

DETERMINATION OF JUICE STORAGE CELLS BROKEN IN THE MILLING TRAIN

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Introduction

In Natal sugar factories only 90 to 95 per cent of the sucrose in cane is extracted in mixed juice, in spite of a compound imbibition process involving the use of a large amount of water. Obviously imbibition can have its maximum effect only when all the residual juice in bagasse is available for mixing with the imbibition liquor.

The larger the volume of juice present in unopened cells, the more incomplete extraction will be. Hence, for a proper understanding of the cause of the relatively low extraction percentages in some Natal mills, knowledge of the juice present in unopened cells in the bagasse discharged by consecutive mills, is essential.

Purpose of the Investigation

The purpose of this investigation is to assess the value, under Natal conditions, of a procedure developed by Khainovsky¹ for the determination in bagasse of that fraction of the sucrose, which was originally present in cane, and is still contained in unopened cells.

As far as the investigation is concerned, cane may be considered to consist of the following parts:

- (1) Juice containing sucrose and non-sucrose soluble material, all of which is present in storage cells.
- (2) Cold water insoluble material² consisting mainly of the walls of sucrose storage and other cells, and usually called natural fibre. It is assumed that natural fibre contains (brix-free) water which cannot be removed by mechanical means, to the amount of approximately 30 per cent on dry fibre.
- (3) Liquid present in fibro-vascular bundles, usually containing very little solids.³

The function of a mill is to open storage cells and to squeeze out the liberated juice. The removal of the juice is furthered by repeated dilution with imbibition liquor. Hence, after the first mill, bagasse normally contains (a) juice in unopened cells, and (b) juice from opened cells which the squeezing action of the mills has failed to remove. The latter juice is mixed with (c) imbibition liquor, but not completely.

With a view to a correct interpretation of the milling performance, we want to determine, in the bagasse from each mill of the tandem, the amount of sucrose present in unopened cells expressed as a percentage of the amount of sucrose in the corres-

ponding weight of cane from which the bagasse originated.

Assuming—

- (a) that the sucrose content of the juice in all storage cells is identical,
- (b) that the capacity (volume) of all storage cells is identical,

we can also say that we want to determine, in the bagasse from each mill, the number of unopened cells expressed as a percentage of the total number of storage cells present in the corresponding weight of cane from which the bagasse originated.

Principle of the Method

The amount of sucrose in bagasse present in unopened cells equals the total amount of sucrose present minus the amount of free sucrose, i.e. the sucrose originating from opened cells, but not yet removed, plus the sucrose present in imbibition liquor. Consequently, sucrose in closed cells in bagasse per cent. sucrose in cane is identifiable with closed cells per cent. total cells in bagasse and is found as total sucrose in bagasse per cent sucrose in cane minus free sucrose in bagasse per cent sucrose in cane.

The determination of the total amount of sucrose does not present undue difficulties⁴ and for the determination of the amount of free sucrose, Khainovsky¹ has developed a suitable method.

He showed that sucrose storage cells are elastic in nature, and during squeezing, broken cells expelled some of the juice content and on release of the squeezing pressure, the cells regained their shape, and at the same time drew air into the broken cells. It is advisable to quote Khainovsky's description of the principle involved during pneumatic extraction.

"If we bring the bagasse, immersed into water, many times and alternately under diminished pressure and atmospheric pressure, all the air bubbles (which are present in broken cells) will expand and contract every time. We get a pulsating motion, which is the essential point of the pneumatic extraction. The air bubbles expand in the already-broken cells, press the liquid out and on contracting suck in the surrounding liquid. As all these air bubbles expand and contract simultaneously, the content of the broken cells is brought into constant and very powerful reciprocating motion. The quantity of liquid, which is in this way pumped to and fro, is many times larger than the total primary quantity of juice. The washing out and mixing with the surrounding liquid therefore are very complete.

The cells, which are opened but do not happen to contain air bubbles, are filled with juice only, undergo also a very thorough lixivation, because they are at some points of their broken walls in contact with the surrounding intercellular spaces. Powerful streams in the surrounding spaces cause in the entrances of the broken air-free cells such eddies that the contents of the cells are washed out too. Here we must emphasise that only the air

bubbles expand and contract by the variations in pressure. The cell walls do not undergo any noticeable change of volume. The cell walls do not pulsate, as is sometimes thought, because they are on both sides in contact with liquid, whose volume does not change during the variations of pressure."

Khainovsky goes on to report that "after about ten evacuations in the pneumatic apparatus; no increase of polarization of extract will be registered."

To test the applicability of this method for bagasse from Natal mills, a suitable extraction apparatus was constructed.

Apparatus used in our Investigations

The apparatus used for the pneumatic extraction of free sucrose in bagasse is shown in the sketch on page 52.

- T Circular tank 12" diameter, height 13". Lip fitted with a rubber gasket set in a machined groove E.
- A Lid of tank, having machined sealing lip B, which fits into groove E. (Lid correctly positioned by four lugs.)
- D $\frac{1}{8}$ " circular copper plate 11 $\frac{1}{4}$ " diameter with $\frac{1}{4}$ " holes drilled. Suspended by three 9" chains C, from lid.
- F $\frac{3}{8}$ " pipe to vacuum pump. F set 11 $\frac{3}{4}$ " from bottom of tank.
- G $\frac{1}{2}$ " sampling pipe set 1 $\frac{7}{8}$ " from bottom of tank.
- H Screen to prevent blockage of sampling pipe.
- J Three-way cock connected with vacuum pump.
- K Vacuum-type Saunders valve to ensure vacuum-tight seal, should bagasse particles lodge in the valve.

Description

The perforated plate D prevents the air-containing bagasse from rising to the surface of the liquid on evacuation of the tank.

The liquid level is above plate D, about 6" from the bottom, and F, the vacuum-supply pipe, is set sufficiently above the liquid level to prevent loss of the froth during the evacuations.

The whole of the apparatus was painted with four coats of an amine-cured, cold-curing enamel, which withstood the conditions of the test remarkably well.

General Description of Testing Khainovsky's Method

A weighed quantity of bagasse and water was placed in the apparatus, the lid clamped down on to the rubber sealing ring and suspended by the handle.

Pipe F was connected *via* a simple mercury manometer to the vacuum pump. By means of the three-way cock J, the vessel was exhausted to the required degree of vacuum as indicated by the manometer and then immediately, by turning the cock J, the vessel was opened to atmosphere. By repeating this process, a means of testing the degree of extraction was obtained.

