MILLING RESULTS AS REVEALED BY INDIVIDUAL UNITS CONTROL.

By J. RAULT, Chief Chemist, Natal Estates, Ltd.

At the 1931 Congress we read a paper on Milling Control, explaining our method of individual units checks and placing on record the average results obtained by our milling plant for the past Campaign.

The practibility or usefulness of such a control did not seem to have been appreciated to its full value in South Africa although we had already used it for 10 years.

Lately results of similar tests (see modern Milling by F. Maxwell, and Hawaiian S.T. Report, 1934) from other sugar lands have been published. It is quite interesting to study them for comparison with our local conditions.

Various types of milling machinery and milling results on soft and Uba canes are very much discussed at the present moment in our expanding Industry

At our factory a larger and more modern crushing plant has been installed since writing the first paper. In common with other factories, increasing tonnages per hour have been every year put through the mills and improved extraction results have been recorded.

The following notes on the result of the past four years' experience at our factory may serve as a useful contribution on the vast subject of milling. We will confine ourselves to extraction results, leaving considerations of electric drive or mechanical efficiency to other technologists more competent to speak on the matter.

The compilation of these notes has been made possible because we have in our hands a suitable and practical method of determining the performance of individual units. Before discussing results of mill performances, a few words should be said on the method of control.

Method of Control.

The principles and calculations have been described already (page 100-101, 1931 Congress S.A.S.T.A.). A slight modification has been introduced in the order of sampling bagasse. Instead of testing a different mill at every hour we prefer to concentrate on one unit during the whole shift of eight hours so as to obtain eight consecutive tests on the same unit.

This modification obviates the possible mistake of the sampling boy confusing the sequence of the mill test which occasionally happened in the past.

It has the advantage of providing the engineer with a fair number of tests on one single unit in the short space of eight hours. This information is sometimes very desirable after a week-end alteration.

The following schedule shows that at the end of the week when the average analytical figures are computed, each shift has had the opportunity of testing every unit. Difference of results on the same unit, between either of the three shifts, can be noted.

Schedule of Sampling.

	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
1st Shift of 8 hours	Crusher	3rd Mill	1st Mill	4th Mill	2nd Mill	Crusher
2nd Shift of 8 hours	1st Mill	4th Mill	2nd Mill	Crusher	3rd Mill	1st Mill
3rd Shift of 8 hours	2nd Mill	Crusher	3rd Mill	1st Mill	4th Mill	2nd Mill

This schedule is for a crusher and five mills. In the case of crusher and four mills the average figure per unit is still more correct as they are worked on a larger number of tests.

All the samples are boiled for at least one hour, the average time being nearer one and a half hours. This time of boiling is longer than the one specified in the official S.A.S.T.A. methods. After numerous tests we have come to the conclusion that for a rich bagasse the danger of extraction of dextro-rotatory non-sucrose, by long boiling is of less importance than the possibility of an incomplete diffusion of sucrose through short boiling.

We based our conclusions on the following tests:-

	Crusher	1st Mill	2nd Mill	3rd Mill	4th Mill
Number of Tests	37	9	20	11	12
Pol of Bagasse					
Half Hour Boiling	12.61	9.87	6.54	5.16	4.09
One and a Quarter Hours Boiling	13.30	10.39	6.92	5.44	4.28
Unextracted Pol by underboiling	0.69	0.52	0.38	0.27	0.19
	5.2%	5.0%	5.4%	5.0%	4.4%

These tests on shredded bagasse indicate a still bigger risk of incomplete diffusion when boiling bagasse from mills without a shredder for a period of half an hour, especially bagasse from the front units.

NOTES ON THE 1931 SEASON.

The milling conditions were fairly similar to those of the 1930 season in so far as tonnage per hour was concerned.

A stronger set of knives and a new crusher with "zig-zag" circumferential grooves helped to keep up a better running time. This new type of crusher showed definite advantages over the standard Krajewski in lessening the chokes. With regard to extraction, the results were poor as this crusher had to be left very open to take the large tonnage passed through.

The milling plant consisted of two sets of knives, one crusher 34in. x 66in., four mills 32in. x 66in. and a fifth mill 36in. x 84in.

Extraction results of individual units do not show much of a difference between that year and the previous one reported in the 1931 paper.

1932 Season.

In view of the larger crops to be crushed in the very near future it was decided to replace the old 14 roller 32in. x 66in. mills by larger units 36in. x 84in. similar to the fifth mill.

This alteration was to be carried out in two stages.

For the first season the front units, knives, Krajewski, shredder, 1st and 2nd mill were to be replaced and in the course of the second year the milling plant was to be completed by the replacement of the 3rd and 4th mill.

If we compare the figures of the 1932 and 1931 season we find that the extraction with a large zig-zag crusher and first mill was raised from 60.36 in 1931, to 70.74 and up to the second larger mill, the advance in extraction was from 75.85 to 80.86. The capacity per hour had increased from 72.5 to 90.8 with a maximum of 100.

The old small 3rd and 4th units had become the bottle-neck of the crushing plant. They had to be left more open than previously, and the pinions had to be altered to run them at a higher speed in order to pass this higher tonnage of cane.

Under such adverse conditions the extraction of these two units, was very low, bringing the total extraction up to the 4th mill to a lower figure than that of the previous 1930 and 1931 seasons in spite of the good advance given by the earlier mills. Nevertheless, the excellent work of the large 5th mill re-established normal conditions again so that the final extraction during the 1932 season with an incomplete plant stood at the same figure as during the previous year, whilst the crushing per hour had been considerably raised.

1933 Season.

During the 1933 season the complete milling plant of one set of knives, crusher, shredder and five mills 36in. x 84in. operated for the first time.

Examination of the Table I. in the appendix shows that the advance in extraction up to the second mill, which was a feature of the previous year, was again repeated. This advance was maintained by the two new 3rd and 4th units which did their fair share of work, so that the final extraction was increased over two degrees in comparison with the previous three years performance. Capacity per hour was also increased.

1934 Season.

For the past campaign yet a further increase of tonnage per hour has been put through the mills, which for a full week crushed at an average of 120 tons per hour.

Softer canes and lower fibre helped to raise the tonnage and also the extraction in the front units which up to the 3rd mill was 1.46 higher than that of the 1933 season.

For some obscure reason the two last mills did not keep up the extraction of the previous year,

so that the final extraction is the same as for the 1933 season.

Comparison of S.A. results with some other results from Cuba, Hawaii and Australia.

