him out as to the tests being taken without mechanical trouble; they went through the tests all right; although he was not supposed to know anything about it, he did not think the results of the tests were quite so satisfactory compared with those at Darnall. It must not be forgotten that with regard to steam quality at Mount Edgecombe, they could not very well get wet steam or priming. They had Babcock boilers which were not working up to the capacity; they could safely consider priming to be nil on account of the inherent design of the boilers. Furthermore, they had superheaters, which made it still more difficult to prime. So probably in weighing the water at Mt. Edgecombe, they were getting results as near the theoretical basis as they could expect to get. He thought it was a great pity for the industry and for everybody, that the bad results were not published with the good results.

At the World Power Conference certain discussions had taken place in connection with air preheaters, and the figures given there by authorities showed that the gain by air preheating was between 8 and 10 per cent. He thought those were figures that one could listen to; but the 30 per cent., or whatever it was in this particular test, he was perfectly certain was not correct.

In connection with priming, quite apart from the fact that water was going out of the boiler that went into the boiler, there was also considerable loss of energy in the steam pipes, in the form of kinetic energy of the water that had to be propelled along with the steam. They could understand what it meant if a big quantity had to go along at 90 feet a second in a steam pipe; it took some pushing through. Furthermore, of course, it affected all the plant.

He saw nothing in that test which made allowance for driving a preheater and the fans in connection with it. It was quite a considerable figure and should be taken into account if they were supposed to investigate this matter thoroughly.

The flue gas temperature was down to 202°F.

He would like to point out that according to the published results of tests in America, where preheaters had been in use for many years, the original tubular type which Babcock's put forward and still put forward, and the plate type, and the Howden-Ljungstrom, together with certain other rotary types, were being used. One of the disadvant-

ages of the rotary types was that they could gauge nothing by the leaving flue gas temperature; if they looked at the design of the heaters in use here, they would find that there was a leakage of cold air under pressure into the discharge of the flue gas leaving the heater under suction, and it must be a very considerable figure. There was quite a big leakage area.

As to the cost of the equipment. They were quite alive to the fact that 8 to 10 per cent. increased economy, was worth having; and he thought some of the sugar estates needed it very badly; he thought some of them needed even more than that. But why preheaters, when there were so many other factors that could be taken into account, together with the factor of capital economy ? Last year they had tried to impress upon the sugar people that by improving combustion and other means, they could electrify half Natal. But there was a remarkable thing; let them take the cost of this equipment. At Umfolozi, where the heating surface was somewhere in the region of 21,000 sq. ft., a preheater operating in connection with all the boilers cost £4,800, and the cost of the ducts which were of concrete underground worked out at £6,000; a total cost of approximately £11,000, to obtain that 8 or 10 per cent ! Allowing £480 a year for depreciation of the preheater, and £780 for interest on capital expenditure, that was £1,260 a year going away. He thought they should investigate cheaper methods of obtaining that increased efficiency. He really thought it was a matter affecting those present very seriously, and that they must not be bluffed into the fact that they must buy a preheater.

There was one way, of course, of getting improved efficiency and, at the same time, getting improved output—that was, by looking after the draught conditions. Balanced draught was a subject on which a paper could be written. It was cheap to instal; and half the benefits that they got from a preheater were attributed to the balanced draught conditions. So why should they not consider, first of all, how far they could go with balanced draught before going the whole hog of going in for preheated air ? If they installed an induced draught fan then, of course they expected a measure of result—and could get it. And, if they balanced that up on the other side of their grate and prevented the ingress of surplus air—they could control the amount of air they burned with their bagasse—they could get a higher furnace temperature as a result of that. They would get an increased output and get better combustion, because they put air in the right place—underneath the fuel bed. Those things had been proved. Last year they put in fans at Felixton which had been called boosters which they used when steam fell short, and he believed it helped them. So there was one method of improving efficiency, which, he thought, judging by his knowledge of some of the conditions existing, was a very important one indeed.

Of course, they had been dealing principally with plants which existed, not new factories.

