REPORT ON HEIN-LEHMANN CONTINUOUS CENTRIFUGAL

By P. N. BOYES

Introduction

For a number of years the cane sugar industry has been experimenting with various types of continuous centrifugals. The obvious advantages of lower power, less labour and uniform performance make this type of operation very attractive. At our 1954 and 1955 Congresses two very interesting papers were read dealing with the performance of the pusher-type of continuous centrifugal developed by the Escher Wyss Company of Switzerland. The Hein-Lehmann continuous centrifugal is another type which has been tested by a number of sugar mills in Natal during the 1956 season. Although results were not up to the standard required of A and B sugars, the machine is nevertheless very interesting owing to its simplicity of construction and ease of operation and may find industrial application in other operations such as fore-curers of C massecuites or in the refinery affination process.

Description

The Hein-Lehmann continuous centrifugal is manufactured in Hamburg, Germany. It has been tested in the beet sugar industry, but as far as can be ascertained never on cane sugar. The first machine to be introduced in South Africa was tested at Huletts S.A. Refineries Ltd. during the beginning of the 1956 season. This machine was re-installed at Amatikulu and a further two erected at Doornkop and Tongaat respectively.

The principle of the machine is very simple. It consists of a vertical truncated cone 5½ inches in diameter at the bottom and 23½ inches at the top. The angle of slope was determined experimentally to keep the sugar layer in balance with the discharge component of the centrifugal force, or in other words, the sugar which is still on the discharge panel will not be discharged when the inflow of massecuite is stopped. The cone is underdriven by a 35 h.p. motor. By a selection of pulley sizes it is possible to run this model at three speeds, 1500, 2000 and 2600 r.p.m. The principal feature of the machine is the screen which is made by a special process enabling the smallest screen size to have slots 0.09 mm. width. Wash could be separated from green syrup by means of a conical baffle, but in the actual trials this baffle was removed and wash and greens allowed to mix.

Mechanically the machine is most attractive. It was never run for more than four hours consecutively, but in all the trials it gave no trouble. The saving in electrical power must be considerable as the current remained steady at 15–20 amps with a grid voltage of 550v. After a time it was noticed that the molasses gutter began to clog up, causing some molasses to drip over the bowl and mix with the sugar. This appeared to be the chief mechanical disadvantage.

In Fig. 1 is given a sketch of the centrifugal and all the relevant parts are detailed. Fig. 2 shows the centrifugal in operation, and Fig. 3 gives a view looking down from above into the conical bowl, while Fig. 4 demonstrates the construction of the centrifugal basket.

Test-Run Procedure

It was reasoned that the Hein-Lehmann would probably be most successful on A sugars and for this reason the machine was installed alongside the A battery. The feed hopper to the Hein-Lehmann was separate from the feeding trough to the A centrifugals and was calibrated to enable accurate determination of massecuite throughput to be made. The A centrifugals were $8 \times 40'' \times 24''$ basket 1500 r.p.m. electrically-driven Pott-Cassels machines. Sugar output was determined by deflecting all the sugar onto a canvas sheet and weighing in bags on a platform scale. Samples of molasses, sugars, etc., were collected every fifteen minutes and as the normal run was one hour this gave a composite of five samples each.

The mother liquor purity of the massecuite was determined with the Nutsch Apparatus. This is an important figure, as from it can be gauged the loss of sugar due to steaming and small crystals penetrating the centrifugal screens. Another important figure, especially for C massecuites, is the viscosity of the molasses. This was determined with a Hoeppler Viscosimeter borrowed from the S.M.R.I. and gives the viscosity direct in centipoises. In order to assess the destruction of grain due to the abrasive action of the centrifugal, the specific grain size was compared with the SGS of the A battery as standard. The method for this determination is fully described by Douwes Dekker in the 1952 S.A.S.T.A. Proceedings, page 46. For C sugars the procedure was slightly changed to giving a preliminary wash in saturated sucrose solution. The latter results shew crystals on the large side as some agglomeration could not be prevented.

It was intended to use hot water as the principal purging agent and for this reason a water meter was installed for accurate measurement of quantity. It was soon discovered, however, that with the sugar only remaining in the basket for three to four seconds, the hot water had insufficient time to purge and only produced a wetter sugar. It was found that steam gave a better result and by producing a relatively drier sugar gave a somewhat higher pol. This will be discussed in more detail during the discussion of results.