Thus samples of extract were taken at frequent intervals by means of valve K, and the test continued after removal of the measured quantity of sample.

The apparatus was also connected to a device which gave the suspended tank continuous regular shaking and this is referred to as "mechanical agitation" in the following text.

The method was investigated without success, until Dr. Khainovsky, who happened to visit the S.M.R.I., suggested that the pneumatic extraction be carried out by gradually increasing the degree of vacuum applied. This procedure is logical, if one is aware that loss of air bubbles occurs if, initially, too high a degree of vacuum is applied. Bubbles, however, are inevitably lost on application of a vacuum, and if a portion of a bubble in a broken cell is lost, a higher vacuum must be applied before the remaining air bubble in the broken cell can expand so as to fill the cell.

Calculation of the Results

The object of Khainovsky's technique is to prepare an homogeneous extract containing all the free sucrose in the bagasse and no other sucrose. From the weight of the extract and its sucrose percentage, we can then calculate free sucrose per cent bagasse.

Let T = Weight of bagasse plus water plus Na₂CO₃ solution in the pneumatic test apparatus, all expressed as a percentage on bagasse.

f_2 = Dry fibre per cent. bagasse.

F_2 = Natural fibre per cent. bagasse = $1.3f_2$.

f_1 = Dry fibre per cent. cane.

F_1 = Natural fibre per cent. cane = $1.3f_1$.

C = Closed cells per cent. total cells in bagasse.

E = Total extract per cent. bagasse.

K = Sucrose per cent. extract due to free sucrose in bagasse.

P = Sucrose per cent. bagasse due to free sucrose in bagasse.

S_2 = Total sucrose per cent. bagasse due to all the sucrose in bagasse.

S_1 = Sucrose per cent. cane.

EK

Then $P = \frac{EK}{100}$ (1)

Remembering our basic assumption that all juice storage cells contain the same amount of sucrose, we can say:

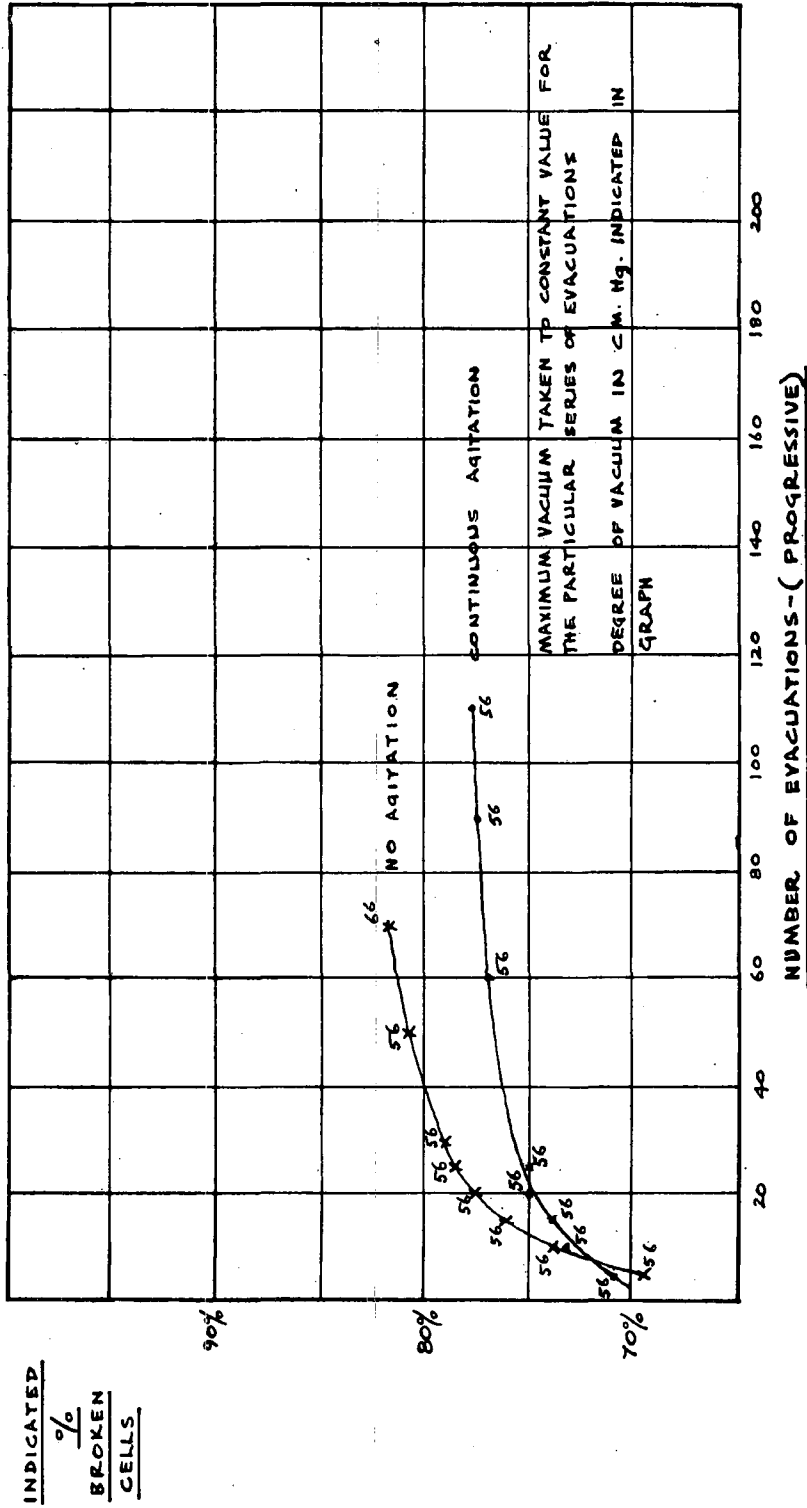
Number of broken cells per 100 original cells

$$= 100 - \frac{f_1}{f_2} \frac{(S_2 - P)}{S_1} \frac{100}{S_1}$$

$$= \left(S_1 - \frac{f_1}{f_2} (S_2 - P) \right) \frac{100}{S_1} \dots \dots \dots (2)$$

Obviously, "number of broken cells in final bagasse per 100 original cells" as found by equation (2), is identically equal to the extraction by tandem which would be obtained if all the free sucrose in bagasse had passed into the mixed juice, and in this way the percentage has practical value.

GRAPH I



Referring to equation (2), all values can be accurately obtained by various methods except P, the free sucrose per cent bagasse.

If K, the sucrose per cent extract, due to free sucrose in bagasse is obtained, we still have to determine the quantity of extract E in the pneumatic extractor.

