THE BRIX OF THE JUICE EXPRESSED FROM CANE BY STATIC PRESSURE

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Summary

Experiments are discussed in which cane, either after having been prepared in a Waddell shredder, or in the form of chips was subjected to pressure in a press and the expressed juice fractions were tested for brix. The effect of shredding on the brix pattern of the consecutive fractions is discussed as also the interest it may have in connection with practical milling.

In another series of tests, chips were first compressed to express about 40 per cent of the juice, the residue then shredded and the shredded mass again subjected to pressure. The juice now expressed showed a brix approximately 10° higher than that of the juice from the chips.

Hence, it was possible to divide juice in cane into a high brix fraction (27°), a much lower brix fraction (17°), and a small fraction retained in the residue. Nodes, internodes, pith and rind were separately tested. Attention is drawn to the—from the practical point of view—objectionable properties of the rind of cane.

The significance of the outcome of the experiments for the basis of milling control systems and the Java Ratio Cane Payment System is also mentioned.

Introduction

To understand milling mechanism and milling results satisfactorily, it is necessary to have a sound knowledge of the mechanical, physical, chemical and biological properties of the raw material, i.e., sugarcane. Consequently, one of the paths followed by the S.M.R.I. in attempts to obtain an understanding of milling, is a study of the relevant cane characteristics.

The anatomy of sugarcane is described extensively in the various handbooks which a.o., tell us that the juice is contained in the ground tissue storage cells, but they usually give very little information on the differences in composition between the juice droplets in those cells.

Noel Deerr,[1] giving a rather simplified picture of the structure of sugarcane, divides the absolute juice in cane into pith juice and rind and node juice. The weight of pith juice averages 70.8 per cent per 100 cane, rind and node juice 15.5 per cent. The concentration and purity of the pith juice is higher than that of the rind and node juice, as is shown by the following average figures:

	Pith Juice	*Rind and Node Juice*
Refractometer Brix ..	20.2%	18.3%
Sucrose (Pol)	18.5%	12.7%
Purity	90.3%	69.4%

The Sugar Research Institute in Mackay[2] has drawn attention to the dilute sugar solutions carried from the leaves to the pith storage cells by the sieve tubes and to the water carried from the roots to the leaves by other vessels in the fibrovascular bundles:

> "The amount of these dilute juices has been estimated to be about 2 per cent of the weight of the cane stick, or about $^1/_5$th of the weight of fibre in cane. Its brix is less than one per cent and hence it accounts for the difference between rind and pith juice to a large degree. Similar considerations apply to the differences between pith and node."

Leaving for the moment the contention of the Sugar Research Institute that the difference in brix between pith and rind juice is largely due to the degree to which dilute fibrovascular vessel juice is present in it, it is obvious that a cane stalk contains juices of different concentrations and purities.

In addition to these juices which can be extracted by mechanical means, we know that cane contains moisture, in Natal known as Brix-free Water, in Queensland as absorption water, which cannot be separated from fibre by pressure.

Our investigations which are not yet complete, have led us to believe that the quantity of Brix-free Water attached to fibre is not present in a fixed ratio to the fibre weight, but that this ratio normally varies in different canes between 25 and 30 per cent.

Apparently in contrast to the facts stated above, is the assumption used in milling control calculations and mentioned by Perk[3] t.w.,

> "According to the results of thousands of 'dry milling' tests, the brix percentage of undiluted juice in cane can be represented most adequately by the brix percentage of the primary juice",

where "undiluted juice" represents the (theoretically expressible) juice in cane, and

"primary juice" is all the juice before dilution begins.

It is, however, not difficult to see that the above assumption, in order to be applicable in milling control calculations, only requires the ratios in which the juices of various concentrations are present in primary juice to be identical to those in which they were originally present in undiluted juice.

[1] Cane Sugar, by Noel Deerr, 2nd Ed. (1921) p. 186.

[2] Sugar Research Institute, Mackay, Tech. Report No. 23 (1954); No. 42 (1957).

[3] Chs. G. M. Perk. A Review of Terms used for indicating Milling Results. Communications from the Sugar Milling Research Institute (Durban) No. 7 (9151).

The possibility must, however, be left open that the happy coincidence of the existence of identical juice ratios depends on the particular pattern of the pressure by which the juice is extracted and that the dynamic squeezing action of our milling units may in this respect act quite differently from that in which juice is expressed by static pressure.

In fact, Fig. 1 in a paper by van der Pol and Young[4] shows clearly that it is possible by exerting static pressure on cane, to squeeze out juices of different refractometer brix values, a fact which had earlier also been observed by Spoelstra.[5]

It was the purpose of the investigation reported on in this paper to collect more data on the brix pattern of the juice fractions squeezed out of cane in a static press. The investigation was carried out with laudable care at the S.M.R.I. by Mr. W. J. Hoek, a science student at the University of Natal, during the holiday period 1959-60 and his report on his investigation has been freely used in this paper.

Press Used in the Experiments

The press itself consisted of a 30 ton hydraulic jack on top of which was fitted a circular metal table of 11 inches diameter. Four concentric channels were cut into the top surface of this table, and these were interconnected by a channel leading to a spout at the side of the table. These channels operated as the juice drainage system. A circular metal casing, 7 inches high, was fitted in a step around the circumference of the table with a composition washer in between to prevent juice leakage.

The jack rested on a solid metal base, which had two uprights 4 ft. long and 2 inches in diameter at each end. The uprights were connected by a heavy cross-piece at the top, into which fitted a threaded shaft. Connected to the lower end of the shaft was the circular upper table, which fitted into the casing.

A wheel for screwing down the top table was fixed to the top of the threaded shaft. A perforated circular copper plate was always placed on top of the lower table before any cane was put into the casing; this was to prevent any bagasse getting into the drainage channels and so perhaps being collected with the juice.

Once the cane was in the press, the top-table was screwed down to compress the cane. If shredded cane was being used, juice started to run out before the top-table was screwed down as tightly as possible. The juice was collected in a beaker under the spout. When cane chips were put into the press, usually no juice was obtained when the table was screwed down as tightly as possible.

The hydraulic jack was them pumped up until a pressure was indicated on the dial attached to the jack. This registered pressure was not that acting on the cane material, but only the internal pressure of the jack's piston. The actual pressure on the cane material was calculated according to the ratio of the area of the piston to the area of the surface on which the cane rested, i.e., the area of the lower table.

Cane

The cane used in this investigation was taken from the S.M.R.I. experimental plot, variety and age unfortunately unknown. The cane was prepared for the test by either cutting into chips, or by shredding, and separate tests were carried out on whole cane, nodes, internodes, pith and rind.

Procedure

For each individual experiment on normal cane, 5 sticks of cane were cut. For experiments on nodes, internodes, pith and rind, 10 sticks were cut, so that after preparation, there was enough to each type of material to satisfactorily conduct the experiment.

All the trash and green tops were removed and a small sub-sample was cut from each of the sticks. These were cut from the top, middle and butt sections of the sticks to ensure as representative a sample as possible. This cane sub-sample was then used for the determination of the fibre content of the cane by the modified Queensland method, using brass canisters.[6] The fibre content of the cane was required to calculate Undiluted Juice per cent Cane.

The remaining lengths of cane were then cut into chips of approximately ⅜ths inch length in a chaff cutter. If the chips themselves were used for an experiment, they were weighed and placed in the hydraulic press. If not, then the chips were shredded in a Waddell shredder, after which the shredded cane was weighed and placed in the press.

In the series of experiments in which nodes and internodes were used, these were taken from the same sticks of cane.

Pressure was then applied until the pressure gauge showed the desired value and by continued pumping whilst the juice was expressed, the pressure was kept constant for 5 minutes. All the juice expressed at this pressure was collected, weighed and sampled for the determination of the brix by refractometer. The pressure was then increased to the next desired value and the manipulations were repeated.

To calculate the proportional fraction of the Undiluted Juice which was expressed, Undiluted Juice per cent Cane was calculated from the fibre percentage as found analytically, and assuming Brix-free Water per cent Fibre to be 30. Since the weight of the cane subjected to pressure in each experiment was known, the weight of Undiluted Juice in this amount of cane could also be calculated and the weight of each fraction of juice expressed as a percentage of the total weight of juice.

[4] C. van der Pol and C. M. Young. Determination of Qualities of Individual Cane Consignments. S.M.R.I. Quarterly Bulletin No. 5 (1958) 9.

[5] H. J. Spoelstra. Sapgehalte en Brix-vrij Rietwater. Verhandelingen voor de Leden van het Proefstation voor de Java-Suiker-industrie 7 (1935).

[6] D. E. Cundill. The Determination of Fibre in Sugar Cane, Communications from the Sugar Milling Research Institute (Durban), No. 17 (1953).

The results of the experiments are shown in a set of graphs: on the x-axis we find: expressed juice per cent total juice, and on the y-axis, the refractometer brix.