He thought Mr. Murray had hit on the right thing when he mentioned increased heating surface. That was a most important thing. His principals, Messrs. Babcock & Wilcox had always offered as an alternative instead of economisers and preheaters, a boiler with much bigger heating surface, for bringing the temperature of the flue gases down in that way. There was no doubt that was the better thing. They got a higher efficiency boiler; they got a low-temperature exhaust gas; they had a bigger conservation of heat and stored energy. The question of heating surface per ton of cane seemed to be a very complicated one. He would have approached it from another point of view altogether; he would not have considered any individual factory, but would have said, "How much bagasse will there be available?" and, "How can we convert it all into steam efficiently?" Then design the boilers to consume efficiently, all the bagasse available; it might result in having a surplus boiler plant, which would not make any difference; it could be used as a stand-by plant; but he thought they had hit the nail on the head when they asked for more heating surface.

There was another thing. He had mentioned the fact that the quality of the steam from the boiler was a very important factor. As regards the test of a boiler, of course it was absolutely essential to have this-figure in order to get a reliable test. That being the case, there arose in one's mind the very dreadful conditions that must exist at nearly every mill, especially where multitubular boilers are used with preheaters, because they must be evaporating very nearly as much water per square foot as at Darnall. That entered into the question of maintenance at the factory. Why not consider drying the steam ? Why not let them consider bringing the boilers down to a normal rate of evaporation and instal superheaters, the improved efficiency of which, due to the use of dry saturated steam or superheated steam, was in the region of 15%, considerably more, very often. He knew that it was not advisable to have superheated steam floating about in the mains of a sugar factory because it would do damage to the sugar and that sort of thing. The mere fact of changing from wet saturated steam to dry steam made an enormous difference, and it would cost very little to do, besides being very simple to instal and he thought it would prove of great benefit.

There was another point he would like to raise—that was, with regard to the question of burning bagasse. It was quite true that most of the furnaces were too small in capacity; he was sure of that. They should look for better furnace design, and better methods of feeding the fuel, quite apart from increasing the quantity and quality of the steam, which, of course, was of very great interest. He was fortunate enough to meet his friend on his left, Mr. Richards, who had just come out from England in connection with a big gas proposition for Johannesburg. Mr. Richards' firm were the manufacturers of a refuse destructor. This was brought to his notice yesterday, and to him it was very obvious that this refuse

destructor seemed to be an ideal method of handling bagasse. So he had asked Mr. Richards to come along to the meeting in case anybody would like to ask him any question or would like to go into the matter. He had a drawing and a pamphlet which they could quite easily pass round now if it would be of interest. This was not propaganda; it was purely a coincidence that Mr. Richards had turned up.

(Mr. Pullar then briefly described the principles of the Refuse Destructor, adding that it would appear to be an ideal way of disposing of surplus molasses and one which should appeal to the industry.)

Mr. J. Murray said, regarding Mr. Pullar's remarks about the furnaces, he would like to point out that about the year 1892 one was put in at Cuba, a round furnace, such as he had been talking about, with the exception that it had not got that slicer at the bottom. The only fault about it was that the light parts of bagasse, were likely to be taken up the chimney.

Mr. Pullar stated that the plant he had mentioned was working in lots of places. Such a one had been operating in one particular place for seven years with success and part of its duty of course, besides the burning of boots and cans and that sort of thing, was to burn paper. He could not conceive of anything going up a chimney quicker than pieces of paper. He thought it was merely a question of design to keep the velocities right in order to overcome that little difficulty; besides it was not a very big thing.

Mr. Watson pointed out that yesterday they had had a long discussion as to how to get rid of surplus molasses in this country, and he thought something was said about calcining it. He would like to ask Mr. Pullar if it was possible to make those new furnaces applicable to the burning of molasses, in which case the ash could be utilized for fertilizer.

Mr. Pullar replied that that particular point was discussed by them that morning, and he thought Mr. Richards had come to the conclusion that they could quite easily burn molasses in the high temperature zone, outside the furnace proper, by a suitable injector; in the same way as they injected fuel oil, it could be quite easily injected into that particular type of furnace by a system of nozzles. If it was burnt in the combustion chamber proper it was quite possible the ash resulting might be used.