We know that the extract in the pneumatic extractor is less than bagasse plus water plus sodium carbonate solution minus natural fibre.

i.e. E is less than $(T - F_2)$.

We have then,

$$E = (T - F_2 - X)$$

where X = juice in closed cells per cent bagasse.

Juice in closed cells in bagasse, however, was originally present in the cane. Therefore, the ratio of juice in closed cells in bagasse to juice in all the cells in the cane, gives the fraction of unopened cells in bagasse.

We may write this as—

$$X = \frac{f_2}{f_1} \left(\frac{C}{100} \cdot Y \right) \dots \dots \dots (3)$$

where Y = juice in all the cane cells per cent cane.

The quantity of juice in cane cells, however, is uncertain, since we know that water in fibro-vascular bundles is present outside juice storage cells.

Then, Y is less than $(100 - F_1)$ and substituting this inequality in the expression for X , we have—

$$X \text{ is less than } \frac{f_2}{f_1} \left(\frac{C}{100} (100 - F_1) \right)$$

$$\therefore E \text{ is greater than } \left[T - F_2 - \frac{f_2}{f_1} \left(\frac{C}{100} (100 - F_1) \right) \right]$$

and less than $(T - F_2)$

$$\text{Let } E = (T - F_2) \dots \dots \dots (4)$$

It can be shown (see Appendix) that the calculated value for broken cells using equation (4) is greater than the value obtained using the correction term, by approximately 2 per cent for crusher bagasse samples and 0.02 per cent for final bagasse samples. Therefore equation (4) is used for calculating E .

Hence:

Number of broken cells per 100 original cells

$$= 100 \frac{f_1}{f_2} \left(S_2 - \frac{K}{100} (T - F_2) \right) \frac{100}{S_1} \dots \dots \dots (5)$$

We now see that K is the only determination in equation (5) which remains to be assessed, and the results of the experiments depend on how accurately

the real value of K can be determined. All other data in equation (5) depend on the accuracy of brix and sucrose determination of dilute solutions obtained from the high-speed extractor.

If the brix is determined by the S.G. bottle method, as given in the third edition of the *Queensland Handbook*, and the sucrose by chemical means, these quantities can be accurately determined. The sub-sampling of bagasse, however, introduces an error, and therefore it was decided to use simple direct pol determination of the dilute extracts, and omit the brix determinations since the latter hardly affects the calculation of free pol per cent bagasse.

Preliminary Tests

1,000 g of the bagasse sample and 10,000 g water and 30 g 5 per cent w/w Na_2CO_3 solution was placed in the apparatus. This weight of sodium carbonate was determined by the results given in Table I. After the required number of evacuation cycles, approximately 300 ml of extract was drawn off through valve K, returned to the vessel *via* cock J, and then 100 ml sample taken for test. (This step is to remove "stagnant" liquid in pipe G and behind screen H—see sketch of apparatus.)

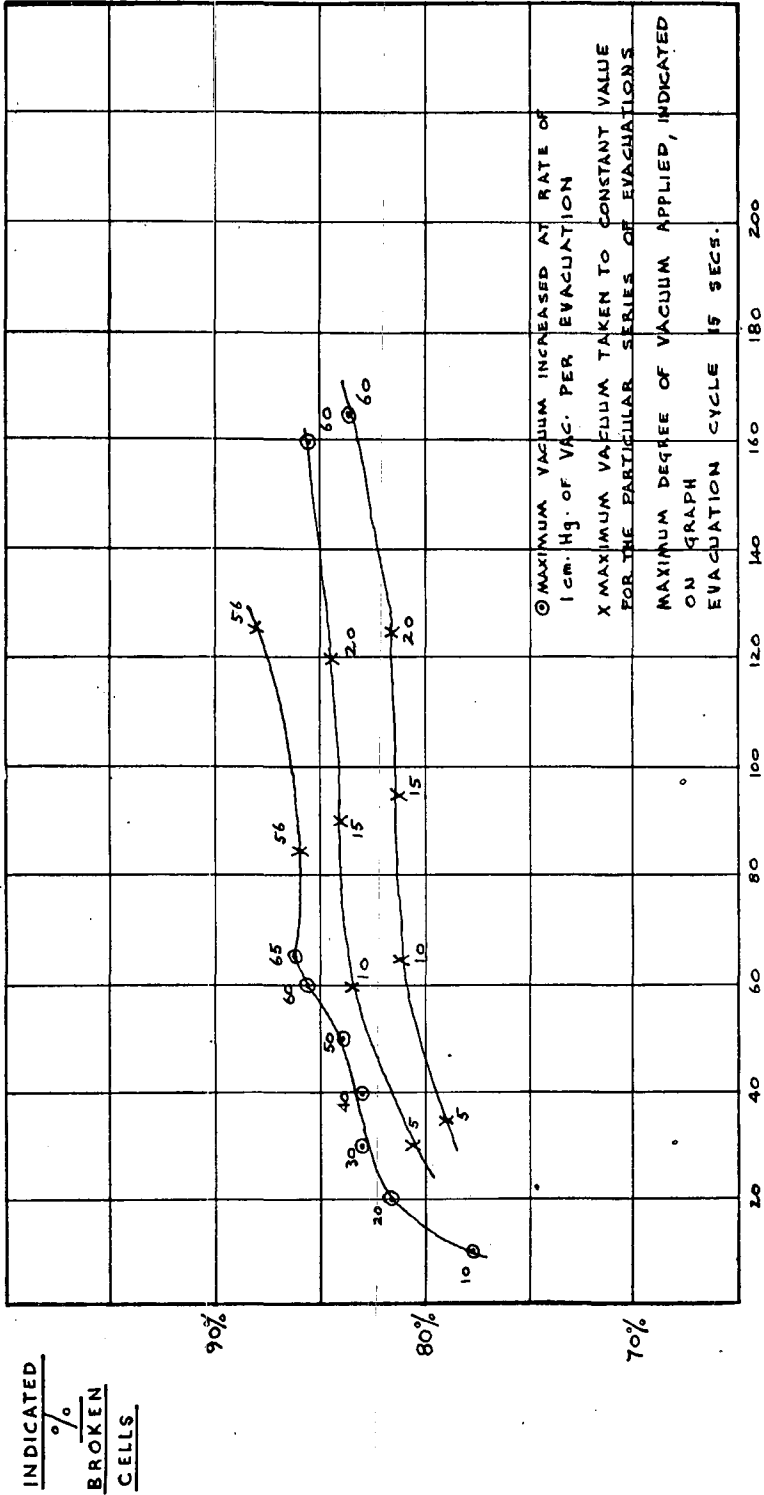
The apparatus was suspended by the lid handle, and the effect of little or no agitation of the tank during the tests was compared with that of continuous rapid mechanical agitation of the tank. It was concluded that continuous agitation caused loss of air bubbles, which then retarded the extraction rate—see Graph I. It was also found, however, that the mixture was not homogeneous if no agitation was applied; invariably the sample withdrawn before stirring of the contents gave a higher pol than that obtained after the contents were well mixed. This drop of pol caused by a 1 per cent drop in calculated broken cells for a first mill bagasse sample, $2\frac{1}{2}$ per cent drop for a shredded sample, and no change for a fifth mill sample. This indicates that particle size has an effect on the free path of the sucrose. (Note: on graphs, the term "indicated per cent broken cells" is used, and is due to an arbitrary value of sucrose per cent cane being taken, since differences only were investigated.)