Results

Fig. 1 shows a typical curve for shredded cane. The total volume of juice expressed at the maximum pressure (734 p.s.i.) is approximately 78 per cent of the juice originally present in the cane. During pressing, the refractometer brix dropped from 23.3° to 20°, the drop being gradual in the beginning, but becoming increasingly steep as more juice was expressed.

Juice was obtained from shredded cane before the upper table of the press had been fully screwed down, and initially at low pressures, large quantities of juice were expressed. This juice as very cloudy and opaque. As the pressure was increased, the juice tended to become clearer, the final juice at maximum pressure being fairly clear and transparent.

Fig. 2 shows a curve obtained when the press was filled with cane chips. This type of curve is different from the curve of Fig. 1, in that although only 50 per cent of the juice was expressed when the pressure was raised to approximately 750 p.s.i., the recorded drop in brix was much greater, t.w., from 20° to 14°. Moreover, we notice that now the beginning of the curve is its steepest part, whilst after 40 per cent juice had been expressed, hardly any further drop in brix occurred.

The juice was fairly clear initially and did not change appreciably throughout the experiment. When compressing the chips, the first juice only appeared at a pressure of about 1,000—1,400 p.s.i. on the gauge, i.e., 78—100 p.s.i. on the cane material.

When the chips were shredded and again compressed, the juice was again very cloudy and quite dirty (Fig. 3).

Fig. 3 shows what happens when chips are subjected to pressure until approximately 40 per cent of the juice has been removed by increasing the pressure to approximately 578 p.s.i. We notice again a rather steep drop in brix from over 21° to near to 13°. After releasing the pressure, the mass was taken out of the press, shredded and replaced. Pressure was again applied. At 31 p.s.i., juice was already squeezed out, but now of an unexpectedly high brix of 27°.

Increasing the pressure to 734 p.s.i. produced in total, another 45 per cent of juice, all of a very high brix. The brix of the last expressed fraction was still over 25°.

Fig. 4 depicts the curve obtained when the nodes selected from the cut up cane from the chaff cutter were first shredded and then subjected to pressure. The curve, although somewhat irregular, is similar to the curve of Fig. 1, the final drop being slightly steeper.

When the internodes were tested in a similar way (Fig. 5), a very even curve was obtained.

For both the above types of shredded cane, the juice was initially cloudy, becoming clearer towards the end of the 'run'.

The curve for cane chips, nodes only, resembles the curve of Fig. 2 (whole cane chips). A total drop in brix of 5 to 6 units was recorded. And the same can be said for the curve for cane chips, internodes only. The drop in brix here was, however, 4 to 5 units only. These curves are not separately shown and will later be extensively discussed.

When cane chips consisting of nodes only were compressed to obtain about 40 per cent of the juice, the curve obtained was essentially similar to that representing cane chips compressed to maximum pressure. After shredding the residue, the brix of the first expressed juice was again 10° greater than the brix of the last juice from the chips. There was a slight increase in brix initially with a sharp drop towards the end.

For the internodes, the same holds true—the curve for chips showin a uniform drop, and that for the shredded chips showing a slight decrease at first with a sudden decrease at the end.

Pith and rind were also separately studied. Figs. 6 and 7 give the curves for shredded pith and rind respectively. Both show a sharp drop at the end whilst the brix of the juice from the shredded rind tended to rise slightly initially. The juice obtained from the rind was of a darker colour.

The curves for cane chips, pith only and rind only, differed somewhat. At 765 p.s.i. pressure, more juice was expressed from the pith, and the brix had dropped a mere 4 units as compared with more than 7 units in the case of rind only.

In the composite experiments where some 40 per cent of juice was expressed from cane, and the residue shredded and again compressed, a much greater difference between the last expressed chip juice and the first expressed shredded residue juice was observed when the treated material was pith than when it was rind only. In the former case, the difference was more than 12°, in the latter about 8°.

Comments

The experiments which have just been described throw some more light on the quantitative relationship of the various juices in a cane stalk. The points interconnected by straight lines which, together, constitute the curves of Figs. 1 to 8, represent the brix values of the consecutive fractions of the juice expressed in these experiments. The straight lines therefore do not indicate the steady drop in brix occurring when juice is continuously expressed by slowly raising the compression pressure. The curve recording this actual brix drop would lie somewhat lower.

The recorded curves enable us, however, to calculate what percentages of the total expressed weight of brix were expressed in each of the individual fractions.

Table I shows the relative amounts of brix expressed in each of the eleven fractions, which together, constituted all the expressed juice in the experiments, the results of which are given in Fig. 1.

Table 1

Distribution of Brix over Fractions (shredded cane)

Fraction Number	°Brix of Fraction	Perc. of Total brix	Cumulative Perc. of brix	Fraction Number	°Brix of Fraction	Perc. of Total	Cumulative Perc. of brix
1	23.3	27.6	27.6	7	21.0	2.6	93.6
2	22.4	29.8	57.4	8	20.8	3.0	96.6
3	22.2	14.2	71.6	9	20.5	1.4	98.0
4	21.9	9.1	80.7	10	20.2	1.2	99.2
5	21.6	4.6	85.3	11	20.0	0.8	100.0
6	21.2	5.7	91.0	—	—	—	—

Table I shows that when shredded cane was subjected to static pressure, more than 80 per cent of all expressed brix was collected in the first four fractions and 91 per cent in the first six fractions. In these six fractions, the brix had dropped only 2.1 out of the total 3.3 units. It would, of course, be interesting to know at what concentration the residual brix was retained in the bagasse, but although we know that nearly 23 per cent of the juice was not squeezed out, we can only infer from the sharp drop at the end of the curve that the brix of the residual juice must have been relatively low and that less than 23 per cent of brix was retained.

Table II refers to the squeezing of chips.

Table 2

Distribution of Brix over Fractions (shredded cane)

Fraction Number	°Brix of Fraction	Perc. of Total brix	Cumulative Perc. of brix	Fraction Number	°Brix of Fraction	Perc. of Total	Cumulative Perc. of brix
1	20.0	9.9	9.9	6	14.6	11.9	68.1
2	18.7	9.3	19.2	7	14.1	9.2	77.3
3	17.5	11.1	30.3	8	13.8	8.9	86.2
4	16.6	14.3	44.6	9	13.7	10.1	96.3
5	15.8	11.6	56.2	10	13.7	3.7	100.0

To obtain a better understanding of Fig. 2 and Table II, it is necessary to refer to Fig. 3 representing the experiment in which the residue of the chips was again, after shredding, subjected to pressure. In this latter experiment only 37.3 per cent of the total expressed amount of brix was squeezed out of the chips, at an average brix of 17.0° (actually the brix dropped from 21.7° to 13.5°) and during the compression of the residue, 62.7 per cent at an avrage of 26.85° (actually the brix dropped from 27.4° to 25.0°).

Since in total 87.5 per cent of the juice originally present in the chips was expressed, nearly 52 per cent of the expressed juice (and an even higher percentage of the brix°) was obtained at a remarkably high concentration. A duplicate experiment showed similar data. Here 30.7 per cent of the amount of brix expressed in the two compressions was obtained at an average brix of 15.6° (20.4° to 12.1°) and 69.3 per cent at an average brix of 27.0° (27.4° to 25.2°). At least 53.6 per cent of the brix originally present in the chips was obtained at a very high concentration.

Hence, it has been possible by a rather simple technique to divide the juice in cane into three fractions, t.w.,

(*a*) a high brix fraction constituting approximately 45 per cent of the juice;

(*b*) a low brix fraction constituting approximately 40 per cent of the juice;

(*c*) a fraction which is still present in the final residue of unknown brix and constituting approximately 15 per cent of the juice.

It is realized, of course, that the relative sizes of the fractions depend on the particular compression technique applied and that it may be possible by modifying the technique to achieve a sharper division between high and low brix juices. The maximum and minimum brix values shown by fractions of juice obtained from the same cane were 27.4° and 12.1°, and it is quite likely that even lower brix liquid has—separately contained—been present in the cane.

It was further observed that the low brix juice was fairly clear and the high brix juice cloudy and dirty. Shredding cane opens the storage cells. It is estimated that by our technique, at least 90 per cent of the storage cells are opened. The murky juice of the opened cells mixes readily and is easily expressed as soon as pressure is applied. The gradual drop in brix shown by the curve of Fig. 1 may be due to the fact that some thicker walled storage cells containing lower brix juice, were not opened by the shredding operation, but it is also possible that the juice originating from the fibrovascular bundles is already present in the first expressed fraction and that its relative proportion increases as the pressure rises. The increasing proportion of low brix juice is certainly responsible for the sharp drop in brix during the later stages of the compression operation, and the residual juice must be of a much lower brix. The low brix juice is apparently most difficult to express.

