

REPORT OF THE COMMITTEE ON STEAM BALANCE AND BOILER HOUSE PRACTICE

INTRODUCTION.

The title of the Committee from which this report emanates was changed from that of Boiler and Boiler Practice to the Committee on Steam Balance and Boiler House Practice because we felt that the latter title defined better our activities. In view of the fact that the Industry is rapidly approaching the time when a knowledge of the Steam Balance of each factory will be required we proposed to endeavour to provide the required figures. The introduction of the new canes with a twenty per cent reduction in fibre content will call for the most careful conservation of heat if the factories are to be able to raise the steam required for their operation on the fuel then available. Up to the present by burning the bagasse provided by Uba cane, most factories have been able to provide sufficient steam without having a surplus of fuel, but if there has only just been sufficient fuel with Uba there certainly will be a serious shortage of fuel when the available fuel is cut down twenty per cent. This is a condition which ought not to obtain, for with a 12% fibre it appears that other countries can work their factories successfully and consequently we must do so too. This Committee then, set itself the problem of examining the situation. A beginning has been made this last season and some of the results are reported in what follows.

BOILER TESTS.

Only two tests on lines similar to those already reported were made this year, but they are interesting and are reported in Table I., and for the sake of comparison the figures obtained in the previous test (1932) are given in parallel columns. In the first three columns are given the figures from the Central Factory and between the years 1932 and 1934 this factory improved its draught by putting into operation an induced draught fan and installing superheaters in all its boilers. The beneficial results of these alterations speak for themselves, for it will be seen that the evaporation from and at 212° F. per sq. ft. H.S. per hour was raised from 2.21 to 3.02 and 3.12, and the thermal efficiency increased from 46.6% to 51.7% and 53.9%. Other interesting comparisons are shown in Table II.

	August, 1934.		Nov. 1932.	
Furnace temperature	1,975°F.	Boiler 4	1,715°F.	
	1,878°F.	„ 1	1,730°F.	
Flue temperature ..	450°F.	Boiler 1	530°F.	
	459°F.	„ 2	—	
	445°F.	„ 3	—	
	470°F.	„ 4	548°F.	
Draught	0.78"	Boiler 1	0.40"	
	0.80"	„ 2	—	
	0.80"	„ 3	—	
	0.70"	„ 4	0.45"	

Grate area	2 at 63 = 126	
	2 at 42 = 84	
		210 sq. ft.
Combustion space.. .. .	2 at 750 = 1,500	
	2 at 1,250 = 2,500	
		4,000 cu. ft.
Heating surface	2 at 2,531 = 5,062	
	2 at 4,730 = 9,560	
		14,622 sq. ft.
H.S. superheat	2 at 198 = 396	
	2 at 510 = 1,020	
		1,416 sq. ft.

Bagasse Burnt.

	1934.	1934.	1932.
	Aug. 2nd.	Aug. 3rd.	Nov. 10th.
Boiler 1	37,549	36,826	30,581
„ 2	38,272	37,720	28,638
„ 3	46,059	49,504	44,244
„ 4	44,353	44,563	44,912
	166,233	168,613	148,375

It will be noticed that with the improved draught the furnace temperature has been raised from 1715° F. to 1975° F. and from 1730° F. to 1878° F. The installation of superheaters accounts for the lowering of the flue temperatures from 530° F. to about 450° F. thus using the heat of the gases effectively. One outstanding point in this factory is its steady work. There are practically no losses from chokes in the mill or time lost in break-downs, and this satisfactory state of affairs is reflected in the steady feed of bagasse to the boilers. When the first test was carried out, Boilers 3 and 4 were fed for the 8 hours with 44,000 lbs. of bagasse and two years later the same weight of fuel is being fed. Boilers 1 and 2 were not doing sufficient work in 1932, but the increased draught has necessitated an increased feed, and on the two consecutive day's test the total fuel feed over the eight hours was practically the same on each day. It is common knowledge that this factory is working well and undoubtedly the steady crushing with the resulting steady steam is one of the contributing factors. The calculations of the grate areas, combustion space, heating surface of boilers and superheaters are also given in detail in the table.