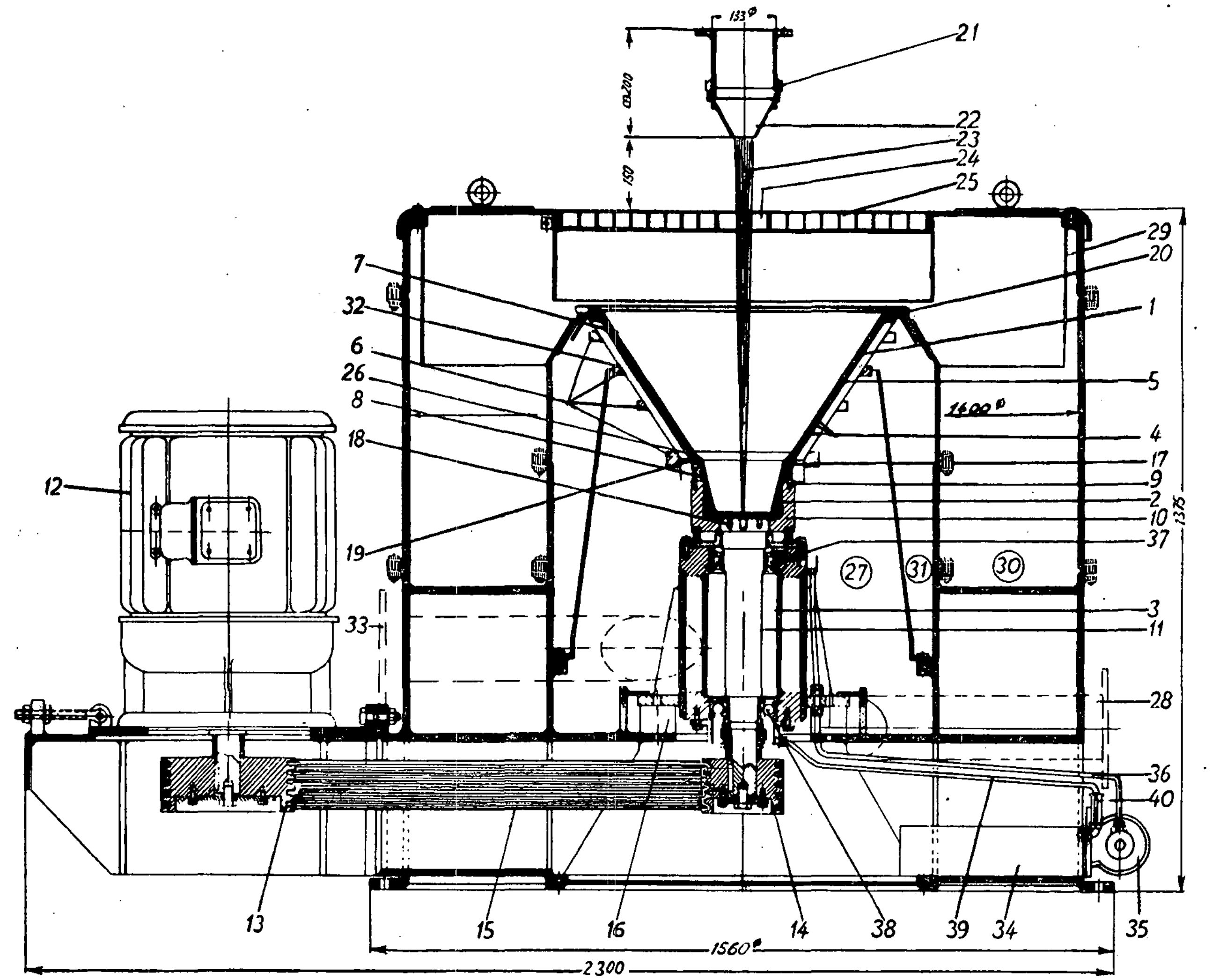
The results obtained above were used to compare the performance of the Hein-Lehmann against the standard centrifugal. Although this comparison is not strictly accurate as conditions on the two sets were never identical, with regard to G factor, washing and throughput, it nevertheless enabled a practical assessment of the new machine. Some of the test-runs were inevitably of short duration due to the conditions and time available.