However, when chips are subjected to pressure, the situation is quite different. Fig. 3 shows quite clearly that after 40 per cent of the, in total expressed juice, was removed at a relatively low brix, the residual juice, which was obviously more difficult to express, had a considerably higher brix. It would seem that when relatively low lateral pressure is exerted on whole cane chips, the fibrovascular bundles are flattened and the liquid contained in them is squeezed out. This would happen less readily when cane is shredded and the pressure on the juice-embedded fibrovascular bundles is random. The type of shredding used in our experiments would hardly rupture the fibrovascular bundles, and it is only the higher pressures applied after most of the storage cell juice has been removed which succeeds in squeezing the low brix liquid out of the fibrovascular bundles. It is clear—in the experiment illustrated in Fig. 2—that if it had been possible to exert a higher pressure, juice of increasing brix would have been expressed. The curve would turn upwards.

We come now to the experiments in which nodes, internodes, pith and rind were separately compressed. The results of those in which shredded cane was compressed are given in Table III, those referring to chips in Table IV.

TABLE 3

Distribution of Brix over Fractions (shredded cane)

No. of Experiment	Nodes		Internodes		Pith	Rind
	8	10	9	11	20	21
No. 1 Fraction						
Wt. Fraction % Wt., Juice in Cane	11.0	17.2	40.3	29.0	57.3	5.0
Cum. Wt. % ,, ,, ,, ,,	11.0	17.2	40.3	29.0	57.3	5.0
°Brix Fraction	21.4	21.1	22.0	22.4	20.8	20.4
Wt. Bx. Fraction % Total Brix Expressed	14.3	22.3	46.6	33.9	58.9	7.2
Cum. Wt. Bx. % Total Brix Expressed	14.3	22.3	46.6	33.9	58.9	7.2
No. 2 Fraction						
Wt. Fraction % Wt. Juice in Cane	28.22	20.5	17.6	25.2	19.4	17.2
Cum. Wt. Æ ,, ,, ,, ,,	39.2	37.7	57.9	54.2	76.7	22.2
°Brix Fraction	21.5	20.9	21.9	22.0	20.7	20.7
Wt. Bx. Fraction % Total Brix Expressed	36.9	26.3	20.3	29.0	19.8	25.2
Cum. Wt. Bx. % Total Brix Expressed	51.2	48.6	66.9	62.9	78.7	32.4
No. 3 Fraction						
Wt. Fraction % Wt. Juice in Cane	6.98	10.6	8.1	9.0	7.1	10.2
Cum. Wt. % ,, ,, ,, ,,	46.2	48.3	66.0	63.2	83.4	32.4
°Brix Fraction	20.8	21.1	21.7	22.0	20.5	20.7
Wt. Bx. Fraction % Total Brix Expressed	8.8	13.7	9.4	10.3	7.2	14.9
Cum. Wt. Bx. % Total Brix Expressed	60.0	62.3	76.3	63.2	85.9	47.3
No. 4 Fraction						
Wt. Fraction % Wt. Juice in Cane	11.00	8.3	7.2	9.0	4.8	10.9
Cum. Wt. % ,, ,, ,, ,,	57.20	56.6	73.2	72.2	88.6	43.3
°Brix Fraction	21.1	21.0	21.6	21.8	20.3	20.7
Wt. Bx. Fraction % Total Brix Expressed	14.1	10.7	8.2	10.2	4.8	16.0
Cum. Wt. Bx. % Total Brix Expressed	74.1	73.0	84.5	83.4	90.7	63.3
No. 5 Fraction						
Wt. Fraction % Wt. Juice in Cane	4.4	5.4	4.1	3.8	3.0	5.7
Cum. Wt. % ,, ,, ,, ,,	61.60	62.0	77.3	76.0	91.6	49.0
°Brix Fraction	20.6	20.8	21.4	21.5	19.8	20.7
Wt. Bx. Fraction % Total Brix Expressed	5.5	6.9	4.6	4.3	2.9	8.3
Cum. Wt. Bx. % Total Brix Expressed	79.6	79.9	89.1	87.7	93.6	71.6
No. 6 Fraction						
Wt. Fraction % Wt. Juice in Cane	4.1	3.6	2.8	3.9	2.4	5.9
Cum. Wt. % ,, ,, ,, ,,	65.70	65.8	80.1	79.9	94.0	54.9
°Brix Fraction	20.4	20.5	21.2	21.3	19.6	20.6
Wt. Bx. Fraction % Total Brix Expressed	5.1	4.5	3.1	4.3	2.3	8.6
Cum. Wt. B. % Total Brix Expressed	84.7	84.4	92.2	92.0	95.9	80.2
No. 7 Fraction						
Wt. Fraction % Wt. Juice in Cane	3.3	3.3	2.1	2.1	0.8	3.8
Cum. Wt. % ,, ,, ,, ,,	69.00	68.9	82.2	82.0	94.8	58.7
°Brix Fraction	20.3	20.3	20.8	21.1	19.1	20.5
Wt. Bx. Fraction % Total Brix Expressed	4.1	4.1	2.3	2.3	0.8	5.5
Cum. Wt. Bx. % Total Brix Expressed	88.8	88.5	94.5	94.3	96.7	85.7
No. 8 Fraction						
Wt. Fraction % Wt. Juice in Cane	2.8	2.7	2.0	1.7	1.3	3.5
Cum. Wt. % ,, ,, ,, ,,	71.80	71.6	84.2	83.7	96.1	62.2
°Brix Fraction	19.9	19.9	20.5	20.5	18.9	20.3
Wt. Bx. Fraction % Total Brix Expressed	3.4	3.3	2.2	1.8	1.2	5.0
Cum. Wt. Bx. % Total Brix Expressed	92.2	91.8	96.7	96.1	97.9	90.7
No. 9 Fraction						
Wt. Fraction % Wt. Juice in Cane	1.8	2.1	1.3	1.1	0.8	1.7
Cum. Wt. % ,, ,, ,, ,,	73.60	73.7	85.5	84.8	96.9	63.9
°Brix Fraction	19.5	19.4	20.2	20.1	18.2	20.1
Wt. Bx. Fraction % Total Brix Expressed	2.1	2.5	1.4	1.2	0.7	2.4
Cum. Wt. Bx. % Total Brix Expressed	94.3	94.3	98.1	97.3	98.6	93.1

TABLE 3

Distribution of Brix over Fractions (shredded cane)—*continued.*

	Nodes		Internodes		Pith	Rind
No. of Experiment	8	10	9	11	20	21
No. 10 Fraction						
Wt. Fraction % Wt. Juice in Cane	2.1	2.1	1.2	1.1	0.5	1.7
Cum. Wt. % „ „ „ „	75.70	75.8	86.7	85.9	97.4	65.6
°Brix Fraction	18.7	18.9	19.6	19.9	17.6	19.9
Wt. Bx. Fraction % Totzl Brix Expressed	2.4	2.4	1.2	1.1	0.4	2.4
Cum. Wt. Ex. % Total Brix pressed	96.7	96.7	99.3	98.4	99.0	95.5
No. 11 Fraction						
Wt. Fraction % Wt. Juice in Cane	1.7	1.5	0.9	0.9	0.6	1.6
Cum. Wt. % „ „ „ „	77.40	77.3	87.6	86.8	98.0	67.2
°Brix Fraction	18.6	18.4	18.9	19.3	17.2	19.6
Wt. Bx. Fraction % Total Brix Expressed	1.9	1.7	0.9	0.9	0.5	2.2
Cum. Wt. Bx. % Total Brix expressed	98.6	98.4	100.0	99.3	99.5	97.7
No. 12 Fsaction						
Wt. Fraction % Wt. Juice in Cane	1.2	1.4	—	0.6	0.5	1.6
Cum. Wt. % „ „ „ „ „	78.60	78.7	—	87.4	98.5	68.8
°Brix Fraction	18.4	17.9	—	18.8	17.0	19.1
Wt. Bx. Fraction % Total Brix Expressed	1.3	1.5	—	0.6	0.4	2.2
Cum. Wt. Bx. % Total Brix Expressed	100.0	100.0	—	100.0	100.0	100.0
Ultimate Pressure (p.s.i.)	766	766	656	766	750	750
Fibre % Cane	14.31	13.9	14.31	13.9	13.85	13.85

Table 4

Distribution of Brix over Fractions (chips)