Tables II., III. and IV. of the appendix are very interesting to study.

The Cuban mill which is of the same size as ours, but has an extra 6th mill, crushes 140 tons per hour. On a fibre basis this represents a 15 tons fibre per hour against our maximum 18 tons per hour. Much less maceration is used than in Natal. Up to the 5th mill the extraction is about the same as ours with five mills also, notwithstanding our handicap of high fibre in cane. 33 per cent of the sugar leaving the 5th mill is extracted by the last 6th mill and accordingly the final extraction is over 96. This final extraction should have been beter but for the poor work of the fifth mill of the Cuban plant.

The Hawaiian mill with two sets of knives, no shredder, one crusher and six mills of 78in. reaches the high extraction for which the Hawaiian mills are famous. The tonnage per hour is kept at about 80 tons per hour on canes of 12.78 fibre, mostly grown under irrigation.

The very detailed figures published on the work of the past five years, have been re-calculated by us. They show a remarkable progressive drop in the extraction of the crusher, which is more pronounced for the 1933 season. The total extraction up to the 4th mill also shows a considerable drop during the 1932 and 1933 seasons, due to the low efficiency of the 4th mill. Doubtless the evidence of these figures can be backed by concrete facts known to the local operating staff. These facts we can only surmise at this distance. Nevertheless the very high efficiency of the last units, 5th and 6th mills, have made good the loss of the front units and the final extraction has been kept constant for all the years under review.

Should we not infer that the performance of the individual units at Mount Edgecombe are not altogether to be blamed when trying to explain the reasons for the inferior extraction on Uba cane when compared with Cuba and Hawaii.

A better start with the first crusher on softer canes at lower capacity is the principal feature of the Hawaiian results.

The influence of softer and lower fibred cane varieties was proved in the following tests carried out during the 1933 season at our mill on a few hours' run with the newly introduced varieties:—

	Uba	Soft Canes
Fibre % Cane	15.0	12.35
Tons per hour	100.0	129.0
Extraction up to 1st mill	70.4	81.4
Final Extraction	94.2	96.7

An additional unit in the way of a 6th mill is an advantage possessed by both Hawaiian and Cuban Mills.

We are of opinion that under our present conditions of high fibre and big tonnage per hour, the addition of a 6th mill would still be a profitable proposition, which would increase the final extraction to a figure of near 96.

The experience of the past two years has shown that far from influencing adversely the recovery of sucrose from juice a 2 per cent increase in the mill extraction did not appreciably lower the average mixed juice purity and did even synchronise with an increase of recovery from juice.

Individual extraction as influenced by an efficient maceration system is brought out by comparing our results in 1926, when the milling plant consisted of shredder and 14 roller 32in. x 66in. mills, with another plant of similar size operating at the present moment in Queensland (private communication). The average fibre at this mill is very high for Australia due to some peculiarity of the district, but compares very closely with our Natal figures.

The effect of quality of fibre which is an unknown factor not without influence on results is not taken into account in this comparison. Maceration is used in larger quantities in Australia than the amount we used in Natal in 1926. Although the moisture % of the last mills is no better than that of the Natal Mill and much higher than the low figures of Hawaii, yet the sugar in bagasse is practically the same as in Hawaii, notwithstanding a fairly high sucrose and fibre in cane. The extraction up to the first mill is about the same as is obtained at the present moment with our plant, but the efficiency of the subsequent individual units working with maceration is so high that three mills after the first one are able to put up a final extraction 1.5% higher than that obtained with our present four mills, and 3.9% higher than the results obtained with our old plant of size and number of rollers similar to the Australian one.

This very high extraction of the Australian Mill is mainly caused by a high efficiency of water used in maceration baths at high temperature.

APPENDIX.

I.—SOUTH AFRICA.—Mount Edgecombe Mill, Natal Estates.

	1931.	1932.	1933.	1934.
Tons Cane per hour—Average for Season	72.50	90.82	102.74	109.4
Tons Cane per hour—Maximum for One Week	76.9	100.0	111.9	120.5
Fibre % Cane	15.71	15.28	15.25	15.28
Maceration % Cane	40.1	36.3	41.0	38.9

	Extraction % Sucrose in Cane by Unit.					Extraction % Sucrose in Cane Total up to Unit.					Efficiency, i.e., Extraction % Sucrose entering Unit.				
Year	1930.	1931.	1932.	1933.	1934.	1930.	1931.	1932.	1933.	1934.	1930.	1931.	1932.	1933.	1934.
Crusher	—	20.5	32.13	36.89	38.33	—	20.50	32.13	36.89	38.33	—	20.5	32.1	36.9	38.3
1st Mill	—	39.86	38.61	33.30	34.78	60.0	60.36	70.74	70.19	73.11	—	50.1	56.9	52.8	56.4
2nd Mill	14.87	15.49	10.12	11.84	10.64	74.86	75.85	80.86	82.03	83.75	37.2	39.1	34.6	49.7	39.6
3rd Mill	7.52	6.76	1.71	5.55	5.29	82.38	82.61	82.57	87.58	89.04	29.9	28.0	8.9	30.9	32.5
4th Mill	4.19	4.53	2.92	3.42	2.37	86.57	87.14	85.49	91.00	91.41	23.8	26.0	16.8	27.5	21.6
5th Mill	5.66	4.85	6.60	3.21	2.79	92.24	91.99	92.09	94.21	94.20	42.2	37.7	45.5	35.7	32.5

II.—CUBA.—1931 (published in "Modern Milling of Sugar Cane," by F. Maxwell, p. 393).

Tons per hour, 140; Sucrose % Cane, 13.0; Fibre % Cane, 10.8; Maceration, 21.2%.

Kraj. + 1st Mill	74.28	74.28	74.28
2nd Mill	9.94	84.22	38.4
3rd Mill	6.22	90.44	39.5
4th Mill	3.16	93.60	32.9
5th Mill	0.80	94.40	12.8
6th Mill	1.84	96.24	32.9

III.—HAWAII.—Reports Association Hawaiian Sugar Technologists, 1934.

Ewa plantation average figures for 1934 are:—Sucrose % Cane, 13.24; Fibre % Cane, 12.70; Tons per hour, 79.90. Equipment:—2 K. (2RC 78), 6 mills 78in.