The other factory reported is also interesting. In 1932 one of the two ranges of Multitubular boilers had a very small combustion space, 256 cubic feet and in the interval some of the furnaces were rebuilt and the combustion space was en-

TEST DATE	CENTRAL FACTORY.				SEZELA			
	1934. Aug. 2nd.	1934. Aug. 3rd.	1932. Nov. 10th.	1934. Sept. 10th.	1934. Sept. 11th.	1932. Sept. 6th.	1932. Sept. 7th.	
Duration of test (hours)	8	8	8	8	8	8	8	
Type of boiler	B. & W.	B. & W.	B. & W.	Multi	Multi	Multi	Multi	
Number of boilers on range being tested	4	4	4	2	2	7	7	
Heating surface, sq. ft. (or per test)	14,622	14,622	14,622	5,000	5,000	—	—	
Heating surface, superheater	1,416	1,416	None	Nil	Nil	Nil	Nil	
Type of furnace	Flat grate	Flat grate	Flat grate	Semi-cook	Semi-cook	Step-grate	Step-grate	
Grate surface, sq. ft.	210	210	210	47	47	35	35	
Ratio of heating surface/Grate area	—	—	—	—	—	—	—	
Combustion space, cu. ft. per boiler	4,000	4,000	4,000	734	734	256	256	
Ratio of combustion space/Heating surface	—	—	—	—	—	—	—	
Water apparently evaporated—lbs.	331,360	326,035	299,301	231,833	234,319	405,043	443,154	
Moisture in steam %	Nil	Nil	15.7	18.1	18.3	17.8	17.1	
Water evaporated—lbs. (corrected for moisture)	No correction	No correction	252,311	189,872	191,439	332,946	367,375	
Feed water temperature—° F.	208	223	222	176	178	215	212	
Superheat temperature, ° F.	437	435	—	—	—	—	—	
Factor of evaporation from and at 212° F. into dry steam	1.1022	1.0881	1.028	1.080	1.078	1.038	1.038	
Water evaporated from and at 212° F.	365,225	354,758	259,376	203,163	206,371	345,598	381,335	
Steam pressure by gauge	97.3	97	90	98	97	83	84.5	
Weight of bagasse burnt—lbs.	166,233	168,613	148,375	91,901	98,086	210,000	200,870	
Moisture in bagasse	51	51	50.5	49.3	49.2	46.1	48.3	
Weight of dry bagasse	81,454	82,620	73,445	46,593	49,827	113,190	103,849	
RATE RESULTS.								
Water evaporated from and at 212° F. per sq. ft. heating surface per hour—lbs.	3.12	3.03	2.21	5.07	5.16	2.47	2.72	
Wet bagasse burnt per sq. ft. grate surface per hour—lbs.	98.8	100.3	96.8	—	—	107	102	
Water apparently evaporated—lbs. per hour	41,420	40,750	—	28,979	29,289	7,232	7,913	
Water apparently evaporated—lbs. per sq. ft. heating surface per hour	2.88	2.78	—	5.79	5.85	2.89	3.16	
Water actually evaporated—lbs. per hour	41,420	40,750	—	23,734	23,929	5,945	6,560	
Water actually evaporated—lbs. per sq. ft. heating surf. per hour	2.88	2.78	—	4.74	4.78	2.37	2.62	
EFFICIENCY RESULTS.								
Water evaporated, apparently, per lb. bagasse	1.99	1.93	2.02	2.52	2.38	1.93	2.21	
Water evaporated, from and at 212° F. per lb. Wet bagasse	2.19	2.10	1.75	2.21	2.10	1.64	1.89	
Water evaporated, from and at 212° F. per lb. Dry bagasse	—	—	3.53	4.36	4.04	3.05	3.67	
Thermal efficiency	53.9	51.7	46.6	52.0	49.2	—	47.0	
Temperature of flue gases, ° F.	Table in text		Table	No. 1— °F.640	No. 2— °F.678	°F.500	°F.580	
Temperature of furnace, ° F.	" "		in text	°F.2,000	°F.2,100	°F.1,600	°F.1,840	
Draught at back of boiler at flue damper—inches	" "		" "	0.8	0.8	0.6	1.1	
	Boiler No.			2.	1.			
CO ₂ %	11.7	12.2 9.9	8.6 7.0 6.2 7.6	10.9	12.6	—	13.8	
O ₂ %	8.0	7.0 10.0	10.2 8.0 12.0 11.4	6.6	6.4	—	3.6	
CO %	0.1	0.2 0.0	0.0 0.0 0.0 0.0	0.2	0.1	—	1.8	
Excess air %	60.7	20.4 111.0	118.6 114.3 193.5 150.0	—	—	—	26.0	

larged up to 734 cubic feet. In place of the step grate a semi-Cook after Mr. P. Murray's design was built into the setting. This is a flat grate 4ft. 10in. by 4ft., having nine rows of tuyeres 18in. high on three sides thus giving 47 sq. ft. of "grate area." A forced draught fan is set in the side for providing the oxygen for combustion and a fan for induced draught was placed at the back of the range of boilers. When operated correctly the draught is balanced and no cold air is drawn into the furnace at the feed hopper. The test shows that it is possible to get over 5 lbs. evaporation "from and at 212° F." by means of this furnace, though it is admitted that this is too high an evaporation for this type of boiler. The furnace temperature is greatly increased, 2,000° F. and the losses in heat up the flue are too high, the temperature being recorded at 650° F., 670° F. Nevertheless great flexibility has been provided and the fuel is burnt to much greater advantage in this furnace as compared with the step grate. The heat which is in the fuel is never developed on a step grate to anything like the extent which these modern grates develop it.