Discussion of Results

(1) *A Sugars* (For results refer to Table I)

Before any official test-runs were carried out, the machine was started up at 2,600 r.p.m. and 0.09 mm. screen. The wash arrangement consisted of a single ring at the bottom of the cone containing four holes of $^{1}/_{64}''$ diam. These small apertures scarcely gave

Fig. 1: SKETCH OF CENTRIFUGAL



1. Conically shaped screen
2. Accelerating device
3. Driving system
4. Grooved drum of screen basket
5. Ring system supported by 16 triangular ledges
6. Four holding rings
7. Slit screen
8. Connecting screws
9. Set pins
10. Conical top
11. Shaft
12. Motor
13. V-belt pulley
14. V-belt pulley
15. V-belt
16. Rubber blocks
17. Conical ring
18. Counter sunk screws
19. Rubber cord
20. Clamp ring
21. Ring of heating pipe
22. Inlets of various nozzle sizes
23. Massecuite flow
24. Centre hole
25. Grid
26. Beginning of screen
27. Greens discharge space
28. Tangentially placed discharge pipe for greens
29. Rubber wall
30. Solids space
31. Wash discharge space
32. Conical separating baffle
33. Tangentially placed discharge pipe for wash
34. Oil container
35. Electric oil pump
36. Oil pipe
37. Upper cylinder roller bearings
38. Lower roller bearings
39. Return oil pipe
40. Sight glass

any washing effect. The first sugar produced was smashed to a powder by the rasplike action of the screen. The medium speed of 2,000 r.p.m. was next tried and this also destroyed the grain structure.

The first test-run was therefore carried out using the lowest speed of 1,500 r.p.m. and a larger screen size of 0.25 mm. Although there appeared to be little grain destruction, the pol of the sugar at 96.1° was far too low and moisture too high. Obviously the sugar was not being properly purged.

For the second test-run the holes in the ring were increased to eight of $^{1}/_{32}''$ diam. and after finding that purging with water merely produced a wetter sugar, steam was used.

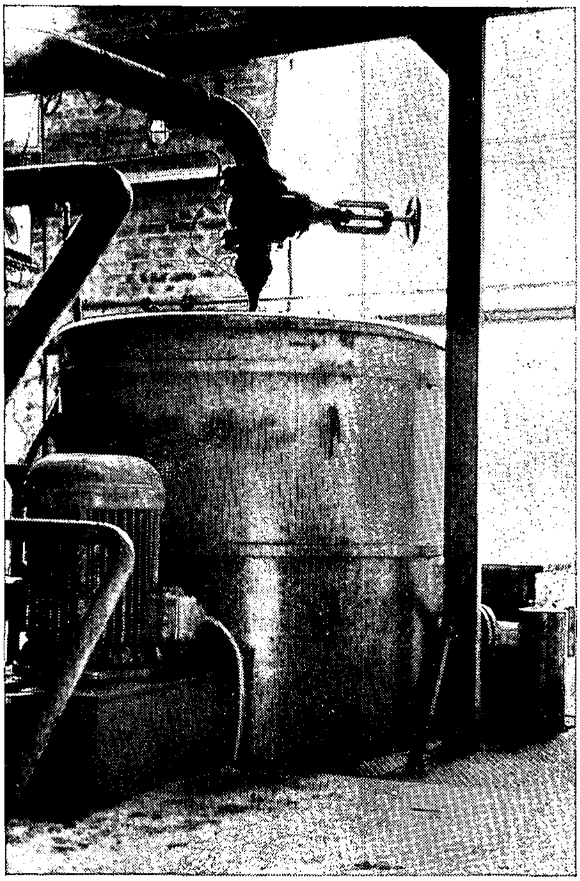


Fig. II: CENTRIFUGAL IN OPERATION

It was realised that the low speed produced insufficient centrifugal force to purge the molasses, so in the third test-run the medium speed of 2,000 r.p.m. was used. The massecuite was diluted with water giving a low viscosity molasses. The washing arrangements were changed. A second ring was installed. The bottom ring of eight $^{1}/_{32}''$ holes being used for water and the top twenty-four $^{1}/_{32}''$ holes for steam. It was soon found that even a trickle of water produced a very wet sugar and it had to be shut off. The saturated steam had its effect and increased the sugar pol to 96.6°. However, the crushing action at this speed was considerable. Small particles of crushed sugar were flung to the walls of the machine, where they collected on a rubber apron to form long slabs of crushed sugar. These finally dropped onto the shaker beneath and analysing these lumps gave pols of 93.5° and 94.1° for test-runs 4 and 5. We avoided collecting these lumps in the sugar sample and therefore the specific grain size would be determined without containing some of the fine crushed sugar produced. Nevertheless, results indicated severe crushing. The pol of 96.6° and moisture 1.30 per cent at a throughput of 5.1 tons massecuite per hour was far from satisfactory.