	Nodes		Internodes		Pith	Rind
No. of Experiment	13	14	12	15	22	23
No. 1 Fraction						
Wt. Fraction % Wt. Juice in Cane	0.81	2.9	3.5	4.1	10.8	6.2
Cum. Wt. % „ „ „ „	0.81	2.9	3.5	4.1	10.8	6.2
°Brix Fraction	18.6	16.9	19.4	19.5	17.5	19.0
Wt. Bx. Fraction % Total Brix Expressed	2.66	7.9	7.8	7.5	18.8	15.7
Cum. Wt. Bx. % Total Brix Expressed	2.66	7.9	7.8	7.5	18.8	15.7
No. 2 Fraction						
Wt. Fraction % Wt. Juice in Cane	1.69	2.7	3.6	3.5	5.5	3.9
Cum. Wt. % „ „ „ „	2.50	5.6	7.1	7.6	16.3	10.1
°Brix Fraction	17.7	16.0	19.1	18.9	17.0	18.7
Wt. Bx. Fraction % Total Brix Expressed	5.26	7.0	7.9	6.3	9.4	9.7
Cum. Wt. Bx. % Total Brix Expressed	7.92	14.9	15.7	13.8	28.2	25.4
No. 3 Fraction						
Wt. Fraction % Wt. Juice in Cane	3.2	4.3	5.6	6.7	8.1	6.7
Cum. Wt. % „ „ „ „	5.70	9.9	12.7	14.3	24.4	16.8
°Brix Fraction	17.0	15.1	19.0	18.5	16.2	18.0
Wt. Bx. Fraction % Total Brix Expressed	9.56	10.5	12.3	12.0	13.1	16.1
Cum. Wt. Bx. % Total Brix Expressed	17.48	25.4	28.0	25.8	41.3	41.5
No. 4 Fraction						
Wt. Fraction % Wt. Juice in Cane	5.0	5.1	5.6	6.0	6.3	4.0
Cum. Wt. % „ „ „ „	10.70	15.0	18.3	20.3	30.7	20.8
°Brix Fraction	16.0	14.4	18.3	17.8	15.2	17.4
Wt. Bx. Fraction % Total Brix Expressed	14.07	11.9	11.8	10.3	9.5	9.3
Cum. Wt. Bx. % Total Brix Expressed	31.55	37.3	39.8	36.1	50.8	50.8

Table 4

Distribution of Brix over Fractions (chips)—*continued*

	Nodes		Internodes		Pith	Rind
No. of Experiment	13	14	12	15	22	23
No. 5 Fraction						
Wt. Fraction % Wt. Juice in Cane	4.7	6.7	5.2	9.6	7.7	5.2
Cum. Wt. % ,, ,, ,, ,,	15.40	21.7	23.5	29.9	38.4	36.0
°Brix Fraction	15.1	13.7	17.0	17.2	15.0	16.6
Wt. Bx. Fraction % Total Brix Expressed	12.49	14.8	10.2	16.0	11.5	11.5
Cum. Wt. Bx. % Total Brix Expressed	44.04	52.1	50.0	52.1	62.3	62.3
No. 6 Fraction						
Wt. Fraction % Wt. Juice in Cane	5.6	4.8	5.3	5.4	7.2	3.7
Cum. Wt. % ,, ,, ,, ,,	21.00	26.5	28.8	35.3	45.6	29.7
°Brix Fraction	14.1	13.2	15.9	16.4	14.3	15.5
Wt. Bx. Fraction % Total Brix Expressed	13.89	10.2	9.7	8.6	10.3	7.7
Cum. Wt. Bx. % Total Brix Expressed	57.93	62.3	59.7	60.7	72.6	70.0
No. 7 Fraction						
Wt. Fraction % Wt. Juice in Cane	5.3	5.0	7.1	7.5	5.5	5.7
Cum. Wt. % ,, ,, ,, ,,	26.30	31.5	35.9	42.8	51.1	35.4
°Brix Fraction	13.5	12.6	15.3	16.1	13.7	14.8
Wt. Bx. Fraction % Total Brix Expressed	12.9	10.2	12.5	11.7	7.5	11.3
Cum. Wt. Bx. % Total Brix Expressed	70.52	72.5	72.2	72.4	80.1	81.3
No. 8 Fraction						
Wt. Fraction % Wt. Juice in Cane	5.3	5.2	5.0	4.5	5.2	2.8
Cum. Wt. % ,, ,, ,, ,,	31.60	36.7	40.9	47.3	56.3	38.2
°Brix Fraction	13.1	12.3	14.5	15.6	13.4	13.7
Wt. Bx. Fraction % Total Brix Expressed	12.21	10.3	8.4	6.8	6.9	5.1
Cum. Wt. Bx. % Total Brix Expressed	82.73	82.8	80.6	79.2	87.0	86.4
No. 9 Fraction						
Wt. Fraction % Wt. Juice in Cane	4.3	4.1	4.4	6.5	4.9	3.1
Cum. Wt. % ,, ,, ,,	35.90	40.8	45.3	53.8	61.2	41.3
°Brix Fraction	12.8	12.1	14.0	15.4	13.3	13.0
Wt. Bx. Fraction % Total Brix Expressed	9.67	8.0	7.1	9.7	6.5	5.4
Cum. Wt. Bx. % Total Brix Expressed	92.40	90.8	87.7	88.9	93.5	91.8
No. 10 Fraction						
Wt. Fraction % Wt. Juice in Cane	3.4	4.7	4.7	3.9	3.1	2.3
Cum. Wt. % ,, ,, ,, ,,	39.30	45.5	50.0	57.7	64.3	43.6
°Brix Fraction	12.7	12.0	13.8	15.2	13.3	12.3
Wt. Bx. Fsaction % Total Brix Expressed	7.60	9.1	7.5	5.7	4.1	3.8
Cum. Wt. Bx. % Total Brix Expressed	100.00	100.00	95.2	94.6	97.6	95.6
No. 11 Fraction						
Wt. Fraction % Wt. Juice in Cane	—	—	2.9	3.8	1.9	2.9
Cum. Wt. % ,, ,, ,, ,,	—	—	52.9	61.5	66.2	46.5
°Brix Fraction	—	—	13.7	14.9	13.2	11.6
Wt. Bx. Fraction % Total Brix Expressed	—	—	4.6	5.5	2.5	4.5
Cum. Wt. Bx. % Total Brix E ressed	—	—	100.0	100.0	100.0	100.0
Ultimate Pressures (p.s.i.)	766	766	766	766	766	766
Fibre % Cane	15.03	17.26	15.03	17.27	13.25	13.25

Generally speaking, the data of Table III present the same picture as those of Table I. Initially the brix of the fractions drops slowly, but at an accelerated rate towards the end. There are, however, differences in the total amounts of juice expressed before the maximum pressure is attained. The rind yields considerably less juice than the pith, and the nodes less than the internodes.[7]

[7] The fibre percentages of nodes and corresponding internodes, and of pith and corresponding rind were unfortunately not separately determined. The fibre data at the end of the Table refer to the whole cane. Hence, Juice per cent Cane was probably calculated too high for rind and nodes, and too low for pith and internodes, but it is felt that this fact has not affected the above conclusion materially.

A similar effect was observed when chips were compressed (Table IV). It would seem that, in regard to the ease with which juice can be expressed from chips, there is little to choose between the contradistinctions pith—rind and nodes—internodes.

The levelling of the curve which was characteristic of Fig. 2, was, however, not observed when chips consisting of rind only were compressed.

The composite compression experiments on nodes, internodes, pith and rind, gave similar results to those on whole cane. Table V shows the most interesting data of these experiments.

Table 5

Composite Compression Tests

No. of Expt.	Material Compressed	Brix % Total Expressed Brix in 1st Compression	Av. Brix 1st Fraction	Brix Limits 1st Fraction	Brix % Total Expressed Brix in 2nd Compression	Av. Brix 2nd Fraction	Brix Limits 2nd Fraction
16	Nodes	37.8	14.58	12.9—19.1	62.2	24.73	22.4—25.0
18	Nodes	47.6	14.41	12.4—17.5	52.4	22.08	20.8—22.5
17	Internodes	34.3	16.92	14.7—19.0	65.7	24.30	22.2—24.6
19	Internodes	43.3	16.01	14.1—17.5	56.7	23.22	21.0—23.5
24	Pith	31.1	14.26	11.0—19.3	68.9	22.29	20.9—22.6
25	Rind	55.8	16.49	12.6—19.3	44.2	20.78	19.9—21.2

The extremely high brix values observed when whole cane chips were double compressed were not found when nodes, internodes, pith and rind were separately examined. This is probably due to different cane being used for the experiments.

As was expected, pith gave relatively less low brix juice than rind, and internodes less than nodes. The difference between pith versus rind was larger than between nodes versus internodes, in this respect.

The lowest brix value observed in any fraction unexpectedly originated from pith (11.0), the highest brix value being observed in a high brix fraction extracted from nodes (25.0).

It was originally hoped that these experiments might throw some more light on the contention of the Sugar Research Institute (Mackay), that it is the degree to which dilute fibrovascular vessel juice is present rather than a possible brix difference between juices in various storage cells which causes the difference between pith and rind juice (see p. 2), but no conclusion could be drawn from the data and it has probably to be accepted that the presence of fibrovascular vessel juice is the much more powerful factor.

The difference in brix between low and high brix fractions is smallest for rind, rind yielding the lowest brix high-brix juice fraction. It would seem that from the practical point of view, rind is more objectionale than nodes.

The assumption that the brix of primary juice most adequately represents the brix of undiluted juice (see p. 3) does not find much support in the outcome of the experiment described in this paper, but as has already been explained, this is not really necessary.

There is, however, another point which needs to be discussed. The Java Ratio Cane Payment System as applied in Natal assumes more or less tacidly that the ratio of Sucrose per cent First Expressed Juice to Sucrose per cent Cane is independent of the method by which the first expressed juice is extracted from the cane, i.e., to what type of preparation the cane is submitted before extraction starts.