It was intended to examine the horse-shoe Cook furnaces installed in several factories by Messrs. Vincent & Pullar, but it was not found possible to do the work this last season. A mere inspection without taking any figures shows that these furnaces are doing splendid work and it will be of great interest to get reliable data on their work.

THE FURNACE ASH.

The ash which both of these types of furnace produce is usually perfectly white, but it was noticed that in some factories it was pink, or a beautiful green, or semi-fused or completely fused. The fusing of the ash in particular was a source of trouble and it was decided to analyse the different varieties. Mr. B. E. Beater, of the Experiment Station, kindly carried out this work and the results are shown in Table III.

	1.	2.	3.	4.	5.	6.	7.	8.
Silica (SiO ₂)	82.52	84.20	82.92	71.56	80.50	77.32	76.76	71.92
Potash (K ₂ O)	4.60	4.40	4.04	5.10	7.00	10.37	8.30	9.13
Phosphate (P ₂ O ₅)	2.08	2.16	2.10	1.27	1.99	1.64	2.51	1.44
Lime (CaO)	4.00	3.40	3.25	2.72	2.15	2.62	4.30	7.60
Magnesia (MgO)	3.52	3.28	4.01	1.92	3.60	4.07	5.12	4.08
Manganese oxide (MnO)	0.28	0.23	0.20	0.14	0.11	0.11	0.14	0.09
Iron oxide (Fe ₂ O ₃)	2.40	1.28	} 3.70	10.73	} 5.45	} 4.40	} 2.89	} 5.76
Aluminium oxide (Al ₂ O ₃)	0.56	1.04		6.24				
Total	99.96	99.99	100.22	99.68	100.80	100.53	100.02	100.04

1, 2, 3.—Loose white ash.
4.—Rust-coloured ash.

5.—Pink ash.
6.—Green ash fused.

7.—Bluish-white fused lump.
8.—Olive green fused lump.

The first three ashes are of about the same composition. No. 1 comes from Sezela, No. 2 from Esperanza, No. 3 from Doornkop and others of similar composition can be shown from anywhere from Umfolozi to Sezela. The ash of the cane is

therefore fairly constant. No. 4 is of particular interest. It came from the combustion chamber of a Cook's furnace where the ash had been deposited in coloured layers, rust coloured layers alternating with pure white layers. At times the operators of this furnace experience great trouble in keeping steam and the cane is blamed for it. On the face of it, one would expect the calorific value of the cane to remain constant. Many canes have been examined throughout the world for their calorific value and the results published show that there is little variation in this figure.

An examination of the analysis of the ash No. 4 shows that there is a very high proportion of alumina and iron in its composition, 16.97%, none of the others in this list (nor any of the many not published) have anything like this figure. It is well known to the mill officials concerned that the cane from certain districts is badly contaminated with soil and that these canes are difficult to burn, so it is suggested that we have now definite proof of the reason for this refractoriness, especially since the crushing of this difficult cane alternated with good burning cane. The latter is responsible for the white layers in the ash deposit of the combustion chamber and the rust coloured layers are due to the iron of the soil being carried over from the horse-shoe with the rest of the ash by the draught and deposited on top of the white layer. This argument seems justified, for suppose that one were to continually throw small quantities of soil on to a fire would it not damp the intensity of the fire? Here is a large specimen of this deposit and you see the white layer an inch or two thick then a layer of rust coloured deposit.

The remaining four ashes are all coloured. The colours of all are due to the state in which the manganese is found in Nos. 5 and 6. Nos. 6, 7 and 8 are fused and possibly the high content of potash together with the high temperatures obtaining in the furnaces account for the fused state of the deposit. These temperatures, which were over

2100° F. are too high for furnaces of the horse-shoe type. The flying ash fused on the protecting sheath of the pyrometer while taking the temperatures, but in No. 8 some molasses was burnt with the bagasse and everyone knows that such a practice