The fourth test-run could best be described as an attempt to see how much the machine could take. The higher throughput of 8.4 tons per hour massecuite gave the best results to date 96.9° pol, 1.05 per cent moisture, but still with considerable crushing. Due to the feeding arrangement this proved the maximum flow rate that could be attained.

Our final test-run on A sugars was an attempt to dry out the crushed grain sufficiently to prevent caking. A preliminary trial was carried out using an air hose at the top of the basket—this had no visible effect. We next demonstrated that if a series of air jets were impinging downwards on the rubber apron it could be kept free of build-up. We next reasoned that if an additional ring of superheated steam were placed three-quarters of the way up the bowl containing twenty-four $^{1}/_{32}''$ holes this might promote drying of the sugar. The sixth test-run using two rings of superheated steam showed a slight improvement but still far from satisfactory.

Quite clearly a speed of 2,000 r.p.m. remains insufficient to purge A sugars while the crushing action and grain destruction are considerable. The sugar remains very wet, over 1.00 per cent moisture compared to 0.4 easily obtained by the conventional machines. A drier would therefore be an essential.

(2) *B Sugars* (For results see Table II)

Due to the difficulty of curing B sugars on the A set, only two trials were carried out.

In the first trial water was initially used but produced a sugar which was too wet and subsequently only steam was used. Viscosity of the molasses was much higher than for A sugars as was to be expected, but what was a surprise was the reduction in the crushing of the sugar. The more viscous molasses appeared to act as a lubricant for the sugar crystal. The pol was extremely poor at 94.2° and 2.25 per cent moisture.

Since there was not appreciable break-up of sugar at 2,000 r.p.m. although slabs of sugar were still forming continuously and dropping into the shaker, it was decided to carry out a second test-run at the same throughput of 3.4 tons per hour massecuite and at the top speed of 2,600 r.p.m. The increase in speed did improve the pol somewhat to 94.8° and 2.50 per cent moisture and the crystals were not appreciably destroyed.

(3) *C Sugars* (For results see Table II)

Reports from Amatikulu and Doornkop indicated that there was a possibility of using the machine on C massecuites. Our set-up was such that the Hein-Lehmann would have to be hand-fed by carrying across buckets of third massecuite from the crystallizers. We reasoned that the process would take so long that the massecuite would be cold by the time sufficient had accumulated to carry out a trial. A steel heating coil of approximately 66 feet in length and 1 inch in diameter using hot water condensate from the first effect of the quads proved very successful and enabled massecuite to be reheated to any desired temperature.

The season was coming to a close and the process of liquidating third massecuites well advanced. The massecuites were therefore being cured hot without the normal time for crystallizing. The trials could therefore not be considered representative of normal operation.

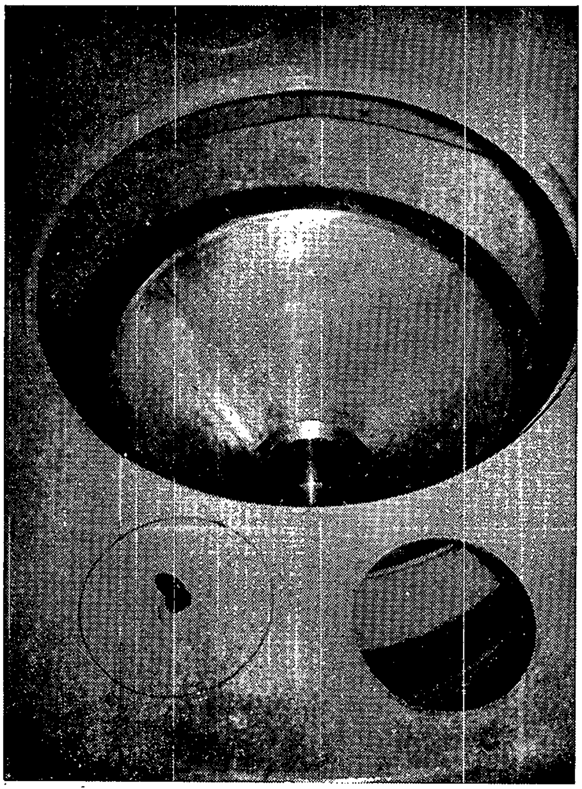


Fig. III: VIEW OF CENTRIFUGAL FROM ABOVE

In all, six test-runs were carried out and it was found that the maximum throughput was 2.5 to 3.0 tons per hour massecuite. At higher throughputs the sugar became black with unpurged molasses.