	Extraction % Sucrose in Cane by Unit.					Extraction % Sucrose in Cane Total up to Unit.					Efficiency, i.e., Extraction % Sucrose entering Unit.				
Year	1929.	1930.	1931.	1932.	1933.	1929.	1930.	1931.	1932.	1933.	1929.	1930.	1931.	1932.	1933.
Crusher	72.58	70.95	71.74	68.15	61.36	72.58	70.95	71.74	68.15	61.36	72.55	70.95	71.74	68.15	61.86
1st Mill	11.18	11.63	10.87	13.21	19.39	83.76	82.58	82.61	81.36	80.75	40.8	40.0	38.5	41.5	50.2
2nd Mill	6.55	6.98	6.91	7.85	7.78	90.31	89.56	89.52	89.21	88.53	40.3	40.1	39.7	42.7	40.4
3rd Mill	3.73	3.68	3.80	4.00	3.92	94.04	93.24	93.32	93.21	92.45	38.5	35.2	36.3	37.1	34.2
4th Mill	1.49	2.18	2.57	0.45	0.81	95.54	95.42	95.90	93.66	93.26	25.0	32.3	38.5	6.7	10.7
5th Mill	1.71	1.73	1.39	2.87	3.11	97.25	97.15	97.29	96.54	96.37	38.4	37.8	33.9	45.4	48.0
6th Mill	0.97	1.05	0.93	1.66	1.78	98.21	98.20	98.21	98.19	98.15	35.3	36.8	34.3	48.0	49.1

IV.—Comparison of a South African Mill with a Queensland Mill (private communication):—

Milling Equipment.	Knives, Kraj. Shredder + 4 Mills, 32 x 66. South Africa.	Knives, National Shredder + 4 Mills, 34 x 66. Queensland.
Tonnage per hour	59.1	60.4
Fibre % Cane	15.15	15.11
Sucrose % Cane	13.24	14.40
Maceration	28.4	37.1

	Extraction % Sucrose in Cane by Unit.		Extraction % Sucrose in Cane Total up to Unit.		Efficiency, i.e., Extraction % Sucrose entering Unit.	
	South Africa.	Queensland.	South Africa.	Queensland.	South Africa.	Queensland.
Kraj. + 1st Mill	69.4	72.51	69.4	72.51	69.4	72.5
2nd Mill	12.68	9.43	2.08	81.94	41.5	34.3
3rd Mill	6.64	9.00	88.72	90.94	37.1	49.8
4th Mill	3.10	4.79	91.82	95.73	27.5	52.8

The CHAIRMAN then declared both papers on the subject of Milling to be open for discussion.

Mr. P. MURRAY: We are greatly indebted to Mr. Macbeth for his paper—Cane Milling—based on his experience at Natal Estates. No important paper an Cane Milling has been presented to this Association and I hope this paper will be the forerunner of others which will help to improve this the most important station in the factory.

I would like to submit the following comments:—

CANE KNIVES.

A speed of about 500 r.p.m. is recommended, although speeds of 1,200 are used elsewhere, and you suggest that this speed would shorten the life of the blades. I would have thought that a higher speed than 500 would have helped the blades and they would keep sharp longer.

THE ZIG-ZAG CRUSHER.

Has definitely proved itself the best crusher for Uba cane and it is now installed at Entumeni, Chakas Kraal, Doornkop and Umzimkulu, and in each case increased the extraction and cut down the chokes in the plant.

This crusher was first installed at Entumeni, and although something like it was patented by Aitken many years ago, it was not developed until Duncan Stewart & Co., Ltd., installed it at Entumeni, and on being seen there by Mr. Macbeth was immediately ordered by him for Mount Edgecombe. The speed of this crusher appears to be an important point, and Mr. Macbeth's recommendation should be carefully followed.

SHREDDER.

Mr. Macbeth recommends the shredder. I am not satisfied that it is any better than, say, another crusher or another mill unit in its place. I feel if Mount Edgecombe had installed another crushing unit in place of the shredder, the extraction might have been better. Mr. Macbeth compares the power of the milling plant with and without shredder, and gives the reduction in power as 15 to 19%.

The power of the crusher is shown as 208 amps. without shredder and 180 with shredder a difference of 15.6%. This unit is not affected by the shredder so the power must have been affected by the quality of the cane and this would also affect the other units.

If Mr. Macbeth had adjusted his mill settings to suit operation without the shredder it would have altered the whole result.

The hydraulic pressure applied appears very low according to usual practice roughly 350 to 385 tons per roller. The 84in. mills at Empangeni carry 500 to 550 tons load, and I feel that with heavier loads he would have got better extraction. With regard to the even lifting of the top roller of mills, this has been greatly improved by the amps. coupling developed at Empangeni. This allows free sliding of the tail bar and does not jam the roller end-ways.

Messrs. Duncan Stewart & Co., have recently put on the market the Hadden-Stewart Accumulator which definitely makes the top roller rise vertically parallel to the side rollers.

With regard to **Hydraulic Load on Mills and Crushers—**

It is usual to report the hydraulic load on mill rollers and crusher rollers as tons per foot length of roller. This is all right when comparing mills of the same size, but is no use for comparison if the rollers are of a different size.

It is obvious that a 20in. roller cannot take the same load per foot as a 36in. roller. The better and correct method is that used by Duncan Stewart & Co., Ltd., the original inventors of hydraulics, namely, that the load varies as D x L.

D = diameter of roller in inches.

L = length of roller in inches.

Their formula is:—

$$\text{Total load on roller in tons} = \frac{D \times L \times A}{20}$$

A = cwts. per square inch of roller, varying from 2 for a crusher to 3½ for a mill.

This would give the following loads for mills with A = 3 cwts. and shows up the difference when compared with the previous method.

Size of mill	Load in tons D x L x 3/20	Load per foot of roller-tons
20 x 36	108 tons	36
24 x 48	172.8 tons	43.2
26 x 54	210.6 tons	46.8
30 x 60	270 tons	54
32 x 66	316.8 tons	57.6
34 x 72	367.2 tons	61.2
36 x 84	453.6 tons	64.8

We feel all loads on mills should be reported as total tons per roller or cwts. per square inch of cross section of roller and similar to what is done in bearing loads.

With regard to mill settings, I would suggest that these be calculated on the basis of cubic feet of opening per ton of cane per minute.