TAKEN AT

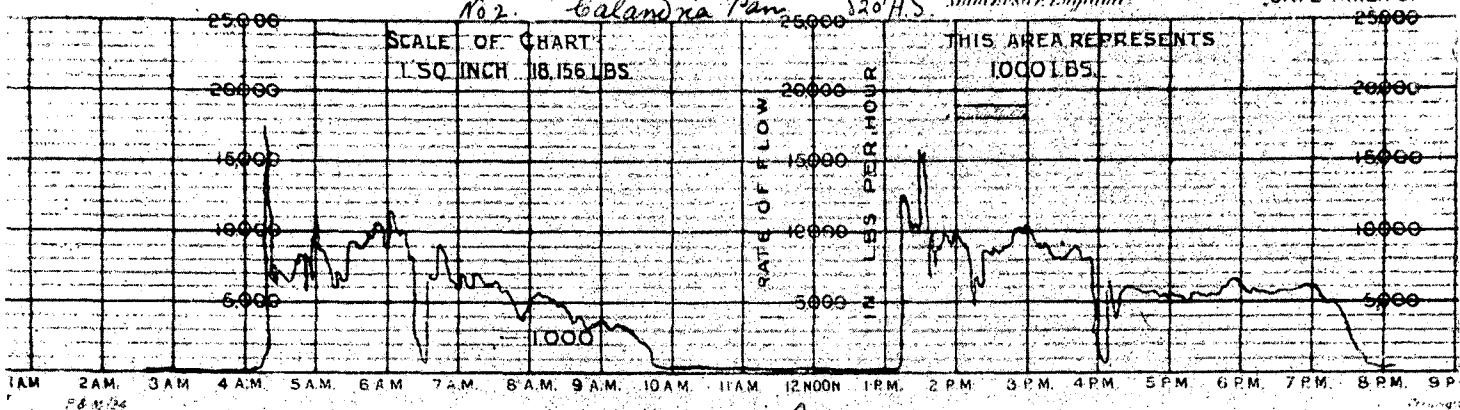
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LEA'S PATENT RECORDER

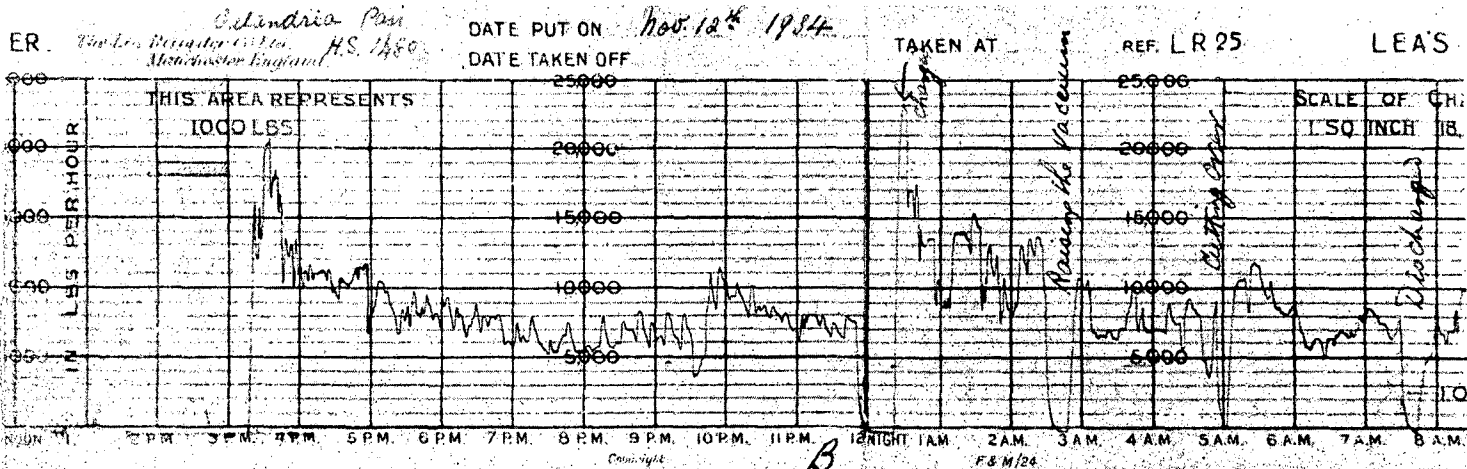
The Lea Recorder Co. Ltd. Manchester, England.

DATE PUT ON

DATE TAKEN OFF



A



B

FIG. 3.