The first two test-runs were carried out on the same massecuite at two throughputs. Surprisingly, the higher throughput of 3.14 tons per hour gave equal results to the lower at 1.14 tons per hour. The pol was very satisfactory but the molasses purities of 50.0 and 49.9 with the Nutsch at 43.8 indicated sugar passing through the screen. Since the screen size was 0.25 mm. all subsequent trials were carried out with a screen of 0.09 mm. This massecuite had been diluted with water and with a reheating temperature of 60°C it is possible that sugar was dissolved. The very low viscosity of the molasses, 1330 centipoises, is virtual proof of the above.

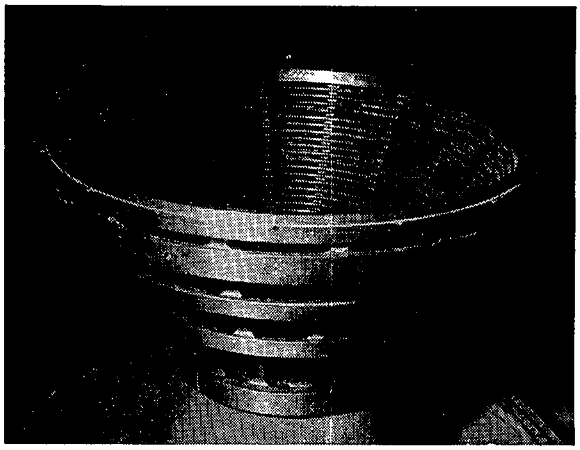


Fig. IV: CONSTRUCTION OF CENTRIFUGAL BASKET

In test-run No. 3, using the 0.09 screen and processing an undiluted massecuite reheated to 54°C, it was found that the Hein-Lehmann gave a superior performance to the C set—44.8 purity molasses and 90.7° pol compared with 46.9 and 90.0° pol respectively. It will be noted that the viscosity of the molasses of this undiluted massecuite was 15,200 cps., nearly fifteen times as viscous as the massecuite in experiments 1 and 2.

When considering the results in experiment 3, it must be realised that the C set was struggling to cure massecuites at about 45°C and some grain was passing through the screens. Therefore, in experiment 4 it was decided to reheat to 45°C and cure the massecuite at a comparable temperature. The result was very much in favour of the C battery, 91.0° pol against 86.4° and 44.2 purity molasses against 44.8. The moisture of the sugars is not important for C sugars. The viscosity of the molasses was 44,600 at 45°C and 11,350 at 60°C, clearly indicating that reheating temperature is vital in reducing viscosity.

Test-run No. 5 was an unfortunate test-run in that an exceptionally viscous massecuite, obtained by re-boiling final molasses with syrup, was cured. This massecuite was reheated to 50°C and was so viscous that it dropped out of the feed nozzle in large blobs which hit the bowl with a crack like thunder.

The bowl began to get into a wobble and the machine was just shut down in time. This experience is a warning if the machine is used in the future. Water had to be added to the massecuite and reheating continued for two hours using both the hot-water coil and open steam line. The resulting viscosity of 282 cps. is mute evidence of this. The results of this test-run when compared with the C set were surprisingly better. Needless to say the C machines also had considerable trouble curing the massecuite.

The final run, No. 6, was more or less a repetition of No. 3, reheating to a slightly higher temperature of 62.5°C. The resulting sugar had a higher pol than the C set, 89.2° against 88.4°.

Conclusions

For A sugars the reasplike action of the screen caused serious crushing of the grain at speeds required to purge the massecuite successfully. Coupled with this was the fact that washing and drying had to be accomplished in a matter of three to four seconds. The wash medium must be finely atomised and for this reason wet steam was preferred to water. Superheated steam was used as a drying agent with some success in a few of the experiments. In all experiments the moisture content of the sugar remained high.

The same results were found for B sugars although the crushing action at the top speed of 2,600 r.p.m. was not so great. The sugar was still found to be insufficiently purged and too wet.