Basing on Mr. Macbeth's figures on page 10 of his paper:—

A. Feed opening—126 square inches.

B. Entrance trashplate, 126+65% = 208.9 sq. in.

C. Exit trashplate, B+20% = 250.7 sq. in.

D. Bagasse opening A÷2¼ = 5.6 sq. in.

Taking a mill giving a surface speed of, say, 24 feet per minute and a tonnage of 97 per hour this would give the following openings:—

A=13 cu. ft. per ton of cane per minute.
B=21.4 cu. ft. per ton of cane per minute.
C=25.7 cu. ft. per ton of cane per minute.
D=5.77 cu. ft. per ton of cane per minute.

This setting appears to me to be for the 1st mill.

If every engineer would calculate out his openings in this manner he would be surprised how his openings vary in capacity.

Mr. Macbeth's openings have been compared in the past with other settings based on this principle and have compared very well.

The openings of the later mills would be much less.

The power of the mills given by Mr. Macbeth are as follows:—

	At Unity Power factor
Crusher 180 amperes	= 209 Horse power
1st mill 244 amperes	= 284 Horse power
2nd mill 221 amperes	= 257 Horse power
3rd mill 236 amperes	= 272 Horse power
4th mill 219 amperes	= 255 Horse power

These horse-powers appear very high for the hydraulic load but the power factor may be low and reduce the above powers accordingly.

The 37½in. x 84in. Stewart mills at Empangeni with a hydraulic load of 500 tons and speeds over 30 feet per minute take the following power, roughly 0.177 B.H.P. With regard to the variable speed of mills, I fail to see the use of having a large range of speed and installing expensive commutator motors. Surely ordinary slip-ring motors would do for driving mills and a range of speed of, say, 10 to 15% less obtained by drum controller.

I have tests taken at Empangeni over long periods and the speed variation did not exceed 6 to 7 per cent.

In engine driven mills we have several units driven by one engine and in this case it is impossible to vary the speeds relative to each other. I should like to know from Mr. Macbeth what variation of speeds he has found necessary at Mount Edgecombe. These 84in. milling plants are expected to handle round about 130 tons of Uba cane per hour and this is much over the economical capacity and greater than obtained elsewhere.

I am sure it will be necessary to have 6 mills to give this capacity.

Again, regarding powers of mills, the horsepower varies with the hydraulic load and speed, and the Mount Edgecombe mills, even allowing for an ample power factor, take too much power. It would be interesting to know if this is due to the construction of the mill, perhaps wide trash turners and the top roller sticking. Trash turners must be narrow and the top roller lift freely in its bearings, and the Amps. coupling would likely help to overcome this.

I appreciate Mr. Macbeth's paper very much, and I think a strong Milling Committee should be formed to collect data and study out milling, as was done by the Boiler Committee. Dr. Hedley could be appointed to collect this data and check up at the various mills, and I am sure the present fairly good milling results would be further improved upon.

Mr. W. A. CAMPBELL: On the question of the shredder, this may interest some of the mill engineers here. At our mill, tests have been done on the final bagasse by separating the average into fine and coarse particles and testing them separately. We found large differences in their sucrose per cent, the finer particles showing an average of 1.29% lower than the coarser ones. Our chemist, after numerous tests of a similar nature on all the mills, found that the finer particles were originally sweeter than the larger ones, in the bagasse from the front units. This difference was reversed in the subsequent mills as a result of the finer particles giving up their sucrose content in a much easier way, by pressure and maceration. These tests proved definitely the great advantage to be gained in extraction by the work of a Searby Shredder. Practical confirmation of these tests was given by still increasing the shredding action of the Searby Shredder, when improved extraction resulted. Engineers and chemists should remember that results of analysis may be misleading if discrimination is used in rejecting bagasse particles of a certain size, or the whole average should be actually mixed before sending to the laboratory. (See Congress, 1931, p. 102, Milling Control, by J. Rault).

Mr. N. MITCHELL: I should like to say a few words regarding Mr. Macbeth's paper. The Umfolosi Company installed, last year, two of the Mount Edgecombe old mills, the third and fourth mills. In the first, second, third and fourth mills we installed corrugated trash plates similar in design to figure 6 in Mr. Macbeth's paper. The corrugations we installed in the trash plates were put in in unison with the sweep of the trash plate. By putting these corrugations in we found that we eliminated a great percentage of wear on the trash plates, also we prevented the bagasse diverting to the sides and in consequence eliminated all chance of roller flanges being broken off. It was a very noticeable fact when we opened up the old Mount Edgecombe mills—they installed a toggle bar and I could not understand it that on the face of the plates of the Mount Edgecombe mill they were clean surface plates, and the bagasse definitely

diverted from the centre up to each end of the flanges. I have never seen it so noticeable before and I put it down to the toggle bar. On our old milling plant before we installed corrugated trash plates we had a similar diversion of the bagasse on the trash plates but not nearly so marked as what it was with the old Mount Edgecombe mill. These old mills had hydraulic gear. The reason why we put in corrugated trash plates was simply because we wanted to eliminate as far as possible an extra pusher gear and eliminate chokes as much as possible from the mills and also to try and increase the tonnage per hour. The corrugations certainly have eliminated pusher gears. They have also eliminated 75% of the choking. I have drawn your attention to this point as I think it is well worth other companies trying the experiment. The plates, I believe, cost £5 more for machining, but I think the £5 is well spent. I had a conversation with Mr. Macbeth some time ago regarding this and I understood he wanted to try one of these plates. I would like to ask Mr. Macbeth if he has done so and what results he found.

CHAIRMAN: The question of the grooving of these trash plates is one which I do not think is very well understood at present. We are all interested to hear that these trash plates have been grooved in the first place at Umfolosi and I would like to know from Mr. Mitchell whether these grooves have been made parallel to the line of travel of the cane and parallel to one another, or whether any attempt has been made to follow the natural way in which these grooves diverge on a Dumbturner plate. The divergence of course varies according to the pitch of the grooving but why that divergence should take place I for one at rather at a loss to understand. If we are going to artificially groove the surfaces before putting them to use what standard are we going to work on, what shape are we going to give these grooves, and especially what amount of divergence. If you examine any two or more of these plates after a year or two's use you will find no two are alike although the pitch of the roller grooving may be the same. Mr. Macbeth, in his paper, suggests that some cause may be due to the chevron grooves in the feed rollers. In my experience I have noticed the same thing occurring on rollers without chevron grooves at all. The same amount of grooving takes place and it seems to make no difference at our mill. It is an interesting point and one which will take some time to clear up, but I should like to know from Mr. Mitchell what the original shape of these grooves are.