Mr. Watson thought it was a very important point and was worth while considering further. This excess of molasses was a very big question. Yesterday they had had Dr. Park Ross there discussing the question of getting rid of the waste waters and that sort of thing; but it was the waste molasses which was the greatest trouble. They simply made the waste waters practically untreatable. If they could get rid of the molasses, it would be worth while. He quite understood they had got away from the boiler point of view, but only to a certain extent; because they could still utilise the heat of the combustion of the molasses in heating their feed water.

The Chairman said that the difficulty in the burning of molasses in their furnaces at present was that there were such a lot of clinkers formed that the bars were clogged. He would like to know if, in conection with the new process mentioned by Mr. Pullar, the same trouble would not be experienced if a large quantity of molasses was burnt ?

Mr. Richards replied that he thought the difficulty just referred to might be overcome by spraying the molasses downwards on to the bed of fuel in the combustion chamber, and then any clinker that was left adhering to the fuel bed would go down to the bottom and be cut off by the knife in the usual way. In the burning of ordinary house refuse for which that furnace was designed, they encountered such things as glass bottles and the like. In house rubbish they probably had 25% ash or thereabouts; so that for every one hundred tons of stuff that they burnt they would probably have 25% which they had to dump. In these forms it was saleable, either at a nominal figure, or, at the very worst, they could take it away and use it, so that they were saved the cost of disposing of it which might otherwise amount to a matter of some shillings per ton. In London it cost 6/- or 8/- a ton for anything they wished to have taken away. He thought that the clinkers of the molasses could quite well be dealt with in that way.

Mr. P. Murray remarked that it was news to him that the ordinary multitubular boilers were quite as efficient as the water tube boilers. As regards the tests at Darnall, they were handed to them, but they had not analysed them or anything else and they were not responsible for them.

Mr. Pullar said there was very little difference in the efficiency of one type of boiler and another—in actual steaming efficiency, provided all the conditions were right; but they were talking about 5 lbs. a square foot; and that for a Babcock & Wilcox boiler was some going, and he was perfectly certain that at Darnall, from his actual knowledge of the priming conditions of these boilers, there was a loss and that that was a factor that would have to be taken into account. Therefore their test was not worth having. 5 lbs. on a boiler of that type would be left out by any reputable boiler firm in Britain knowing very well that priming would be almost bound to take place. The conditions would be very bad indeed, and worse than with a Babcock & Wilcox boiler. Working with preheater and superheater and all the conditions for increasing the output, firing with bagasse had not brought it up to anything like what they considered a maximum safe evaporating capacity. With a Stirling boiler they would get trouble sooner; in fact, he believed that the Refinery had a preheater and the Stirling boiler had already shown very serious signs of priming. He did not think he was giving away any secrets. That was where the great difference, in his opinion, came in between the multitubular and the Babcock & Wilcox boiler.

Mr. de Froberville said he must ask Mr. Pullar

to take out of his mind that there was priming in the boilers, when experiments were made. There was absolutely none at the time of the test and all the steam that went into circulation was saturated steam and there was no water in it.

Mr. Angus McLeod, who has been in charge of the installation, made a test before delivering the preheater to the mill and the Chief Engineer and several of the engineering staff and I were there and the test was conducted most correctly.

There had been much trouble during the crushing season with priming in the boilers, but towards the end of the season priming nearly ceased and on the day of the test, there was no priming whatever; Mr. McLeod, if asked, would give full information concerning the 5 lbs. evaporation for the boiler.

Mr. Pullar stated he was not doubting that 5 lbs. evaporation could be obtained from those boilers. As a matter of fact, he had taken tests with balanced draught, under exactly similar conditions, and he had found it was quite possible to maintain 5 lbs. evaporation, but he was perfectly certain no test was taken regarding the quality of the steam. There was no possibility of obtaining dry saturated steam from a boiler of that type without a superheater. He thought the only way to do it was to take the test all over again and to see that the particular factor was looked after. They would then get very different results.