The suspended apparatus was then given only very slight oscillatory motion on opening to atmosphere after each evacuation cycle, except for the final evacuation cycle, when the apparatus was well shaken throughout.

The whole testing apparatus was then taken to Illovo Sugar Estates Ltd, where the tests were continued at the factory.

Graphs II and III show clearly that a greater degree of extraction is obtained if the evacuation is progressively increased to a higher degree of vacuum

GRAPH II



NUMBER OF EVACUATIONS - (PROGRESSIVE)

O MAXIMUM VACUUM INCREASED AT RATE OF
 1 cm. Hg. OF VAC. PER EVACUATION
 X MAXIMUM VACUUM TAKEN TO CONSTANT VALUE
 FOR THE PARTICULAR SERIES OF EVACUATIONS
 MAXIMUM DEGREE OF VACUUM APPLIED, INDICATED
 ON GRAPH
 EVACUATION CYCLE 15 SECS.

INDICATED
%
BROKEN
CELLS

during each successive cycle. Further, Graph III indicated that a 15-second cycle is too short, a 30-second cycle giving better results.

The maximum degree of vacuum required was investigated, but invariably during normal operation at Illovo factory, only 50 to 56 cm Hg of vacuum could be obtained.

Table II indicates that a 30-second evacuation cycle, with the vacuum increasing from 0 to 50 cm of Hg in steps of approximately 2 cm of Hg vacuum per cycle, gives optimum results.

Tests also show that a higher final degree of vacuum (70 cm of Hg) gives greater extraction on samples with higher free sucrose content (crusher and first mill bagasse), and not much difference on final mill bagasse samples. Here again, the bagasse particle size may be retarding extraction, or perhaps sucrose is being extracted from closed cells. This is a matter for further investigation.

Ultimate Test Procedure

To summarise:

- (1) Only very gentle oscillatory motion was given to the suspended apparatus during test.
- (2) Apparatus was well shaken during final evacuation cycle.
- (2) Evacuation increased in steps of approximately 2 cm of Hg per evacuation cycle, from zero.
- (4) Evacuation cycle time of approximately 30 seconds taken.
- (5) Maximum degree of vacuum of 50 cm of Hg applied; giving an overall time of at least 12½ minutes.

From the graphs it can be seen that the free pol so obtained may be equal to and not greater than the true free pol. In this case then, the percentage of broken cells calculated from these results is less than or equal to the true value, where broken cells refers to the definition previously given.

Graph III does not appear to support the above summarised method, but it will be appreciated that these tests were made for a different purpose; samples were withdrawn at various intervals throughout the test, and before sampling, 300 to 500 ml of extract was withdrawn and returned to the vessel. This could easily have upset the conditions for maximum extraction. Also the apparatus could not be shaken to mix the contents before sub-sampling. Hence, more reliance is placed on the tests in Table II for giving optimum conditions, though this should be confirmed in further tests.

Application of Method to Bagasse from Consecutive Mill Units

Tests were then carried out on the Illovo milling train where samples of cane were followed through each mill and a sample taken at each unit. It was found that the percentage broken cells increased with each unit; sub-samples of a particular mill bagasse did not differ by more than 1 per cent in the number of cells broken, except for the crusher sample, where sub-sampling and pneumatic extraction are inaccurate. Also, it is seen from Table IIIA that the fibre content of the bagasse has very little effect on the calculated broken cells. These results in Tables IIIA and IIIB indicate only the difference between mill units since the sucrose per cent cane value was taken from the factory laboratory data, and need not necessarily represent the sucrose in the cane, which actually passed through the mill at the time of the test.

Mill tests were then carried out, in which the mill was run for two hours, enabling a mill balance to be carried out. Samples of bagasse from each unit were taken throughout the run by the factory staff under "wet-milling" conditions. These samples were then sub-sampled and tested in the factory laboratory. The writer also received sub-samples, which were tested for free pol in all cases, and total pol and fibre in some cases. The results are given in Table IV in fuller detail.

Under "mill balance" in Table IV, all details except free pol are taken from factory laboratory data. In each case, however, the pol per cent bagasse was recalculated, taking the natural fibre content of the bagasse into account, as opposed to the so-called "normal weight" method of determining pol in bagasse.

Under "S.M.R.I. Analysis" in Table IV, the fibre and pol content of the bagasse was determined by the high-speed extractor methods.

Broken cells per cent total cells is shown in Column 11.

In Column 12, a figure called "Imbibition Efficiency" is included, where—

"Imbibition efficiency"