Mr. MITCHELL: When we first went into this question we made a model. We made a full sized trash plate and on the drawing board we worked out the curve this groove would take on the pitch of certain parts of the top roller, and we found that from the feed roller the trash plate groove gradually became deeper until it got to the centre point and from the centre point it gradually tailed off to about a quarter. We made the grooves 3/8in. deep, that is at the point of the trash plate where the highest portion was. These grooves were parallel to the roller grooving. Actually the bagasse does not diverge once these grooves are installed. The bagasse simply follows through these grooves on to your discharge roller and no diversion of the bagasse takes place. That has been proved when we opened up the mills this year. Grooves which were machined in the trash plates, when inspected, were just as they were when installed.

CHAIRMAN: That is a very interesting point. It appears then that the bagasse actually follows the paths which you have prepared for it.

Mr. MACBETH: Before proceeding on with Mr. Murray's remarks I would like to touch on the subject of these grooves in the trash plates as brought up by Mr. Mitchell. There is one point on which I cannot agree with Mr. Mitchell and that is that he attributes the divergence of the grooves on the plate to the toggle bar. I think the cause is due to the chevrons on the top roller. In our case the chevrons are very large and are cut on the top roller with grooves 2in. pitch. That is the only mill where we experience the grooves diverging in an outward direction towards the flanges. The other rollers are grooved 1in. pitch. They also have chevrons and we do not get divergence on those plates at all. On the point of grooving on the plate as mentioned by Mr. Mitchell, we are trying one this year in our last mill similar to what he described on his plant, and until it is tried out we cannot say what result we are going to get. But what I go on is this, that the grooving that has taken place on our trash plates previously, to my mind has helped the mill in the results obtained, in this way that you open the flow channels in the plates in the first year and by putting those grooves in you have brought that trash plate to the position where it functions much better. With reference to the depth of the grooves, I would mention that I should say anything from 1/4in. to 3/8in. in the case of 1in. grooving and I think that would help things considerably, because we found after three years wear we have approximately 1/4in. to 5/16ths on the stainless steel plates and the mill functions much better under those conditions.

Now with regard to Mr. Murray's remarks, in the ordinary course of events I would not be able so soon to reply to him, but he very kindly sent me a copy of his notes and questions which has given me an opportunity to reply fully to his queries during this discussion.

CANE KNIVES.

In reply to Mr. Murray's remarks under this heading I am still of the opinion—when dealing with Uba cane, that it is not advisable to run the

knives at a higher speed than 500 r.p.m.; especially when high tonnages are ground, and I think more wear and tear would be experienced at higher speeds. In the case of knives running at 500 r.p.m. it means that the knife registers 500 cuts per minute and at 1,200 r.p.m. the knife registers 1,200 cuts per minute. Based on this theory the knifes run at the higher speed should show more wear. However, I would like to hear the opinion of other on this subject.

ZIG-ZAG CRUSHERS.

This is one item which Mr. Murray and myself agree on.

SHREDDER.

Mr. Murray says he is not satisfied that the shredder is any better than another crusher or a mill unit in its place, and sets out his reasons for saying so.

I am satisfied where high tonnages are ground per tandem, the shredder is an essential unit if high extraction is to be maintained. There is no other unit which can prepare the cane to the same extent as a shredder.

If another crusher was installed in place of the shredder, the extraction on the final mills of the tandem would be lower, as experienced by the week's run without the shredder. The advantage of the shredder lies in the maximum higher extraction maintained at the latter mill units.

Shredders are extensively used in Queensland and Hawaii, and I wish to quote an instance for comparison concerning the latter country.

At the **Oahu Sugar Co.**, the crushing plant comprises One Set Knives, One 2 Roller Crusher 36 x 78, One Shredder 72in. and four mills 34in. x 78., Extraction 98.5%, Fibre % Cane 11.86%, 60 tons per hour.

Ewa Sugar Co., Two Sets Knives, One 2 Roller Crusher 34in. x 78in. and 6 Mills 34in. x 78in., Extraction 98.29%, Fibre 12.7%, 79 tons per hour.

Summarising the above, the mill extraction at Oahu is higher by 0.21%, but the difference in the fibre content is 0.84% lower in favour of Oahu, however, under these conditions the extraction results are about equal. The only difference then, is the quantity of cane milled per hour which is 19 tons more mrushed by Ewa with two additional mill units, and I feel sure that the same results would have been obtained with a shredder and 5 mills.

During the months of October to December last crop at Mount Edgecombe the increase tons of cane per hour milled was 16 to 17. and yet the extraction remained at 94.2%, which points out that where larger tonnages are milled the shredder plays an economical and important part in maintaining high extraction.

The figure of 1.3% quoted in less extraction without the shredder in operation was on a test of 6½ hours only at the end of the season after the crushing plant had completed grinding 334,000 tons of cane, and therefore cannot be counted as an accurate indication of the true results.

The figure of 1.9% less extraction is a true indication of facts, as this was obtained over a week's run without shredder, and if based over the crop would be nearer 2%.

The question of power taken by the crusher, with and without the shredder, i.e., 180 amps. and 208 amps. respectively, the difference may be due to the qualities of the cane milled at these times. The figure of 15 to 19% more power required by the mills without the shredder was reflected also during the week's run referred to in the paper.

Mr. Murray suggests that if I had altered the mill settings to suit operation without the shredder it would have altered the whole result.

I do not think there would have been any difference in extraction, as the mills were up against it as it was, especially the first mill, and the imbibition water had to be reduced.

Mr. Murray makes a comparison between the hydraulic loading at Mount Edgecombe and Empangeni, and suggests that the loads carried by Mount Edgecombe are very low. That is the point raised in the paper, i.e., where a shredder is installed there is no need to carry such heavy loads, as with the higher loading no increased extraction was obtained—hence less wear and tear on the mills, better results are obtained from imbibition water, and less power required by mills.

Another point which should be considered and that is the initial cost of a shredder against a crusher or a mill unit. The two latter units are approximately 125% and 150% higher respectively in cost than a shredder.