The aforegoing experiments clearly show the effect of shredding on the concentration of the juice which is squeezed out as soon as pressure is applied. Although static pressure was used in the experiments, there is no rêason to assume that a similar effect will not occur in a commercial tandem. This must be kept in mind when admitting surprise at differing Java Ratios being applied to cane partly milled by factory A and, due to diversion, partly milled by factory B.

Of direct interest to practical milling may be the conclusion that shredding of cane prior to the first pressure being applied to it in the milling tandem, will probably be conducive to extracting a juice of a higher concentration, and as far as extracting a high proportion of the brix in the first expressed juice is the object of the mill engineer, a shredder in front of the tandem must be advantageous. However, we must be somewhat careful in drawing our conclusions because there is also fairly reliable evidence that a too fine preparation of the cane may lead to a high moisture content of the final bagasse, in that way endangering the overall extraction which, of course, is the ultimate object of crushing.

Finally, I wish to forestall those critics who may say that in practical milling we are interested in sucrose and not in brix, and that for this reason, the results of the experiments discussed should be looked upon with suspicion. The answer is that sucrose determinations were also carried out in some of the experiments, and they generally lead to the same conclusions as those drawn from the brix data. The purity of the various juices is, however, a matter which will be gone into somewhat deeper in a further investigation.

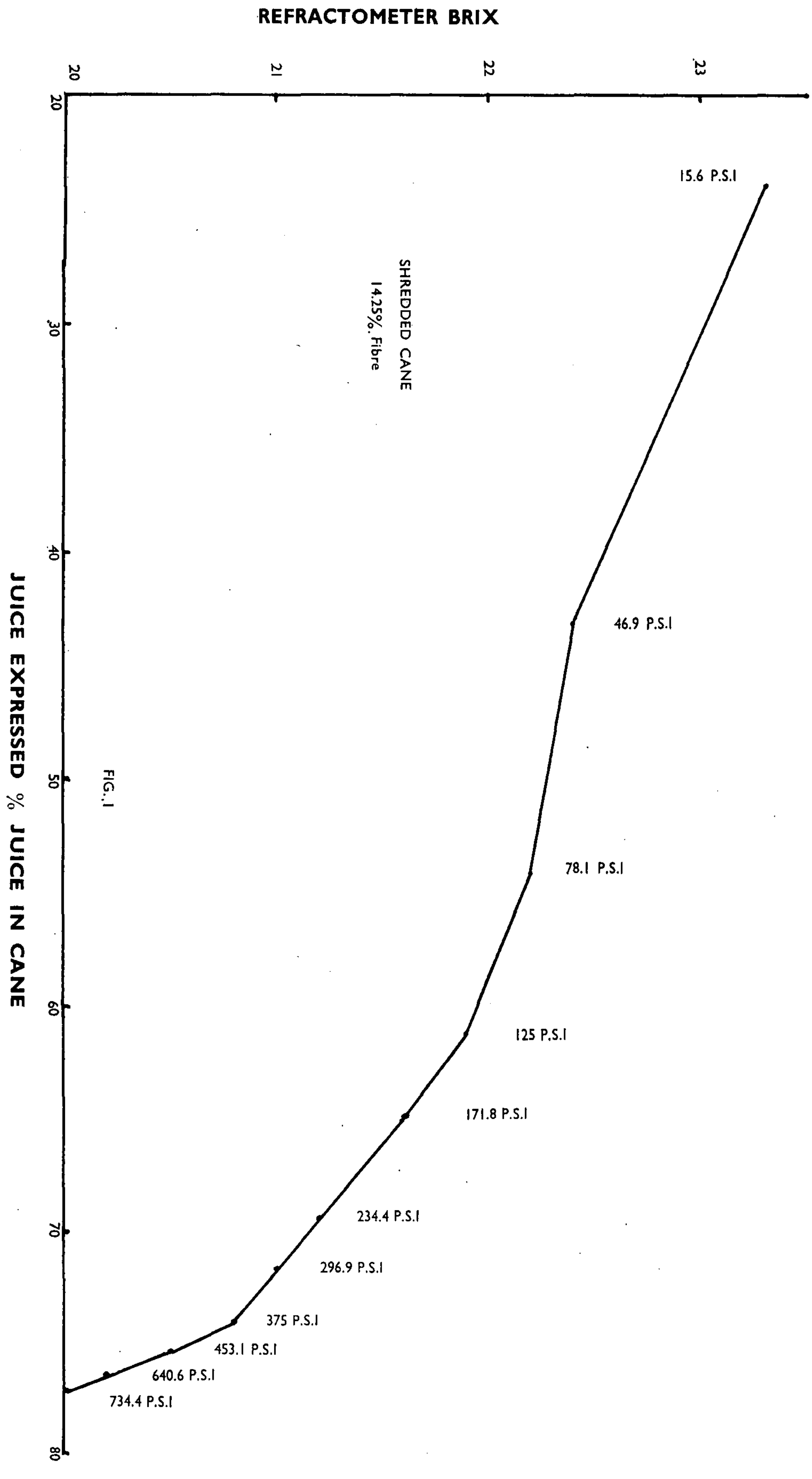
REFRACTOMETER BRIX
20
21
22
23
JUICE EXPRESSED % JUICE IN CANE
20
30
40
50
60
70
80
SHREDDED CANE
14.25%. Fibre
15.6 P.S.I
46.9 P.S.I
78.1 P.S.I
125 P.S.I
171.8 P.S.I
234.4 P.S.I
296.9 P.S.I
375 P.S.I
453.1 P.S.I
640.6 P.S.I
734.4 P.S.I

FIG. I

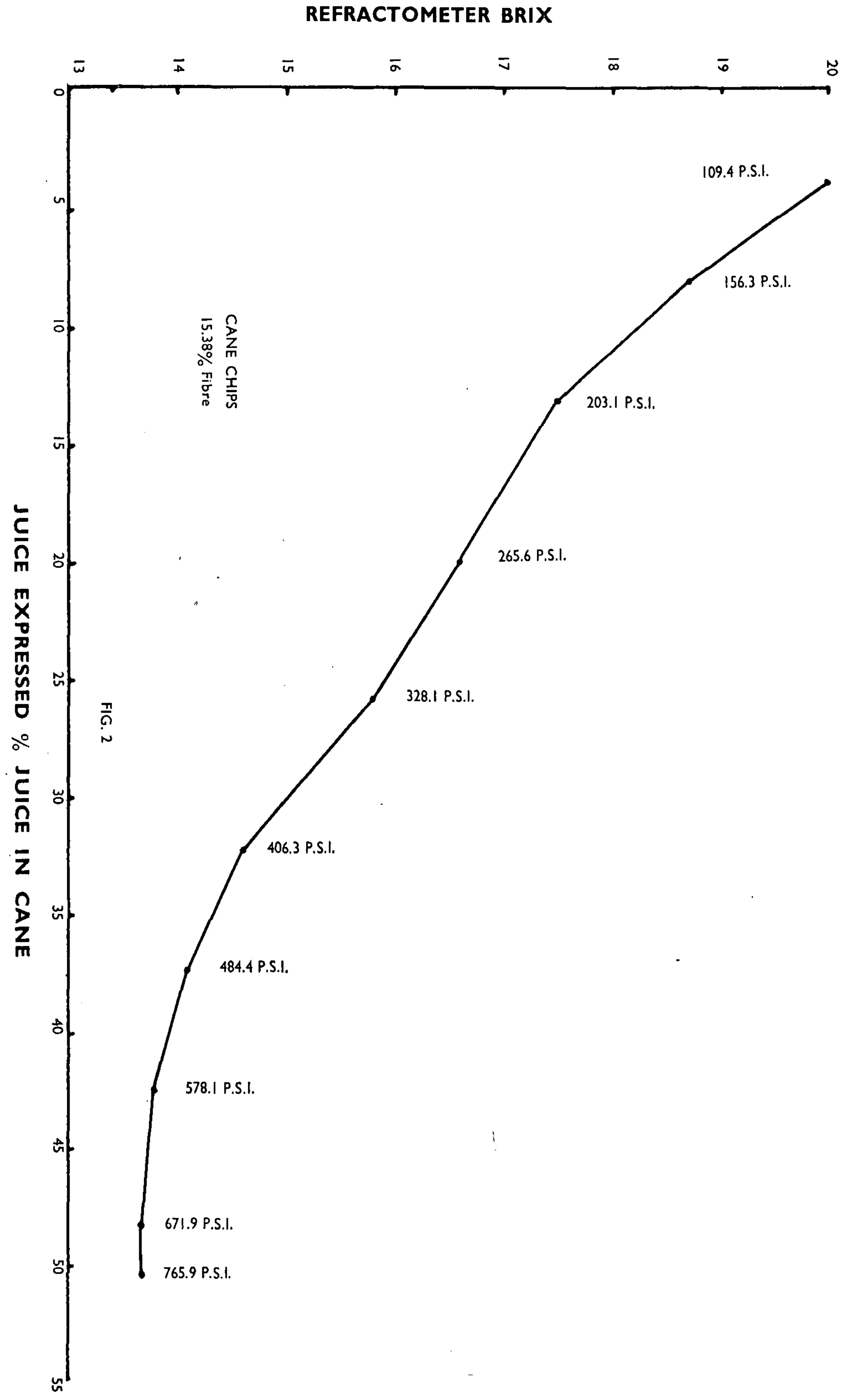
REFRACTOMETER BRIX
13
14
15
16
17
18
19
20
0
5
10
15
20
25
30
35
40
45
50
55
JUICE EXPRESSED % JUICE IN CANE
CANE CHIPS
15.38% Fibre
109.4 P.S.I.
156.3 P.S.I.
203.1 P.S.I.
265.6 P.S.I.
328.1 P.S.I.
406.3 P.S.I.
484.4 P.S.I.
578.1 P.S.I.
671.9 P.S.I.
765.9 P.S.I.