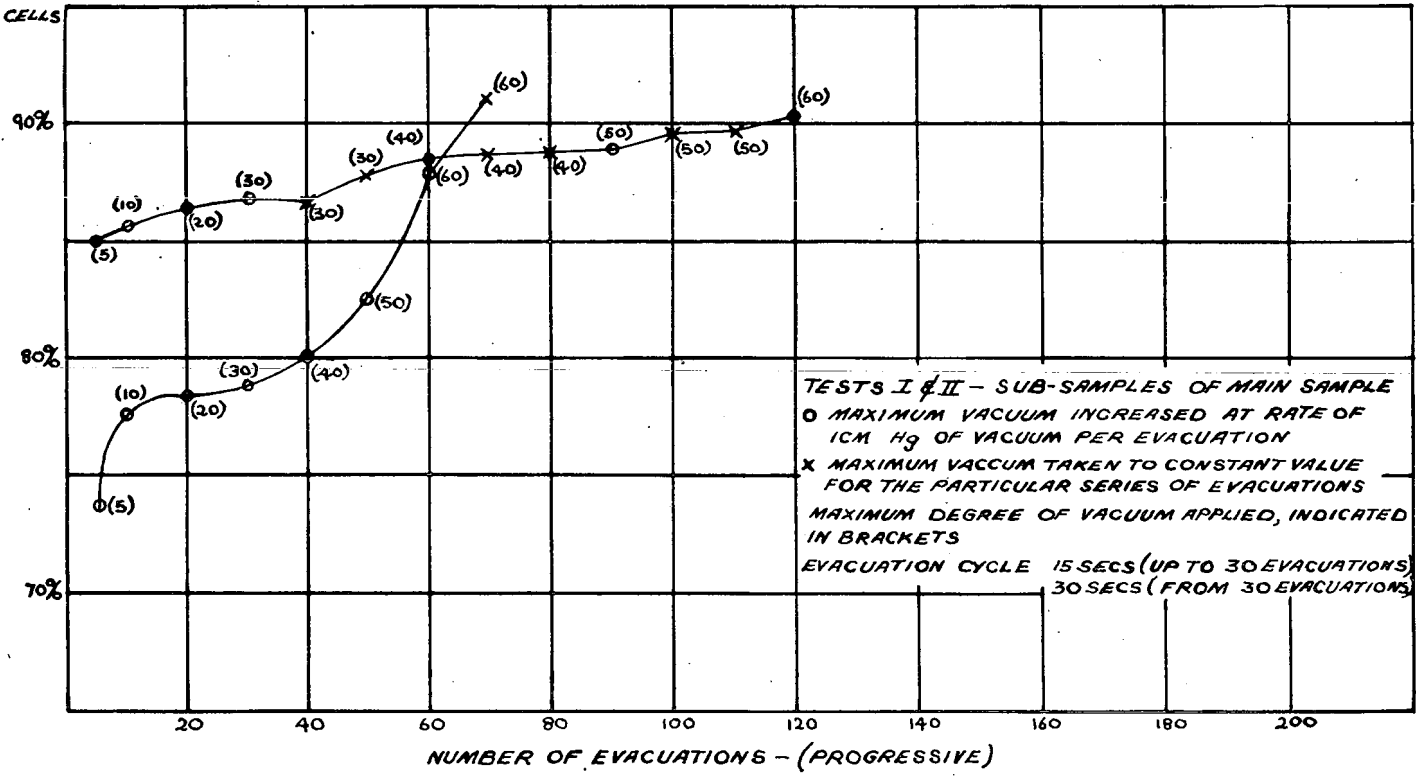
$$= \left(\frac{\text{per cent extraction by tandem up to unit}}{\text{per cent broken cells}} \right) 100$$

= per cent sucrose available due to broken cells extracted by the tandem up to that unit.

This then is a measure of the imbibition efficiency. In other words, if "imbibition efficiency" is 100 per cent, i.e. all the free sucrose in bagasse was extracted, then the extraction by tandem per cent sucrose in cane is identically equal to the per cent broken cells,

INDICATED
%
BROKEN CELLS

GRAPH III



i.e. the sucrose content of the broken cells, which was originally present in the cane per cent sucrose in cane.

In Column 13, pol in closed cells per cent pol in bagasse = $\left(\frac{\text{pol \% bagasse} - \text{free pol \% bagasse}}{\text{pol \% bagasse}} \right) 100$

This figure decreases from 100 per cent for cane to about 35 per cent at the first mill, and increases to about 65 per cent for the fifth mill bagasse.

Effect of Bagasse Particle Size on Number of Cells Opened

The question arose as to how the broken cells varied between the different sized particles of bagasse.

One test was fully carried out on final bagasse in which the fibre content and total pol of the bagasse was determined by the high-speed extractor method—see Table V. The per cent broken cells was 97.5 for the bagasse and increased from 95.2 per cent for the larger particles to 99.9 per cent for the very fine particles. This alone is evidence that the pneumatic extraction method cannot be far out on the free pol in final bagasse determination.

Conclusion

As seen in Table IV, the method given for determining the number of broken juice storage cells gives a good guide to the milling efficiency, where this refers simply to the mechanical action of breaking cells. The operative word is "guide", since the ultimate object of any such test is to determine accurately the number of cells broken at the end of the milling train. To ascertain this figure, more work will have to be done on the determination of free sucrose in bagasse by pneumatic extraction and other methods. However, the figures given for broken cells in Table IV may be a minimum, since the true free pol per cent bagasse is not less than, but may be equal to the value ascertained. This will be clear on examining equation (5).

It should be noted, however, that not all the juice in cells broken by the last mill is available for extrac-

tion. Therefore, the number of cells broken by the tandem up to and including the last unit but one, becomes the main criterion of the overall milling efficiency.

Acknowledgments

The tests were carried out at Illovo Sugar Estates Ltd factory, and the writer thanks the management for their assistance, and for all the facilities given him. Thanks are also due to Mr. Draeger, Chief Chemist at the factory, who personally supervised the mill tests, and Mr. K. Gilmour, who assisted with the laboratory tests.

References

- ¹ Khainovsky, V. (1929): Proc. I.S.S.C.T. 3 457.
- ² Kerr, H. W. (1957): Proc. Q.S.S.C.T., 20 221.
- ³ "Fibro-vascular Water of Sugar Cane," Technical Reports, 9 and 23 of the Sugar Research Institute, Mackay.
- ⁴ "Determination of Certain Qualities of Individual Cane Consignments," IV, S.M.R.I. Quarterly Bulletin No. 5, p. 11.
- ⁵ "Determination of Certain Qualities of Individual Cane Consignments," III, S.M.R.I. Quarterly Bulletin, No. 3, p. 22.

TABLE I

Pneumatic Extraction of Bagasse

10 g Bagasse + 10,000 g Water + Xg 5 per cent w/w Na₂CO₃ solution. pH reading given after extraction of free pol.

Bagasse Sample	WT Na ₂ CO ₃ Soln. (X)	pH	WT Na ₂ CO ₃ Soln. (X)	pH
Waddell Shredded cane	20 g	—	30 g	7.8
Crusher	20 g	7.5	30 g	8.0, 8.0
1st Mill	20 g	6.8	30 g	6.9, 7.1
2nd Mill	20 g	6.8	30 g	7.0, 7.1
3rd Mill	20 g	6.7	30 g	7.0, 7.5
4th Mill	20 g	6.8	30 g	7.2, 7.7
5th Mill	20 g	7.0	30 g	7.5, 8.2

∴ 30 g 5 per cent w/w Na₂CO₃ solution used.