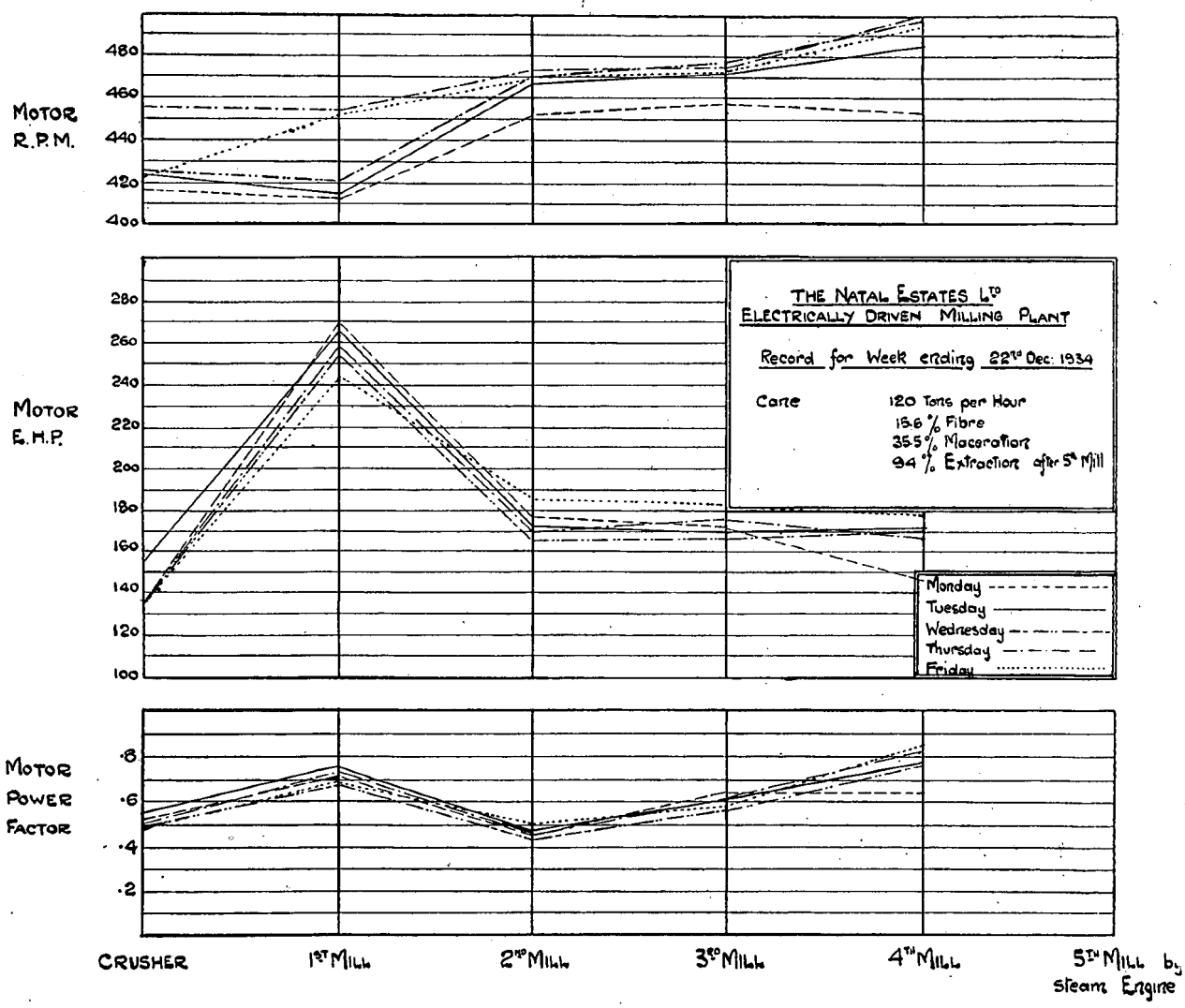
Could Mr. Murray let us know the amount of work done by the two 84in. mills at Empangeni, that is, what proportion of the total extraction are they doing?

With reference to Mr. Murray's remarks on hydraulic loads per foot length of roller and the calculated basis of cubic foot of opening per ton of cane per minute, I wish to say it is an excellent idea and I have checked up mill settings on this formula, which I understand was brought out by one of Duncan Stewart's Engineers.

Since compiling this paper—K.W. Meters have been installed. They were erected immediately upon their arrival which enabled us to take the horse powers of the mill motors over the last week of last crop. The graph below shows the results obtained over a week's run. It will be seen that the power taken by the various mills is considerably lower than suggested by Mr. Murray with the exception of the first mill.

The question of the variation in speeds necessary for cane milling, and the type of motors suitable for electric drives, etc., is really a long story and somewhat involved as far as Mount Edgecombe is concerned, and would be the subject for a paper at some later date.

With the high tonnages ground at Mount Edgecombe, the speed variation found necessary has



In three instances the power taken by the other mills is about equivalent to that of Empangeni, i.e., 177 H.P.

Empangeni crushing rate is 83 tons per hour against Mount Edgecombe's 120 tons per hour when these tests were taken. Of course the hydraulic loading in each case is different.

The power factor on the crusher, 2nd and 3rd mills is somewhat low, but this can be improved upon later.

reached 15%, and when crushing soft canes in conjunction with Uba cane greater variations are necessary.

Mr. Murray remarks that he is sure it will be necessary to have six mills to crush 130 tons per hour of Uba cane; but at what extraction?

I do not think it is necessary to have six mills to crush 130 tons of Uba cane per hour, as Mount Edgecombe crushed 120 tons per hour for one week with 94.0% extraction. The plant comprises one crusher, one shredder and five mills.

With reference to Mr. Murray's concluding paragraph, I think this has been answered in my various former replies, especially where H.P. is concerned. As far as the construction of the mills are concerned —there is absolutely nothing wanted in this respect and the trash plates are no wider than any other mills of their size.

I may add that I do not suggest that there is no room for improvement in mill extraction at Mount Edgecombe—far from it—it is our endeavour to increase if possible. We have only operated two seasons with the completed new crushing plant so there are still many features yet to be tried out.

Again I thank Mr. Murray very much for sending along his comments and queries before hand, and for the capable way he has dealt with the many subjects he has brought forward which has added interest to the discussion on the paper.

Mr. JOHN MURRAY: I would like to say we are all very much obliged to Mr. Macbeth for giving us this paper, and I think it is all the more creditable seeing he is a Natal boy and has had all his education in Natal (hear, hear). It just shows what can be done here! Now there is one question I would like to ask Mr. Macbeth. In Natal and Zululand there are a lot of mills with a number of 32in. x 66in. plants. Some want to increase their tonnage put through these plants and do not know whether to put a mill at the back or front of the other mills. If you wish more extraction with the same tonnage a big mill at the back would show it; but would you get increased tonnage by adding a big mill at the back? If you can get 80% juice it would seem to me to be better to put it at the front.