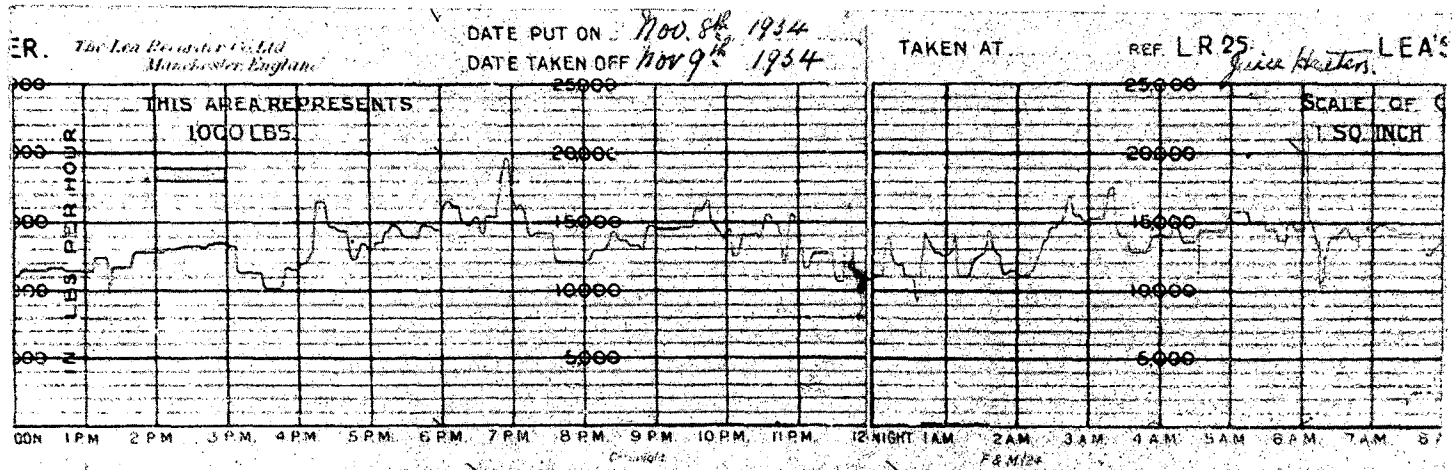


FIG. 4.

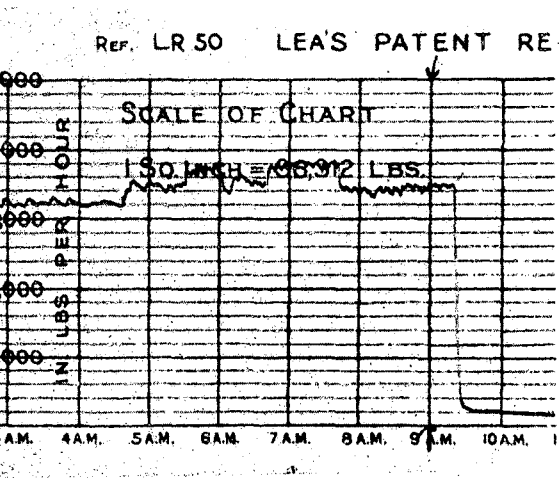
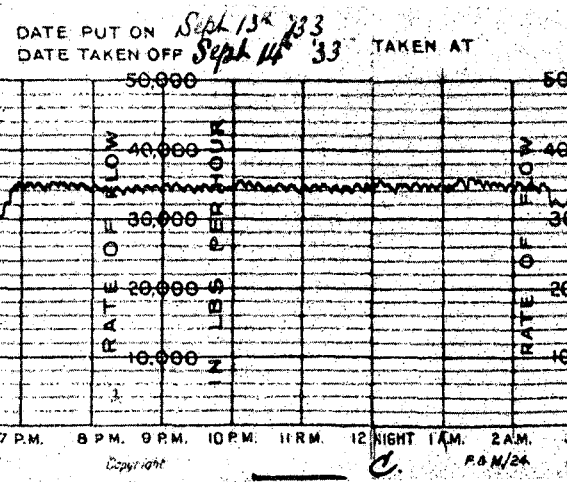
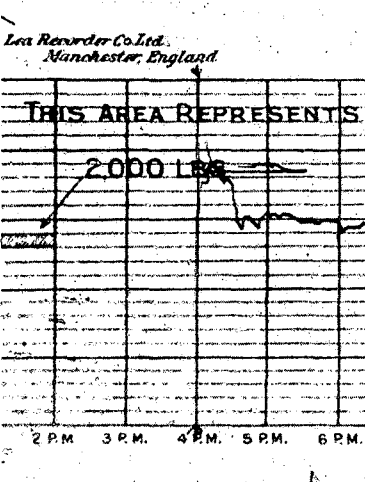
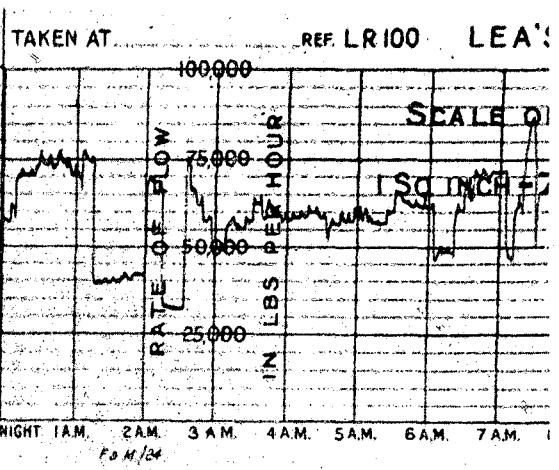
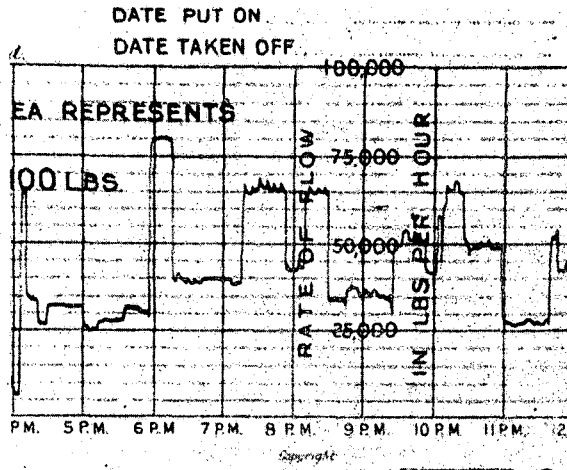
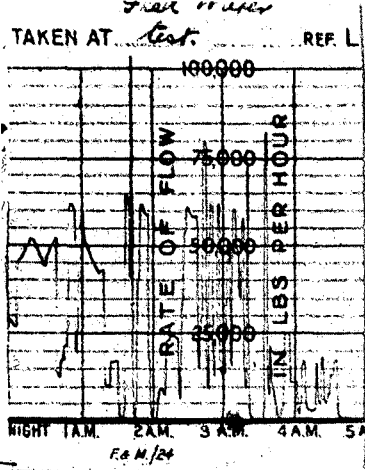