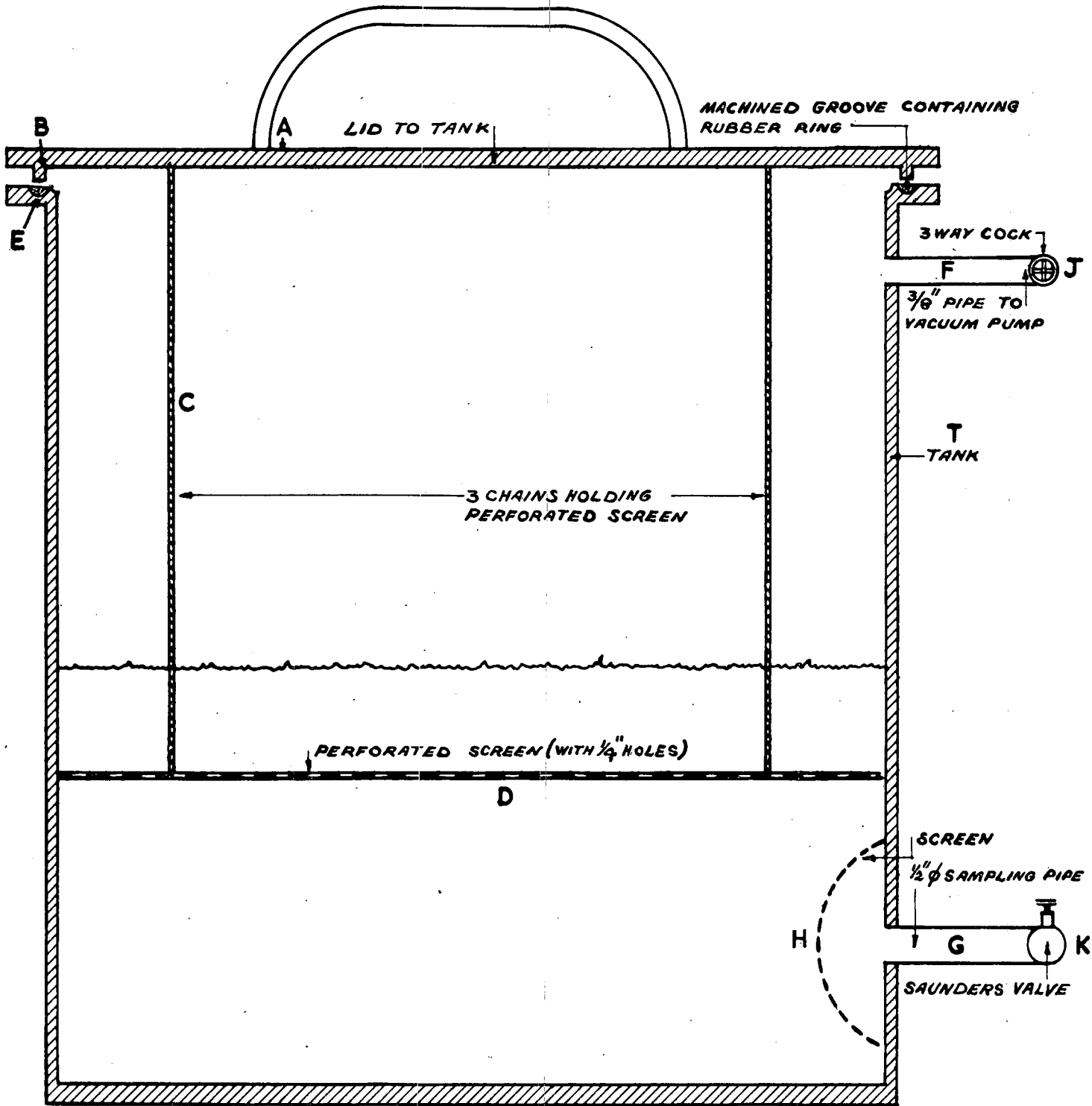


TABLE II

Bagasse sample taken from unit	Maximum degree of vacuum applied (cm Hg)	Rate of increase of maximum degree of vacuum (cm Hg)	Number of Evacuations	Evacuations cycle (seconds)	per cent broken cells	Overall time (mins.)
Shredder	50	2 cm per evacuation	25	30	91.3	12½
	50	1 cm per evacuation	50	7	90.4	5¾
	50	1 cm per evacuation	50	30	91.7	25
	50	1 cm per evacuation	50	30	87.4	25
1st mill	50	2 cm per evacuation	30	30	95.1	15
	50	1 cm per evacuation	50	6	91.8	5
1st mill	50	2 cm per evacuation	25	30	91.5	12½
	50	1 cm per evacuation	50	5	87.7	4
	69	3 cm per evacuation	23	60	91.1	23
3rd mill	50	2 cm per evacuation	30	30	95.8	15
	50	1 cm per evacuation	50	6	91.0	5
5th mill	50	2 cm per evacuation	25	30	95.5	12½
	Followed by 40 — 66	2 cm per evacuation	+13 =38	30	96.0	19

TABLE IIIA

Per cent Broken Cells

Bagasse sample taken from unit	Fibre from latest mill test used to calculate data	Fibre: lowest recorded for season, used to calculate data	Fibre: highest recorded for season, used to calculate data
1st Mill	91.2	91.5	91.1
2nd Mill	93.3	93.6	93.3
3rd Mill	94.4	95.1	94.3
4th Mill	97.0	97.5	97.0

TABLE IIIB

(Fibre from latest mill test used to calculate data)

Bagasse sample taken from unit	Per cent broken cells	Bagasse Sample taken from unit	Per cent broken cells
1st mill	89.5	1st mill	92.7
5th mill	96.4	4th mill	96.4
5th mill	97.2	4th mill	97.0
5th mill	97.9	4th mill	96.8
5th mill	97.9	4th mill	96.8
5th mill	97.2		