Mr. MACBETH: I do not quite follow what you mean by putting it in front.

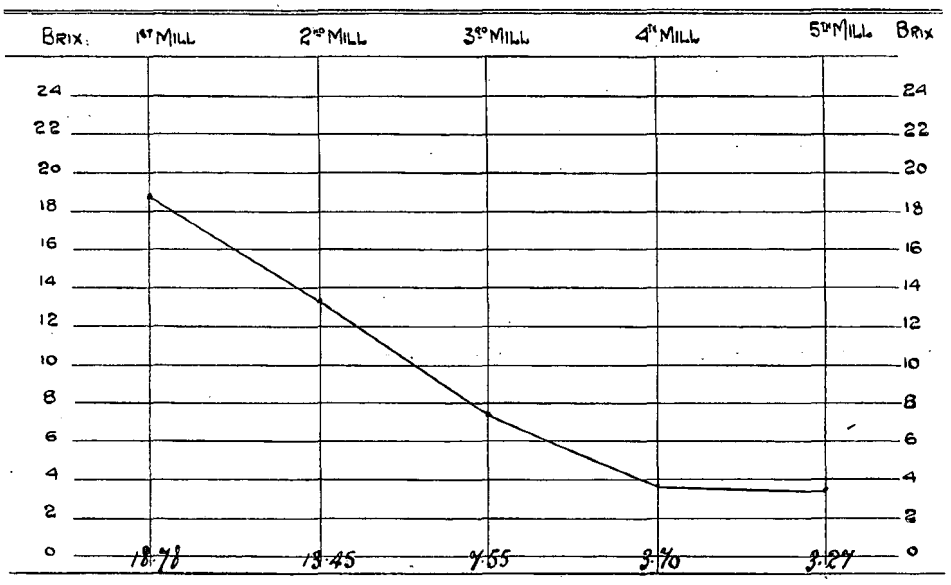
Mr. JOHN MURRAY: Supposing you had a 14 roller 32in. x 66in. plant, and you did like you did at Mount Edgecombe, put a fifth mill 36in. x 84in., if you want to increase up to 70 or 90 tons. If you put a big fifth mill at the back you would not get that tonnage through that plant but might if you put a big crusher and two mills in front of the existing 14 mills.

Mr. MACBETH: I would just like to mention that so far as Mount Edgecombe is concerned, we put the large plant in the front of the old milling plant. That was done for the simple reason that we wanted to raise the tons crushed per hour. We had the fifth mill already installed at the other end 36½ by 84 and of course by putting the new additions in front of the two other mills the centre became a bottle neck and we got practically no work from those two mills. We had to open them up and although the cane did pass through we depended on the pressure of the new milling plant and the fifth mill to give us the extraction results. But in the case where you have a tandem, say, of 32in. x 66in. and you want to increase the tonnage I should say the best thing to do is to add a large mill at the back of the train, open up the others slightly to get the extra tonnage and allow the last larger unit to take care of the extraction. Of course there is a limit to that too, but it would be the best proposition if you want to get extra tonnage and at the same time maintain a fairly high extraction. Of course in saying that I must add that in adding extra mill units to a tandem it does not mean that the percentage of extraction from each additional unit will be the same as the unit preceding it. The feeling is that if you keep on adding mills you will get about 2% extra extraction from each one. This is incorrect, as the extra amount would be approximately 30 to 35% of the total entering the unit on the latter mills.

Mr. G. C. DYMOND: I notice in Mr. Macbeth's paper on the question of grooving he omits what I noticed to be the standard practice in Puerto Rico. He makes no mention of the Kay groove. I would like to ask Mr. Macbeth whether it was the standard practice in the countries he visited in his recent trip overseas. The next question is to Mr. Rault. At Mount Edgecombe, they have developed a method of milling control which has proved very satisfactory, but to my mind is somewhat unwieldy in that it takes a long time to get the results of the tests. Recently a development of milling control has been on the brix curve which appears to me to be a much more simple method of testing individual units, and I should like to have Mr. Rault's opinion on this method of testing the efficiency of mill units.

Mr. MACBETH: With reference to the Kay grooves, the only country that I noticed had installed those grooves was Java, but the Kay grooves are really combined in conjunction with very fine grooving on the rollers. I do not see how you could run a Kay groove on, say, a 1in. pitch grooving. In Queensland, I think, there was one mill which did something resembling the Kay groove in the last mill, the back roller, but in the other factories I visited they had none whatever. So far as Hawaii is concerned they had no Kay grooves at all and I visited some 14 factories there. You touched on the density curves; I think the present method is a very accurate one, but as you remark you may get quicker results or quicker information if you work on the juice density curves, and that is why I mentioned it in my paper. I brought back from Hawaii some charts showing

how it is done, and one is shown in the following figure. It gives the engineer a chance of ascertaining the cause of the variation.



Dilution 42.53 Moisture in Bagasse 39.20 Sucrose in Bagasse 1.42 Extraction 97.61

Averages 44.38 39.93 1.28 97.85

Mr. RAULT: I can assure Mr. Dymond that the method of mill control by bagasse analysis does not increase unduly the work of the laboratory when carried out in the way already described.

It is a matter of opinion as to whether the testing of four extra mill juices every hour for the density curve is less cumbersome and messy than one by which one bagasse and one juice have to be tested in the same interval.

Regarding the speed at which information can be gathered on one special unit, the present method of eight consecutive tests on one unit meets the objection of time lost.

I do think that the juice curve method had merits of its own and should be tried by mills that may not have facilities for carrying out bagasse analyses of every unit.

The assumption of a close relationship between density of back roller juice to residual juice and sucrose in bagasse is not in every case very apparent.

The curves overleaf accompanying extraction figures for three seasons are rather difficult to correlate with facts. It is true that the 1932 curve shows an insufficient drop at the fourth mill. This information is rather vague and extraction results showed definitely that No. 3 mill was still worse than No. 4 in its poor extraction.

Again, we find that the density of final back roller juice was lower in 1932 than in 1927, and yet the total extraction for the 1927 season was well ahead of the 1932 one.

We have also examined curves on Mauritian mills published in "La Revue Agricole" (No. Jan.-Feb., 1935), where extraction of 95.7 are obtained from 15.0% fibre canes, notwithstannding the fact that the density of last mill juice was still over 4½% brix, when in our case a final brix of 2 to 3% barely gives a 94.2 extraction.