Mr. de Froberville stated that this preheater was delivered to them at the end of the season, and as they had finished crushing in the middle of November, they had only a few days in which to carry out the test, results of which had been published in this paper. During the next crushing season, tests will be more numerous and will be carried on scientifically, and Mr. Pullar could be certain that correct figures will be given. He could assure him that the figures given now were neither faked nor erroneous.

Mr. Pullar said he had not insinuated that the tests were faked in any way; he would not like to say that, but he did think there was something wrong, because he did not see how they could get so close to the theoretically obtainable efficiency. He thought after all the time and labour that had been expended in putting some of the large boiler plants in order at enormous expense, by experts from the other side, and then only getting 84% efficiency, it was very improbable they could look to Darnall to give them those figures, by the mere addition of an air preheater.

The Chairman said the only thing he could see for it was to have the experiments repeated next year.

Mr. P. Murray said if any member present had altered their flues or settings and had obtained better results, the committee would be very pleased to hear from them.

Mr. Pullar stated that if the position with regard to bagasse was so important—as it appeared to be—he thought it would be of some advantage to the industry and the millers to have more than one test. They should have time to have at least one test during every season. Then if the committee were asked to give their subsequent analysis thereof on some standard form, they would all benefit by it, instead of coming there once a year and getting at cross purposes over it. He had more than once said he would like to take a test on this, that and the other, and had even gone so far as to take the necessary preparatory steps, but nobody else had turned up. He thought there was not sufficient sympathy between them; the miller thought he was probably trying to get something out of him, and probably did not realise that he could be of some benefit to the miller: it made it difficult for them. Whereas if the miller took those tests and gave the results they would have something to work on. It was very difficult to make a definite date unless one had control of the mill. He had been to mills to take tests and there had been no bagasse or no cane or something of that kind. If they could get at the same results in a much cheaper way, as he suggested they could so much the better. They would not take the trouble to spend money on testing the cheaper method for they thought it was not worth testing, and so discountenanced the whole thing. Therefore he thought they should arrange some means of getting tests on bagasse firing.

Mr. Camden Smith said in view of what Mr. Pullar had said, it would be recognised that the taking of a boiler test was a very complicated subject. He did not wish to say anything about that test at Darnall in particular, but the very fact that the test had only extended over two hours, he thought, would hardly provide sufficient data during that time to arrive at any result which they could call accurate or reliable. A boiler test to be of any real value should really be taken over a matter of four or five days, and to do the thing properly would require three shifts of about five men on each shift who knew their business. There were so many different factors to be taken into consideration. He would like to suggest now that the committee for next year should go ahead and try and organise some system whereby some standard test could be made at various factories, preferably those near to Durban, so that they could get some really reliable information. Organisation counted for more than anything else—that was to say, the getting of their staff together to do the test, and having it carried through in a proper and reliable manner, because after all, figures could be made to prove anything—the results depended naturally upon the data with which they started. He thought instead of relying upon those isolated tests, the Committee should get together and try and organise some tests and carry them through from year to year; they should not accept results, of course, from the first one or two tests, but the taking of these tests should be made an organised thing continued over several seasons. He thought that would be the only way in which they could arrive at any information which would be at all reliable. The combustion of fuel and utilisation of part of the heat of combustion for the raising of steam, was a complicated thing; there were so many varying factors connected with the

matter that it was a highly scientific problem to get a test done reliably. (Hear, hear).

Mr. P. Murray thought Mr. Camden Smith had made a very good suggestion, but it was going to entail an enormous amount of work for any Committee. He thought the South African Sugar Association should set their minds to do what he suggested and, he thought, if they went about the thing in the right way, they might get Messrs. Babcock & Wilcox, and other manufacturers, to do something. He thought Mr. Pullar should put it to Messrs. Babcock & Wilcox as they get a good share of the orders for boilers. He (the speaker) was quite willing to put it up to his own people, and others, to see if they could not get something organised. He thought it was a very good suggestion.