FIG. 1.

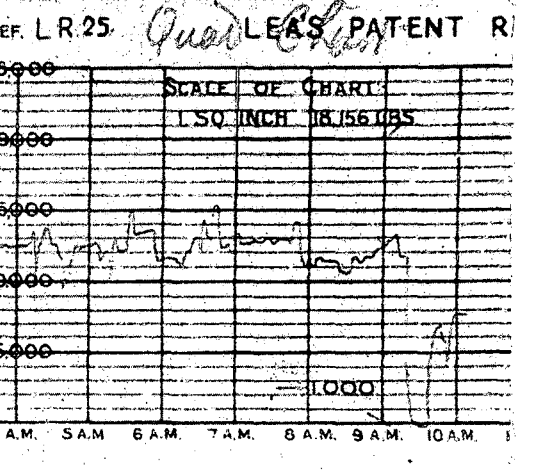
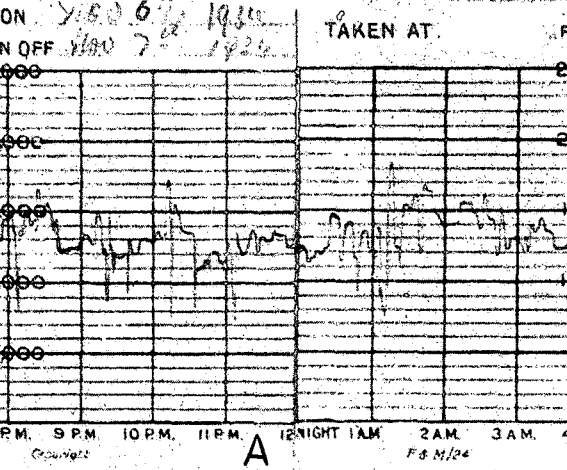
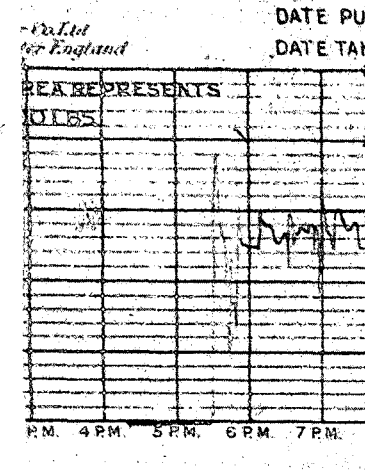
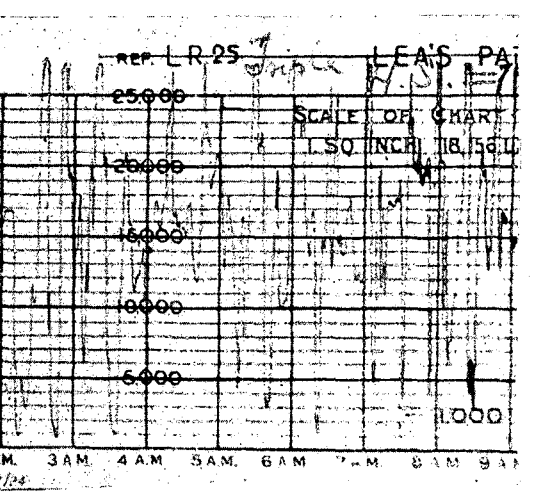
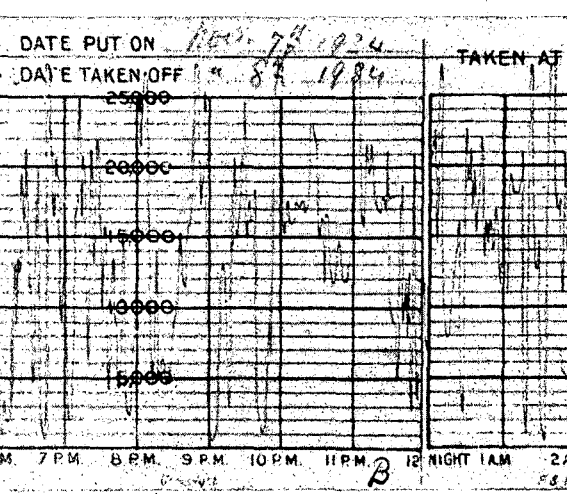
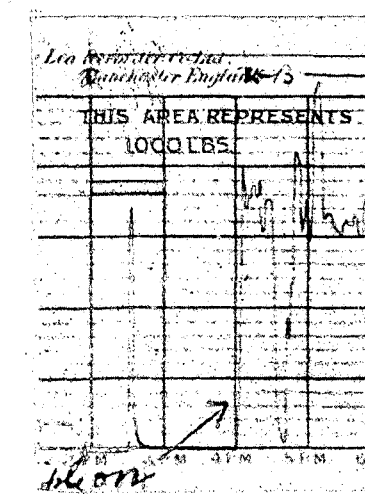