For the above reasons I prefer the bagasse methods, as I feel sure that all engineers are more interested in the moisture of the bagasse and extraction of a particular unit rather than drops in brix of juices expressed in fancy curves, which can be interpreted in various ways.

No comparative figures from year to year and from country to country could have been established on reading juice curves published in technical papers, whereas individual extraction figures open up a bigger scope for comparison of mill performances and can be worked to £ s. d.

Mr. BERENGER: Mr. Macbeth has not made any mention of Cail Crushers or of Krajewski fitted with Messchaert Grooves. I know that a Cail crusher was installed last year in Mauritius on Mon Loisis Sugar Estate. I have been told it has given very good results, but up to my leaving the colony no official report had been published. Regarding Krajewski fitted with Messchaert grooving, there was one installed in 1930 in Highlands Factory belonging to the Anglo-Ceylon & General

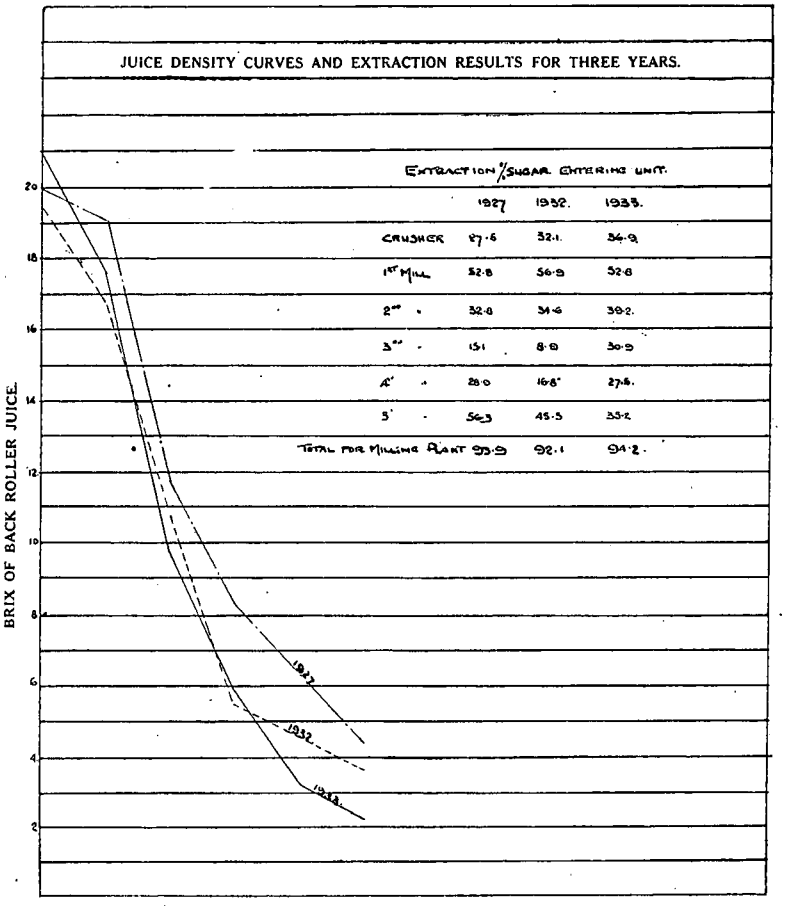
Estates, where I am factory manager, and it is with pleasure that I submit to Mr. Macbeth's attention the following results which we obtained with that type of crusher and I hope it will interest him.

This crusher and the first mill are both driven by the same engine; up to 1930 we ran that engine at 52 r.p.m. so as to crush in a 28in. x 72in. crusher of Krajewski type with horizontal zigzag about 38 to 39 tons (Metric) per hour—as it was found that this crusher needed replacement it was decided to order an ordinary Krajewski with horizontal zig-zags but fitted with Meschaert grooves of 2½in. deep in the flesh of the crusher, this crusher has therefore done already five crops and has crushed up to now about 300,000 tons and is still in perfect condition, the wear on the scraping gear is nill and one set of scrapers (11 in all) will do easily 100,000 tons of cane. To give you an idea of the amount of scrap iron we pass I will tell you that our second mill rollers fitted in the same year will have to be replaced soon owing to the many pieces of the back rollers having been broken away. The crusher does not show any sign of the iron that has gone through it.

This crusher (28in. x 72in.) is set at 3/16in. and the engine running at 42 r.p.m., we are now crushing 42 tons (Metric) of cane per hour (instead of 38 to 39 (Metric) tons at 52 r.p.m.) Our mill extraction figure which was in the region of 94.5 in 1930, is now in the neighbourhood of 95.8 which shows that our new crusher is responsible for more than 1% mill extraction.

Mr. MACBETH: I have noted with interest the remarks passed by Mr. Berènger in connection with crusher rollers as used in Mauritius. As far as the Cail crusher is concerned I have no experience or data on this point. With reference to the Krajewski crusher—horizontal zig-zag—having large Messchaert grooves cut circumferentially, we had a set of rollers fitted with these grooves, but did not have the same results as we now obtain with the present crusher rollers, although I admit that deep Messchaert grooves assist in freeing the juice extracted. Where high tonnages of Uba cane are dealt with per tandem the circumferential zig-zag grooves give far better results in every respect.

The tonnage crushed for five crops, i.e., 300,000



at 42 tons per hour and with canes of low fibre content, naturally the amount of wear would be small. Some of our factories crush 450,000 tons of cane in one crop with canes at 15.5 to 16.5 per cent fibre at 120 tons per hour, therefore more wear and tear will be experienced.

Mr. Berènger shows that under Mauritian conditions of low tonnage per hour by adding Messchaert grooves to an ordinary Krajewski he is able to run at a lower speed and crush more per

hour and also obtain higher total extraction. Details of individual performance not being available it is difficult to assign the superior total extraction to the work of this unit, rather than other succeeding ones.

CHAIRMAN: I must express my gratification at the interest shown in the papers put forward by Mr. Macbeth and Mr. Rault. I may say that I have spoken to Mr. Campbell and Mr. Johnson about the necessity of sending an Engineer representative to the Queensland Congress, and I now make the suggestion from the Chair that the Millers' Association should be approached with a view to appointing a representative.

The Congress agreed unanimously that this course be adopted.

I would ask you to accord Mr. Macbeth and Mr. Rault a hearty vote of thanks for the very valuable contributions they have given us. (Loud applause).