The Chairman remarked that Mr. Pullar had told them that Mr. Richards was willing to tell them something about the new system of burning bagasse in his furnace. Would Mr. Richards now tell them about it ?

Mr. Richards said he was very pleased to supplement a little the information which Mr. Pullar had so very ably given them.

The furnace in question had been evolved entirely for another purpose, of course—that was to say, to dispose of the ordinary domestic refuse collected in their big towns, such as in England, Germany, and elsewhere, as it had been found that the old method of carting and dumping such material had become very expensive and, therefore, some cheaper method had to be found. Well, this furnace had been evolved in order to turn potential heat into steam, so that they could then convert it into electricity or any other form convenient for use. He did not see why it should not be entirely suitable for their purpose here. The bagasse—with which he had only recently made acquaintance—was certainly an easier material to handle that domestic refuse, because, for instance, one might get a mixture consisting of an old mattress, a lot of paper, straw, old boots, bottles, tin cans, and things of that nature. Well mechanically those things were very difficult to handle, and it was not so easy to choose mechanical appliances which would handle such a wide range of things without trouble; but in dealing with their material here, it seemed to him that bagasse was so simple to handle that the handling and feeding should be easy to deal with. Then again, as to the working of the furnace; he thought the working should be easier with their material, inasmuch as he believed that the amount of ash in it was very low; he had been told it might be about 3 per cent. Well, that was a very much simpler proposition than burning a fuel containing 25 per cent. of ash and 40 per cent. of water. He thought, if one was able to burn it satisfactorily, then their fuel was more readily adaptable.

They had now a plant working in London on that system, and the Borough of St. Marylebone, for whom it was built, had now taken it over and accepted it as having fulfilled all their requirements, and the promises his firm gave.

The single unit in its simplest form would burn about 25 to 30 tons per day of house rubbish. He thought it would be safe to say that the capacity with their material here would be very like it—say anything over a ton-and-a-half an hour, and the efficiency of the combustion was very high. The analysis of the gases in the combustion chamber showed something like 16 per cent of carbon dioxide; which for rubbish was quite a good result. They used balanced draught—that was to say, they used forced draught and induced draught so that they could put their neutral point where they liked and avoided, so far as possible, the intake of air which served to dilute the gases and spoil the efficiency.

Mechanically the plant was robust and simple. He had first seen it worked in Switzerland by the ordinary Swiss labourer; he was of higher intelligence than the native here, but he would not like to say that his mechanical ability was any better than the Indian's. From what he knew, he would say the Indian was probably a more alert man than the ordinary Swiss labourer. So he did not think there would be any difficulty in securing the operation of such a plant.

If there were any questions which anyone would like to ask, he would be pleased to answer them.

Mr. Masters asked what the approximate price of the machine would be, to burn 30 to 40 tons a day ?

Mr. Richards replied that it would be difficult for him to answer the question in a form which the questioner would like, because he would probably like the machine associated with the boiler; whereas the only figure he had in mind was the complete installation, including the refuse handling apparatus and everything else, and, very approximately, the cost of that plant in England, complete, was of the order of £ 10,000.

Mr. J. Murray pointed out that in the illustration which Mr. Richards showed, there was a hopper with a feeding arrangement. All the feeders they had tried for bagasse had generally failed; the bagasse was sometimes in long sticks and sometimes in short. He would like to ask Mr. Richards whether it would work with bagasse ?

Mr. Richards, in reply, said the feeding apparatus had been designed with the idea of dealing with awkward material, such as rag, wire, and things of that sort.

Mr. Simpson asked how long a charge would last ?

Mr. Richards said they had been charging, in the case of house refuse in London, about every 5 minutes. They had found the bulk of the refuse was about 200 cubic feet or a little more per ton, and they had been charging about 10 to 12 times an hour; that was to say, they had charged something in the nature of 2 to 2½ cwt. each time. They deliberately kept their charge small, because they could not maintain efficient combustion if they had a fuel bed which was varying constantly in its thickness and temperature.

The Chairman asked whether the hopper and destructor which he saw in the drawing, would suit

some of the sugar estates; would the draught be sufficient ?