FIG. 2.

always gives a fused ash in the furnace. The admixture of the molasses accounts for the olive-green colour. Specimens of Nos. 7 and 8 are here exhibited.

While we were doing the analysis of the ashes it seemed of interest to analyse also the black smuts which are so common in many factories. Properly burnt there should be no smuts passing up the chimney stack from the bagasse furnace and a number of boiler settings in the factories are operating in this fashion. A large number of furnaces, however, are passing away smuts and there has been some difference of opinion as to the percentage of carbon in these smuts. Analysis shows that the carbon content varies 89 to 93%. It is obvious therefore that there is quite an appreciable loss of fuel from this source.

THE TRACY STEAM PURIFIER.

Tracy Purifiers have been installed in some of our factories and during last season it became possible to examine the work done by these instruments. Since the results are of general interest they are recorded in this report.

The Purifier is designed to scrub entrained moisture and dirt out of the steam and is best installed in the boiler drum but in one of the factories the plant is in the main steam line. This necessitates the solids and dirty water, separated by the outer baffles of the purifier, being passed through a steam trap.

At the time of carrying out the test on this plant there was passing through the Purifier about 28,000 lbs. of steam per hour to two 150 K.W. generators, one 300 K.W. generator and one small air compressor. As measured by the Barrus Colorimeter the steam entering the purifier carried about 18% moisture and left it with 3%. The appearance of the steam which issued from the valve before the purifier (to which the Colorimeter was attached) was just like exhaust steam—a dense white cloud. After passing the purifier and on opening the valve to allow the scrubbed steam to escape into the air it is seen that the appearance is quite different, the issuing steam being a blue colour. It is, therefore, evident without taking any measurements that the purifier is doing good work. The following analyses were made:—

	Parts per 100,000
Solids in steam before scrubbing ..	1.75
Solids in steam after scrubbing ..	0.4
Solids in the trap runnings	135.25

The analysis of the trap runnings shows that the scrubbing of the steam is effectual.

In another installation the purifier was fitted inside of each of three boiler drums. At this factory in a former season the steam was shown to contain about 12% moisture. Now, as the result of installing the purifiers, it contains about 1.7% as it issues from one boiler; but in another boiler the scrubbed steam passes through a superheater

the steam is therefore quite invisible when a valve in this boiler is opened. In the others the steam is blue in appearance.