FIG. 2

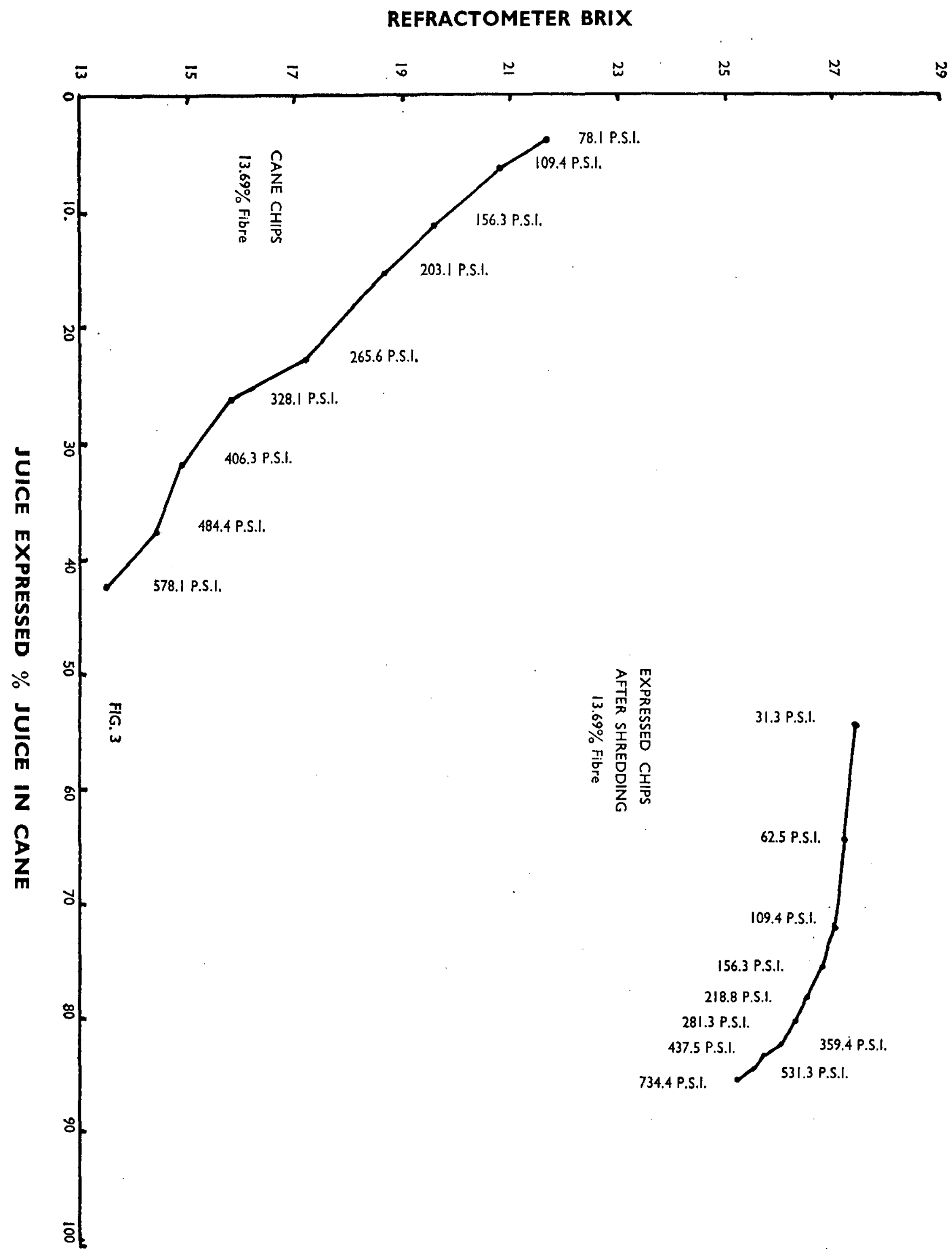
REFRACTOMETER BRIX
13
15
17
19
21
23
25
27
29
JUICE EXPRESSED % JUICE IN CANE
0
10
20
30
40
50
60
70
80
90
100
CANE CHIPS
13.69% Fibre
78.1 P.S.I.
109.4 P.S.I.
156.3 P.S.I.
203.1 P.S.I.
265.6 P.S.I.
328.1 P.S.I.
406.3 P.S.I.
484.4 P.S.I.
578.1 P.S.I.
EXPRESSED CHIPS
AFTER SHREDDING
13.69% Fibre
31.3 P.S.I.
62.5 P.S.I.
109.4 P.S.I.
156.3 P.S.I.
218.8 P.S.I.
281.3 P.S.I.
437.5 P.S.I.
359.4 P.S.I.
531.3 P.S.I.
734.4 P.S.I.

FIG. 3

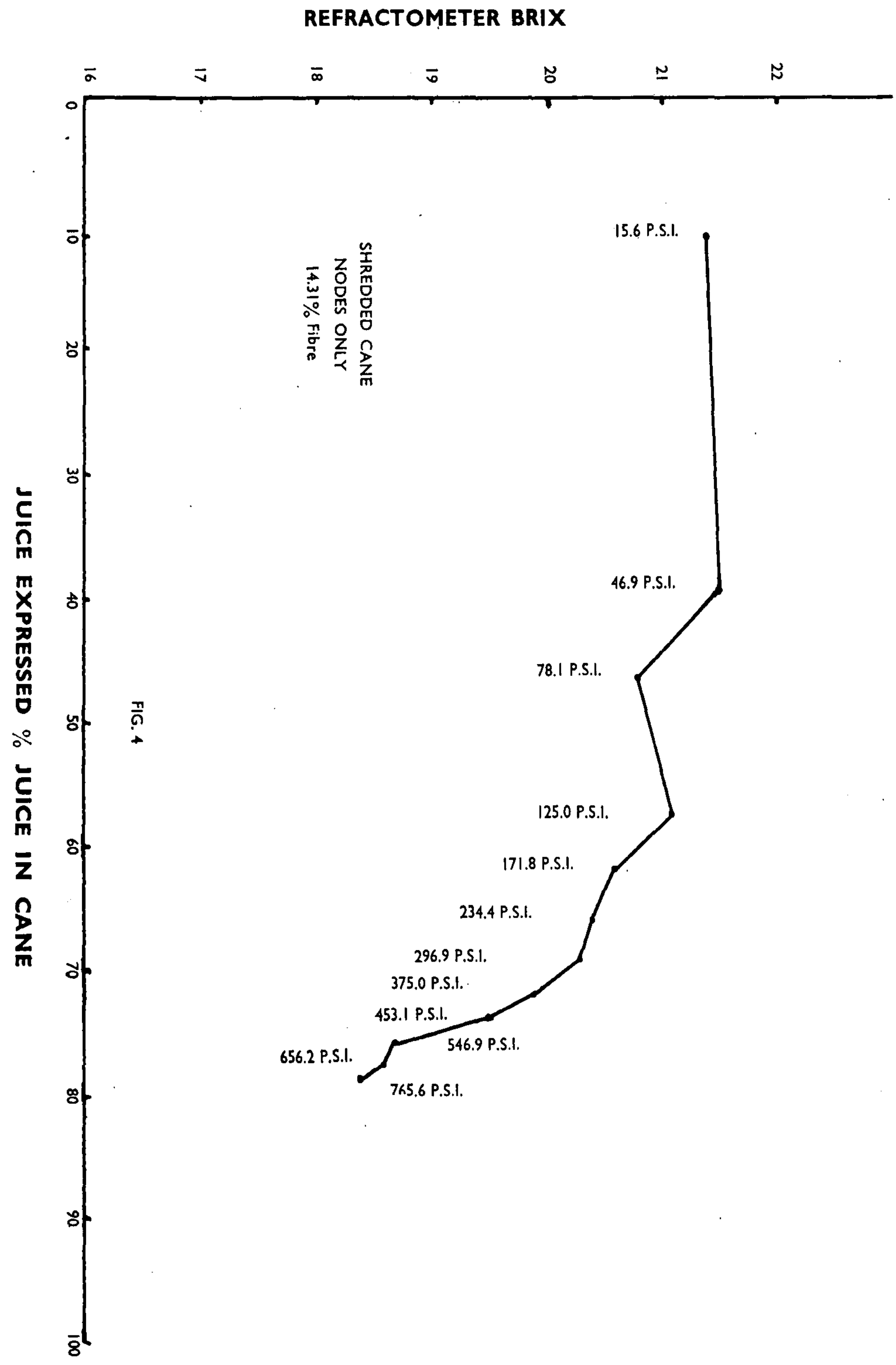
REFRACTOMETER BRIX
16
17
18
19
20
21
22
0
10
20
30
40
50
60
70
80
90
100
JUICE EXPRESSED % JUICE IN CANE
SHREDDED CANE
NODES ONLY
14.31% Fibre
15.6 P.S.I.
46.9 P.S.I.
78.1 P.S.I.
125.0 P.S.I.
171.8 P.S.I.
234.4 P.S.I.
296.9 P.S.I.
375.0 P.S.I.
453.1 P.S.I.
546.9 P.S.I.
656.2 P.S.I.
765.6 P.S.I.