TABLE IV

WET MILL TESTS AT ILLOVO MILL

1	2	3	4	5	6	POL EXTRACTION			10	11	12	13	14	15
						7	8	9						
Date	Method	Data	Per Fibre per cent Bagasse	Natural Fibre per cent Bagasse	Pot per cent Bagasse	By Tandem per cent. Pol in Cane (Extr.)	By Unit per cent Pol in Cane	By Unit per cent Pol Entering	Free Pol per cent Bagasse	Broken Cells per cent Total Cells (BR.)	Efficiency (Extr. + BR.) x 100	Pol in Closed Cells per cent Pol bagasse	Pol in Closed Cells per cent Natural Fibre	Cane Crushed
19.12.57	MILL BALANCE	Cane	14.54	18.90	12.43	—	—	—	—	—	—	100	65.8	Co.310 100 per cent
		Crusher	20.26	26.34	10.93	36.9	36.9	36.9	4.35	62.0	59.5	60	24.9	
		1st mill	36.47	47.41	7.02	77.5	40.6	64.3	4.36	91.5	84.7	38	5.6	
		2nd mill	39.57	51.44	5.79	82.9	5.4	24.0	3.29	92.6	89.5	43	4.8	
		3rd mill	42.69	55.50	3.62	90.1	7.2	42.0	1.10	93.1	96.8	70	4.6	
		4th mill	45.77	59.50	2.62	93.3	3.2	32.5	0.41	94.4	98.8	84	3.7	
12/12/57	S.M.R.I. ANALYSIS	Cane	14.54	18.90	12.43	—	—	—	—	—	—	100	65.8	Co.310 100 per cent
		Crusher	20.93	27.21	11.14	37.7	37.7	37.7	4.35	62.1	60.7	61	25.0	
		1st mill	32.61	42.39	7.64	72.6	34.9	56.0	4.36	88.2	82.3	43	7.7	
		2nd mill	38.56	50.13	5.54	83.2	10.6	38.7	3.29	93.2	89.3	41	4.5	
		3rd mill	40.43	52.56	3.02	91.3	8.1	48.0	1.10	94.4	96.7	64	3.7	
		4th mill	41.53	53.99	2.39	93.3	2.0	23.0	0.41	94.4	98.8	83	3.7	
8/1/58	MILL BALANCE	Cane	16.10	20.93	12.50	—	—	—	—	—	—	100	59.7	Co.310 15.6 per cent Co.293 47.9 per cent Co.331 36.5 per cent
		Crusher	23.80	30.94	10.19	44.9	44.9	44.9	4.41	68.7	65.4	57	18.8	
		1st mill	35.01	45.51	7.59	72.1	27.2	49.4	4.82	89.8	80.3	37	6.2	
		2nd mill	40.13	52.17	5.59	82.1	10.0	35.8	3.29	92.6	88.7	41	4.4	
		3rd mill	42.66	55.46	4.47	86.5	4.4	24.8	2.05	92.7	93.3	54	4.4	
		4th mill	46.16	60.01	3.44	90.4	3.9	28.9	1.30	94.0	96.2	63	3.6	
22/1/58	MILL BALANCE	Cane	15.43	20.06	11.82	—	—	—	—	—	—	100	58.9	Co.310 34.5 per cent Co.331 34.7 per cent Co.293 30.9 per cent
		Crusher	19.89	25.86	11.14	26.9	26.9	26.9	3.23	48.1	55.9	71	30.6	
		1st mill	34.40	44.72	7.80	70.4	43.5	59.5	4.69	88.2	79.8	38	6.6	
		2nd mill	40.12	52.16	5.78	81.2	10.8	36.5	3.15	91.4	88.8	46	5.1	
		3rd mill	44.09	57.32	4.16	87.7	6.5	34.5	2.25	94.3	93.0	46	3.3	
		4th mill	46.84	60.89	2.17	94.0	6.3	50.9	1.56	98.3	95.6	28	1.0	
30/1/58	MILL BALANCE	Cane	18.21	23.67	11.40	—	—	—	—	—	—	100	48.2	Co.301 11.3 per cent Co.292 28.2 per cent Co.339 60.5 per cent
		Crusher	22.88	29.74	11.11	22.4	22.4	22.4	5.46	60.6	37.0	51	19.1	
		1st mill	32.61	42.39	6.86	66.4	44.0	56.7	4.49	88.4	75.1	34	5.6	
		2nd mill	40.57	52.74	5.28	79.2	12.8	38.1	3.25	92.0	86.1	38	3.8	
		3rd mill	45.00	58.50	3.76	86.7	7.5	35.8	2.04	93.9	92.3	46	2.9	
		4th mill	48.08	62.50	2.66	91.2	4.5	33.8	1.25	95.3	95.7	53	2.2	
30/1/58	S.M.R.I. ANALYSIS	Cane	18.21	23.67	11.40	—	—	—	—	—	—	100	48.2	Co.310 32.7 per cent Co.292 67.3 per cent
		Crusher	23.95	31.13	10.41	30.6	30.6	30.6	5.46	67.0	45.7	48	15.9	
		1st mill	36.49	47.43	6.98	69.4	38.8	56.0	4.49	89.1	77.9	36	5.2	
		2nd mill	58.61	50.19	5.37	77.8	8.4	27.3	3.25	91.2	85.3	40	4.2	
		3rd mill	41.90	54.46	3.80	85.5	7.7	34.8	2.04	93.3	91.6	46	3.2	
		4th mill	44.76	58.18	2.63	90.6	5.1	35.2	1.25	95.1	95.3	52	2.4	
5/2/58	MILL BALANCE	Cane	17.24	22.41	12.59	—	—	—	—	—	—	100	56.2	Co.301 11.3 per cent Co.292 28.2 per cent Co.339 60.5 per cent
		Crusher	23.23	30.20	12.67	25.3	25.3	25.3	4.53	52.0	48.7	64	27.0	
		1st mill	40.22	52.29	7.23	75.4	50.1	67.0	5.19	93.1	81.0	28	3.9	
		2nd mill	42.40	55.12	5.86	81.1	5.7	23.1	3.57	92.6	87.6	39	4.2	
		3rd mill	46.95	61.04	4.14	87.9	6.8	36.2	2.23	94.4	93.1	46	3.1	
		4th mill	49.57	64.44	3.04	91.6	3.7	30.5	1.42	95.5	95.9	53	2.5	
5/2/58	S.M.R.I. ANALYSIS	5th mill	47.37	61.58	2.18	93.7	—	—	0.70	95.7	97.9	68	2.4	
		5th mill	47.37	61.58	2.18	93.7	—	—	0.70	95.7	97.9	68	2.4	
12/2/58	MILL BALANCE	Cane	17.60	22.88	13.23	—	—	—	—	—	—	100	57.8	Co.310 13.9 per cent Co.339 86.1 per cent
		Crusher	25.44	33.07	12.81	33.0	33.0	33.0	5.67	62.7	52.6	56	21.6	
		1st mill	37.16	48.31	8.50	69.6	36.6	54.6	5.62	89.7	77.6	34	6.0	
		2nd mill	41.46	53.90	6.41	79.4	9.8	32.4	5.24	96.2	82.5	18	2.2	
		3rd mill	44.88	58.34	4.80	85.8	6.4	30.8	3.02	94.7	90.6	37	3.1	
		4th mill	46.97	61.06	3.70	89.5	3.7	26.4	1.90	94.9	94.3	49	2.9	
12/2/58	S.M.R.I. ANALYSIS	4th mill	46.24	60.11	3.83	89.0	—	—	1.90	94.4	94.3	50	3.2	
		5th mill	48.00	62.40	2.21	93.9	4.9	44.4	0.84	96.2	97.6	62	2.2	