The analyses of the condensed steam and boiler water gave the following results:—

	Part per 100,000
Boiler feed water	2.15
Condensed steam from No. 1 boiler after passing purifier	0.60
Condensed steam from No. 2 boiler after passing purifier	0.75
Water in No. 1 boiler	241.45
Solids filtered from this water ..	168.5

As is well known the feed water for the boilers in most sugar factories is derived from the Quad, or Triple, Juice Heaters, Pans, etc., and therefore the solids in 100,000 parts are not likely to be very high. The make up is usually river water which if there has been no rain is clear, but if the river is muddy it all goes into the make up and accumulates in the boiler. This may be the cause of the high solids in this boiler water but in any case it is clear that the purifier is preventing them from getting into the steam.

BOILER WATER, AND BOILER FEED.

A good many analyses of the water taken from the gauge glass of the boiler were carried out this season, and the concentration of the solids per hundred thousand is astounding. In some instances the solids reach to over 800 parts, one being 895 of which 861 were in suspension. This dirt is carried by the steam right out into the factory. I have found it in measuring instruments even after the steam had passed through superheaters.

For every reason these boiler waters should be kept clean.

LEA RECORDER RESULTS.

A good deal of use was made of the Lea Recorder in examining the amount of steam taken by various units in the factories and a few of the charts are reproduced because of their general interest.

From the point of view of efficiency it is desirable that the feed water be put into the boilers as hot as possible and as regularly as possible. What does one find? Firstly that the temperature is allowed to fall from 205° F. (at which temperature the condensed steam comes from the pans, quads, etc.), to about 160° F. on an average, sometimes it falls even lower. This is then pumped from the hot well through a feed water heater where it is restored to or a bit above its original temperature. The loss of heat is astounding as can easily be seen by any engineer who will calculate out the B.T.U. loss for a day's run. It is perfectly possible to pump the water from the hot well at 205° F. by using a Drysdale Condensate Extraction Pump, and the saving in B.T.U.'s makes such a proceeding well worth while.

Then with regard to regular feeding of water to the boiler only measurement shows how bad this is. In Fig. 1 "A" is reproduced a curve showing the way usually adopted to feed the boilers. The attendant opens the boiler valve and feeds for a few minutes at, for example, the rate of 75,000 lbs. per hour. He soon shuts it, feeding the next time at 50,000 lbs. per hour and so he produces this very wavy curve. After numerous explanations of what is required of him he produces "B" where it will be seen that the valve is never closed for the recorder never falls to the zero line. At last the staff of feeding attendants learn what is required is to crack the feed valve just open and we get curve "C" and we are now ready to begin the boiler test, but it has taken a few days to teach these men how to feed. It is obvious therefore, that a feed water regulator is a desirable and necessary piece of plant.

Fig. 2 shows the steam consumption curve of a Quad (A) and of a Triple (B) in the same factory. There is nothing unusual about the curve recording the steam taken by the quadruple beyond that the curve is not the dead straight line which some people expect the use of the steam to show. Compare curve B with A. Curve B is that given by the triple and it ought to be just like A and in fact it was when A was shut off. No one suspected that it was working so irregularly and unsatisfactorily until this measurement for steam consumption was made. After a good deal of investigation into the cause of the unsteady work it was found to lie in the use of a common feed tank for the quad and the triple.

Fig. 3 records the steam used by two calandria pans. In A is shown the type of curve produced by a pan having 820 sq. ft. H.S. and shows steady work, except that the strike between 4.15 a.m. and 9.45 a.m. was an hour shorter than the boiler who made the strike between 1.15 p.m. and 7.45 p.m. Why this should have been was not enquired into, probably the first man managed to steal more live steam than the second.

The curve in B shows two more strikes in a

larger pan, 1,480 sq. ft. H.S. The rise in the curve at 9.30 a.m. shows something wrong for it should sink regularly to zero. About 12.30 a.m. a second pan, was filled and at 2.30 a.m. owing to putting on another pan, on to the same vacuum pump the steam had to be shut off for nearly half an hour. This shows loss of time due to having more than one pan on the same pump. At 5 a.m. the pan was cut over and at 7.30 a.m. discharged.

Fig. 4 shows the work of a battery of Juice Heaters and just as in all the other cases, by means of the planimeter the steam consumed can be measured.

We have to record our thanks to Mr. F. W. Hayes for photographing the charts.

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Mount Edgecombe,
Natal.
March, 1935.

The CHAIRMAN: That is Dr. Hedley's report on the greater part of the work which we have done in this Committee during the past year. I do not think there is any need to discuss it at present, in fact we have not time. This Committee, of course, is still going on with its work, and possibly next year it will be in a more fortunate position. It had a full innings last Conference. I do not think we can complain by being partly crowded out this time. I will now ask Mr. Rhodes to read his paper on "The Lubrication of Cane Sugar Machinery."