FIG. 4

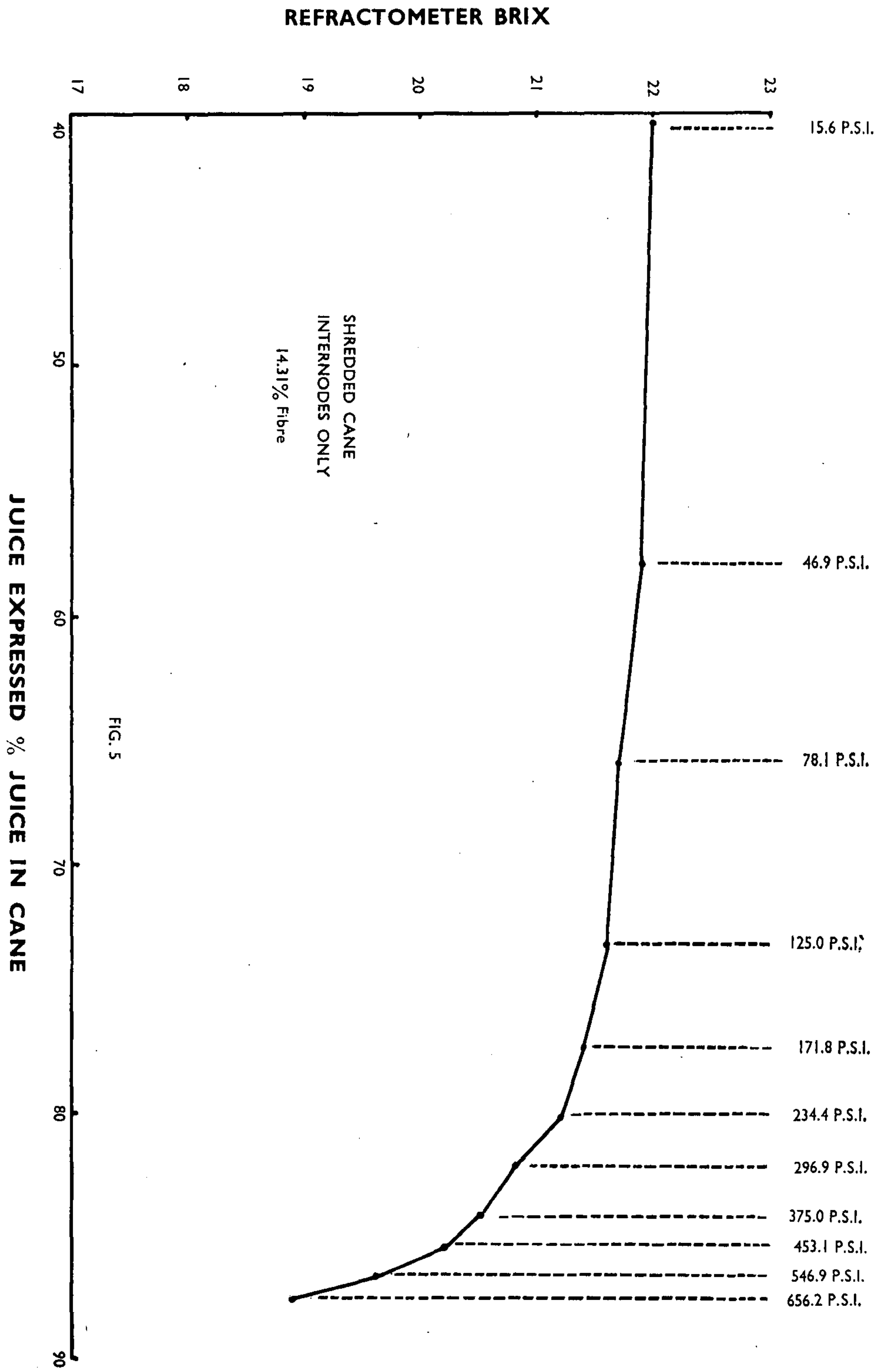
REFRACTOMETER BRIX
17
18
19
20
21
22
23
40
50
60
70
80
90
JUICE EXPRESSED % JUICE IN CANE
SHREDDED CANE
INTERNODES ONLY
14.31% Fibre
15.6 P.S.I.
46.9 P.S.I.
78.1 P.S.I.
125.0 P.S.I.
171.8 P.S.I.
234.4 P.S.I.
296.9 P.S.I.
375.0 P.S.I.
453.1 P.S.I.
546.9 P.S.I.
656.2 P.S.I.

FIG. 5

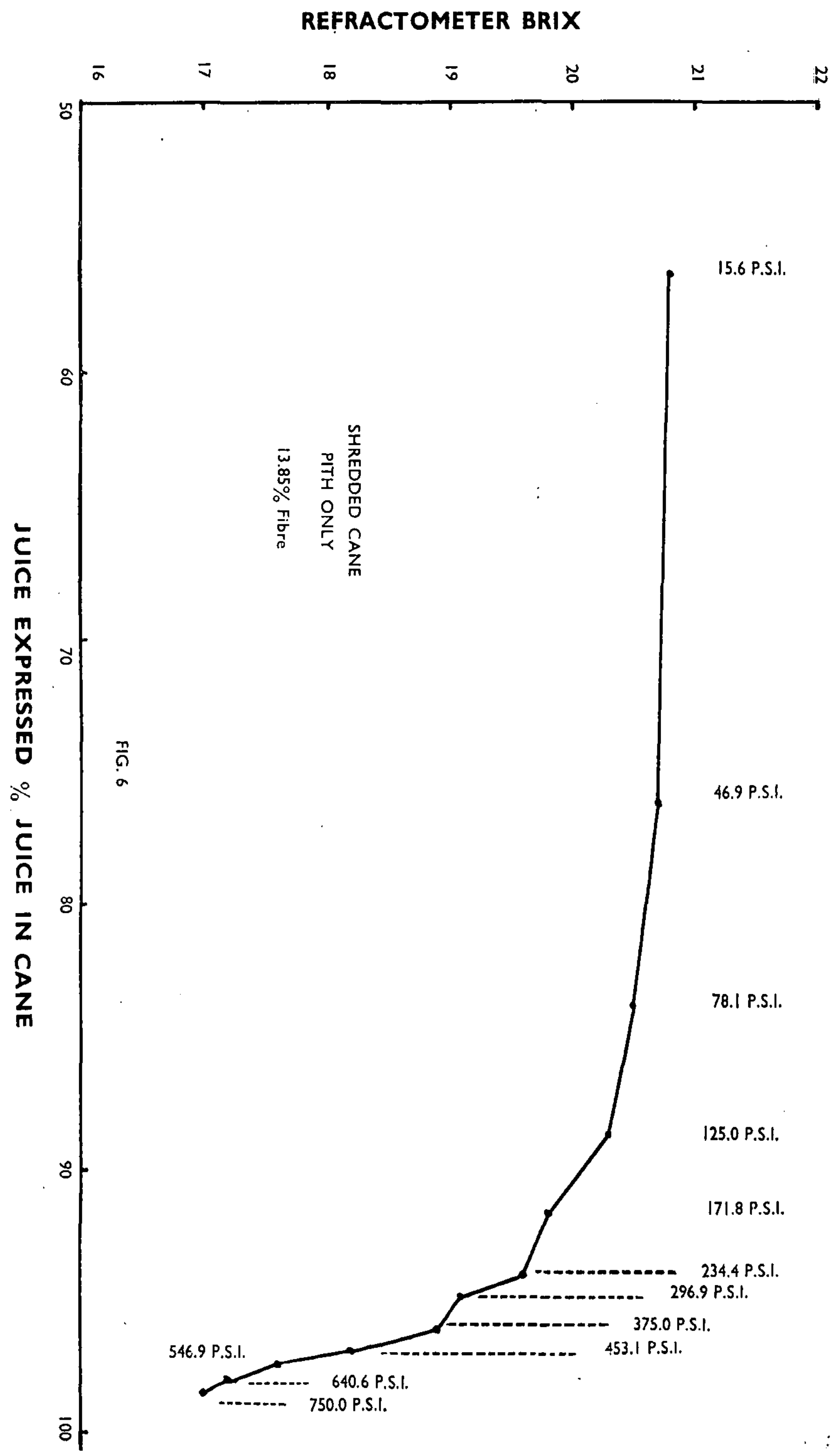
REFRACTOMETER BRIX
16
17
18
19
20
21
22
JUICE EXPRESSED % JUICE IN CANE
50
60
70
80
90
100
SHREDDED CANE
PITH ONLY
13.85% Fibre
15.6 P.S.I.
46.9 P.S.I.
78.1 P.S.I.
125.0 P.S.I.
171.8 P.S.I.
234.4 P.S.I.
296.9 P.S.I.
375.0 P.S.I.
453.1 P.S.I.
546.9 P.S.I.
640.6 P.S.I.
750.0 P.S.I.