Mr. Richards replied that the existing boiler chimneys would furnish enough draught on the outgoing side, but it would be necessary to have a blower-fan. They had a thick bed and had to penetrate that bed; they generally aimed at balancing their draught; so that they got zero at the top of the fire. He thought many of their chimneys—some of which were pretty high—would give all the draught on the waste gas side that was desirable.

Mr. Murray said he would like to suggest that Mr. Richards get a furnace out here, and the Committee would test it. (Laughter).

Mr. R. W. Saunders remarked that, as the paper was one on the Steam Balance of the sugar factory, the subject of the utilisation of steam (as opposed to its generation) should be discussed. In Cuba, considerable attention is paid to this matter, and it is there considered that a factory should be able to operate on 10 per cent fibre cane, without extra fuel. These results are obtained, firstly by economical combustion of bagasse, and secondly by very carefuly lay-out of the factory, permitting of a minimum of steam piping, extensive lagging and vapour heating. (This latter should of course be unnecessary in Natal).

Mr. P. Murray replied that the Committee had not got down to that; they had not got beyond the boiler house. The trouble was they had to earn their livelihood in the meantime. They had not much spare time; there was so much competition. (Laughter).

The Chairman then called on Mr. E. P. Masters to present the report of the committee on the handling of cane from field to crusher.

Mr. Masters said he was very sorry that this paper had been very much curtailed. owing to pressure of work. He did not think that those present would mind that very much, as the hour was now getting late.

They had confined their attempts to trying to show where small economies could be effected in the working of cane under South African conditions, in the hope that later on another paper would be forthcoming showing a comparison between their work here and that in other parts of the world. He wished to take this opportunity of expressing his thanks to those who had assisted him in the paper, Mr. Crawford and Mr. Wickes. Mr. Pearce had regretted that he could not give him any assistance.

Report of the Committee on the Handling of Cane from Field to Crusher.

The usual method of cutting is by an approved brand of knife such as Brades or Collins, and this task is performed under varying conditions.

There is no recognised general standard task for this work, but it might be mentioned that 36 cwt. or about 4,000 lbs., is usual in Fiji with natives and Indian labour, 2,000 lbs. in South Africa and a bonus above these figures in both cases. This applies to trashed cane.

With European labourers, such as are employed in Queensland, a good gang can average 3 to 5 tons per man in burnt cane.

In districts where the habit of burning cane still obtains, in South Africa, the task itself is considerably greater, 3,000 to 4,000 lbs. or roughly 50 per cent. increase, with the bonus of 1d. per 100 lbs. over the stipulated task being usual.

The limiting factor for all this work is the distance the cane has to be carried to the waggon or truck.

Provision should always be made, where portable tramlines are used, to limit the carry to 2 chains—it being cheaper in practice to have a short carry and pay additional for the laying of the track.

We have started off by drawing attention to cutting as well as loading, and the two operations are performed by the same gangs.

CUTTING BY MACHINE:

There have been several of these machines on the market in different parts of the world, and some have given fairly good results where local conditions have been in their favour, but we have yet to see one that would suit the condition obtaining in South Africa.

COSTS:

With the usual 2,000 lbs. for trashed, and taking the value of a native or Indian on shift basis, 1/8d. plus rations and proportion of Medical Fees, etc., we find that 2/5d. to 2/6d. is the actual cost per day.

If a man can be induced to load a heavier tonnage by means of a bonus of 1d. per 100 lbs. over his task of 2,000 lbs., at the same rate of pay, the cost per ton is materially reduced, as for instance:—

2,000 lbs. per man 1/8d. + 10d. = 2/6d. per ton.
3,200 lbs. per man, 1/8d. + 10d. + 1/- bonus,, 3/6d. = 2/4d. per ton.
4,000 lbs. per man 1/8d. + 10d. + 1/8 bonus, 4/8d. = 2/1d. per ton.

Plus 2/- per ton flat rate haulage main line 4/6, 4/4 and 4/1.

The last tonnage figure can be looked upon as a maximum under the best of present day conditions for trashed canes.