TABLE V

Fifth mill bagasse sub sampled and balance screened into different particle size groups
Each group analysed using high speed and pneumatic extraction of the sample

Bagasse sample	Fibre per cent bagasse	Pol per cent bagasse	Free Pol per cent bagasse	Square mesh screen, bagasse passed through	Per cent by weight of size group	Per cent broken cells
5th mill	48.12	2.36	0.88	—	—	96.6
Size 2	—	—	—	3.8 cm	0	—
Size 3	51.18	3.68	1.48	2.8 cm	27	95.2
Size 4	49.66	2.91	1.42	1.3 cm	22	96.7
Size 5	50.19	1.86	1.01	0.6 cm	23	98.1
Size 6	47.00	1.21	1.15	0.25 cm	28	99.9

APPENDIX

Example on Calculation of Per cent Broken Cells
and Demonstration of Effect on Correcting Term

	Cane	Crusher Bagasse	Fifth Mill Bagasse
Fibre	$f_1 = 17.60\%$	$f_2 = 25.44\%$	$\sqrt{f_3} = 48.70\%$
Natural fibre:	$F_1 = 22.80\%$	$F_2 = 33.07\%$	$F_3 = 63.31\%$
Sucrose... ..	$S_1 = 13.23\%$	$S_2 = 12.81\%$	$S_3 = 2.16\%$
Sucrose % pneumatic extract		$K_2 = 0.530$	$K_3 = 0.081$

E = Pneumatic extract per cent bagasse.

P = Free sucrose per cent bagasse.

T = Bagasse + water + Na_2CO_3 solution in pneumatic extractor per cent bagasse

$$= 1103 \text{ per cent.}$$

Crusher Sample

$$T - F_2 - \frac{f_2}{f_1} \left(\frac{C}{100} (100 - F_1) \right) < E < 100 - F_2 \quad \dots \quad (A)$$

substituting, we get $1027.53 < E < 1069.93$

$$P_2 = \frac{KE}{100} \quad \dots \quad (B)$$

$$5.45 < P_2 < 5.67$$

$$\text{per cent broken cells} = 100 - \frac{f_1}{f} (S_2 - P_2) \frac{100}{S_1} \quad \dots \quad (C)$$

$$= 100 - \frac{17.60}{25.44} (12.81 - P_2) \frac{100}{13.23}$$

$$\therefore 61.51 < \text{per cent broken cells} < 62.66$$

Fifth Mill Bagasse

Similarly, using the above data

$$96.38 < \text{per cent broken cells} < 96.40$$

Note—The R.H.S. of the inequality (A) is developed, the approximate per cent closed cells calculated and substituted for C on the L.H.S.

Dr. Douwes Dekker said that Dr. Khainovsky had designed this method thirty years ago and used the method to determine the performance of mills. It was thought that the method could be directly applicable in Natal but it was found that further work was required on the method. The same thing was found in Australia. Mr. Young had continued Khainovsky's work and had now reached a method which was fairly satisfactory. It might be further improved but we now have a method which could be applied to our mills. One point we want to study is the effect of shredders on the opening of cells.

Mr. Bentley said that it would appear from the figures in the table that some mill units were doing far less work than others. He asked if any effort was being made at the time of the test to balance the work done by each unit.

Mr. Young said that these tests were not carried out under normal operating conditions. They were special tests run a few hours each to enable him to carry out his tests. During the stops between these periods various alterations to the mills were made, which however, enabled him to further study the determination of the open cells under these varying conditions.

Dr. Douwes Dekker said that one of the reasons for the extraction not being higher at Illovo was the fact that not all the cells had been opened. Even at the fourth mill the percentage of open cells only rose up to 97.2 and was at times as low as 94.4.

Mr. Bentley wanted to know if there was any correlation between columns 11 and 9 in Table IV.

Dr. Douwes Dekker replied in the negative. The purpose of the tests at Illovo was not so much to find out what was happening at that particular mill as to test out the apparatus.

Mr. Dick wished to know why it was necessary to assume that all the cells were of equal size, because under a microscope they did not appear to be so.

Mr. Young replied that the basic assumption was necessary to give practical value to the determinations. He referred to the last paragraph at the bottom of page 2, and said that had the assumptions not been made, this statement would not be true.

Mr. Rault asked if this method could serve as a basis for demonstrating whether a mill was working efficiently or not.

Dr. Douwes Dekker said that only in the case of very low percentage of unbroken cells could the method be used to point to inefficiency of mills, but we did also find that one could get quite a low extraction for a high proportion of broken cells.

Mr. Rault said that they had found by increasing imbibition they did not necessarily get a better extraction.

Dr. Douwes Dekker said that if this method was applied to various mills in Natal we would see if this method could give better results. In replying to Mr. Rault he said that from many calculations made by himself he found that a mixture of imbibition and residual juice was far from perfect. If complete mixing could be assured after each mill the loss in bagasse could be reduced down to one third of what it is now.

Mr. Royston said it would appear that shredding was not particularly effective in opening the cells as it seemed to shred mostly along the length of the cane.

Dr. Douwes Dekker said that when the method was applied to mills it would be possible to determine how effective the shredder actually is.

Mr. Rault inquired if the high temperature maceration tried with the Nobel carrier in Java, was now abandoned, and if so, was that due to high steam requirements.

Dr. Douwes Dekker agreed that the abandonment of this system was due to high steam consumption.

Mr. Boyes said that a great deal of reliance had been placed on the high speed extractor. He wished to know if this could be used for determination of sucrose in normal mill bagasse.

Mr. Young said that only in the case of those tests headed S.M.R.I. analysis was the high speed extractor used. It could only be used if great care were exercised.

Dr. Douwes Dekker said that at the moment he was not quite sure if this method could be recommended to the industry. It had obvious advantages in taking a much shorter time than the boiling method, but it remained to be seen if it worked accurately enough for general application to mill bagasse. He hoped that Mr. Boyes would be in a position to compare the two methods next year.