FIG. 6

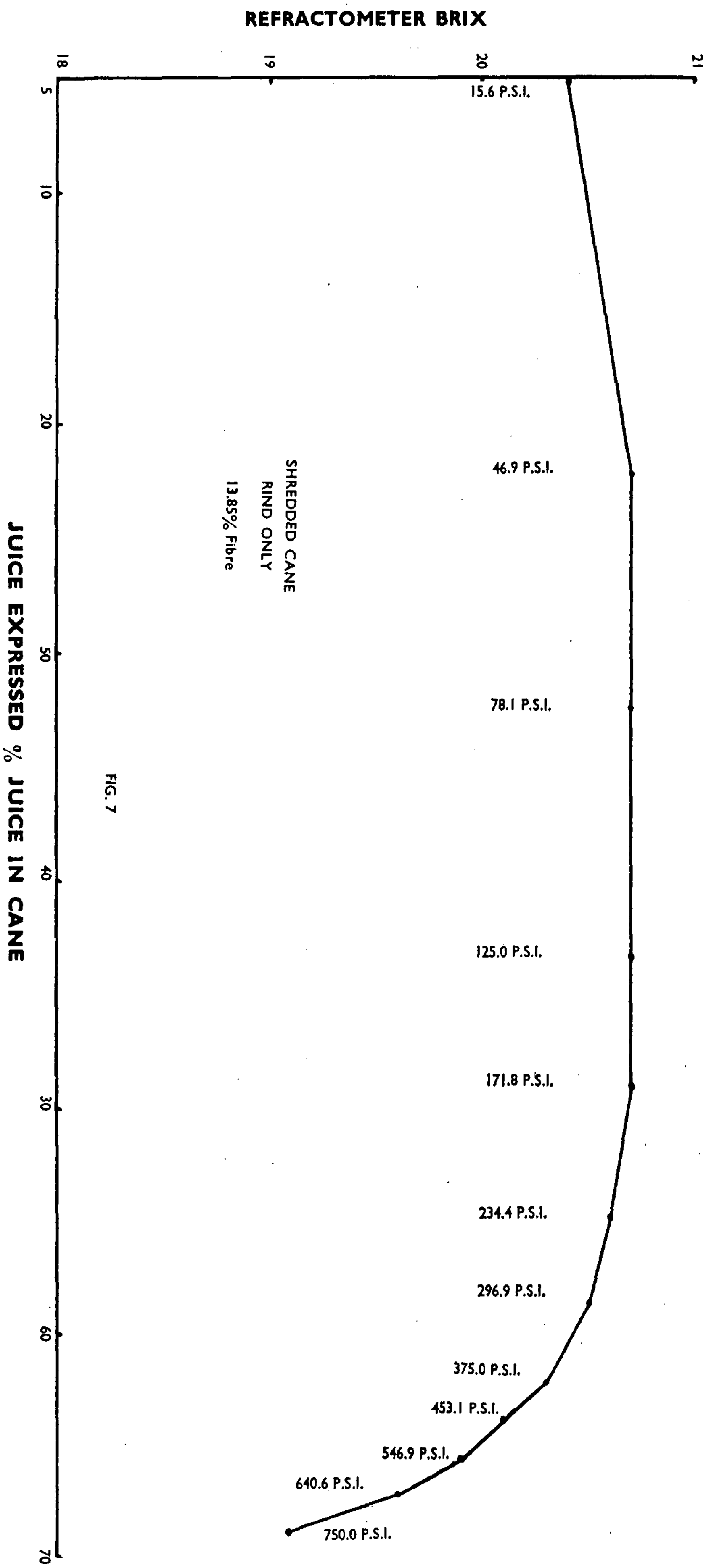
REFRACTOMETER BRIX
18
19
20
21
JUICE EXPRESSED % JUICE IN CANE
SHREDDED CANE
RIND ONLY
13.85% Fibre
15.6 P.S.I.
46.9 P.S.I.
78.1 P.S.I.
125.0 P.S.I.
171.8 P.S.I.
234.4 P.S.I.
296.9 P.S.I.
375.0 P.S.I.
453.1 P.S.I.
546.9 P.S.I.
640.6 P.S.I.
750.0 P.S.I.

FIG. 7

Mr. J. P. N. Bentley (in the Chair) said the paper opened the way to many factory engineers getting a clearer idea of where they would like to put the shredder. It seemed from tables 1 and 2 that the shredder might be better in front, or in other words, eliminate the knives altogether. Another point was that in Australia, which was very advanced in technique, the shredder was placed in front of the mills but 75 per cent of the hammers were removed. This might be due to the possibility of re-absorbtion further down the train but it would appear to reduce the efficiency of the shredder and not to be in accordance with the figures given by Dr. Douwes Dekker.

Dr. K. Douwes Dekker said tests had been done on nodes, pith and rind separately and the data were shown in the paper. It was obviously easier to squeeze the juice from the pith than from the rind and nodes. One conclusion that could be drawn was that rind was more difficult to extract than were nodes. Cane breeders might well attempt to develop varieties with thin rind.

Dr. J. Dick said the difficulty with such cane was that it was likely to break in the field.

Mr. C. G. M. Perk stated that the cane should be prepared i.e. desintergrated before squeezing. However, if this preparation had to be carried out by a shredder, the shredder had to be preceded by one or two sets of cane knives. Hence, why not prepare tne cane completely with cane knives as was the case in Java, where short-pitched knives (Meinecke cane knives) were used for this purpose. According to Meinecke these knives should run at 900 r.p.m., but it appeared that two sets of Meinecke knives cut the cane so fine that it was difficult to fire. In addition the moisture content of the bagasse increased, even when a bigger grooving was applied to the rollers of the last mill. The speed of the knives had therefore to be reduced to approximately 600 r.p.m.

Mr. J. R. Gunn said Graph No. 1 indicated by analogy that a shredder in front of the first mill would give less juice extraction, for a pressure of 700 lbs. per square inch gave only 78 per cent, while Graph No. 3 simulating the common Natal condition of placing the shredder behind the first mill, showed that a pressure of 743 lbs. per square inch gave a juice expression of 90 per cent.

Dr. K. Douwes Dekker said Mr. Gunn had made a good point. By squeezing shredded cane one got a 75 per cent juice extraction. After the low brix juice had been squeezed out and the cane shredded, this gave a higher percentage. A shredder in front of the mill would help the extraction of the highest percentage of brix which was a good thing, in that all the first expressed juice went straight into the factory, while the other juice stood more chance of deterioration.

He was not impressed by the statement that large grooving, say 2 inch to 3 inch, did not help extraction at the last mill for the most difficult juice to extract was that in the fibro-vascular bundles which had to flatten and therefore grooving at the last mill should be as small as possible.

Mr. W. H. Walsh referred to Table No. 3 and said that the experiments illustrated the effect of static pressure. He asked what would be the effect of imbibition as between chipped cane and shredded cane in a milling plant?

Dr. K. Douwes Dekker said extraction in a milling train was accomplished by squeezing allied to dilution by imbibition. The juice should be freely available for dilution and he considered that shredding would increase the effect of imbibition.

Mr. J. Rault said cane milling was a complex operation. One point to be noted was the feeding of the mill, and if cane was reduced to a very fine condition it did not feed well into a mill. On the other hand we know that fine bagasse absorbed imbibition better, and at Natal Estates it had been found that the coarse particles in final bagasse were over 1 per cent richer in sucrose than were the finer particles. It was therefore necessary to compromise between fine and coarse reduction of cane. Good preparation of cane was stated to aid extraction at the first mill but some mills with only fair preparation and extraction at the first mill were able to pick up in the later mills and obtain good overall results.

He had found that by squeezing last mill bagasse, instead of getting a juice of 1-2° Brix as in the last mill juice, the brix was as high as 7°. Obviously the efficiency of imbibition was vital, but not enough research in raising this efficiency had been done in this country.

Dr. K. Douwes Dekker agreed with Mr. Rault but said that the fact remained that the use of a shredder in front of the first mill gave a better extraction at that mill.