The results for C sugars were encouraging and a machine may be developed which can handle C massecuites successfully. It must be remembered, however, that the continuous centrifuge was compared with a set of centrifugals which had inadequate reheating. Although the moisture content of the C sugars is not of great importance when the sugars are being used as a footing for A and B sugars, it has the effect of reducing the pol and gives the impression of low purging efficiency.

Acknowledgments

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Maidstone
February, 25th 1957

TABLE I

Trials on Hein-Lehmann Continuous Centrifuge — A and B Sugars

	A Sugar	*A Sugar*	*A Sugar*	*A Sugar*	*A Sugar*	*A Sugar*	*B Sugar*	*B Sugar*
	1	**2**	**3**	**4**	**5**	**6**	**1**	**2**
MASSECUITE								
Temperature °C	56	53	61	60	53	60	60	61
Brix...	93.7	91.6	93.2	93.0	93.7	93.3	94.5	95.3
Purity	86.8	88.2	87.0	88.4	87.6	87.0	73.4	74.6
Throughput—FT³ /HR	79.6	140.0	108.5	181.0	124.5	99.0	73.0	73.5
TNS/HR	3.7	6.5	5.1	8.4	5.86	4.6	3.4	3.4
NUTSCH								
Purity	68.4	71.1	69.6	70.0	70.1	68.7	53.2	52.2
MOLASSES								
(1) Hein-Lehmann								
Purity	70.1	72.6	73.5	71.8	71.2	71.2	56.0	52.2
(2) A Set Fugals								
Purity	69.2	72.3	69.2	71.0	70.6	69.8	55.5	—
SUGARS								
(1) Hein-Lehmann								
Moisture per cent ...	1.20	1.28	1.30	1.05	1.24	1.10	2.25	2.50
Pol...	96.1	96.0	96.6	96.9	96.6	96.8	94.2	94.8
Specific grain size	0.93	0.80	0.72	0.81	0.93	0.74	0.88	0.68
Throughput T/HR ...	1.98	3.69	2.76	5.46	—	2.31	—	1.53
(2) A Set Fugals								
Moisture per cent ...	0.30	0.46	0.40	0.40	0.38	0.40	0.70	0.70
Pol...	98.2	98.4	98.3	98.6	98.3	98.3	97.9	97.9
Specific grain size ...	0.97	0.85	0.85	1.00	0.93	0.90	0.80	0.64
MOLASSES VISCOSITY (Centipoises)								
At temperature of curing ...	500	540	332	368	815	309	2360	2380
A 65°C	450	276	269	—	363	247	—	1820
Nominal screen size (mm.) ...	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Nominal speed (r.p.m.)	1500	1500	2000	2000	2000	2000	2000	2600

TABLE II

Trials on Hein-Lehmann Continuous Centrifuge — C Sugars

	1	2	3	4	5	6
MASSECUITE						
Temperature °C...	60.0	60.0	54.0	45.0	65.0	62.5
Brix	95.6	95.6	97.5	97.8	98.2	97.2
Purity...	68.0	68.0	64.1	64.4	61.3	62.4
Throughput—FT³ /HR	24.5	65.6	50.5	49.6	55.0	60.0
TONS/HR...	1.17	3.14	2.41	2.37	2.63	2.88
NUTSCH						
Purity...	43.8	43.8	43.4	42.2	44.2	47.0
MOLASSES						
(1) Hein-Lehmann						
Purity.	50.0	49.9	44.8	44.8	46.9	47.6
(2) C Set Fugals						
Purity.	46.7	46.7	46.9	44.2	46.4	—
SUGARS						
(1) Hein-Lehmann						
Moisture per cent	2.05	1.95	2.40	3.60	3.29	3.09
Pol	92.4	92.4	90.7	86.4	83.3	89.2
Specific grain size	0.45	—	0.52	0.61	0.52	0.43
Throughput T/H	0.44	1.04	0.88	—	—	—
(2) C Set Fugals						
Pol	90.4	90.4	90.0	91.0	81.4	88.4
MOLASSES VISCOSITY						
At temperature of curing...	1330	1330	15,200	44,600	—	8,400
At temperature indicated	1100 (65°C)	1100 (65°C)	9,340 (60°C)	11,350 (60°C)	—	6,650 (65°C)
Nominal screen size (mm.)	0.25	0.25	0.09	0.09	0.09	0.09
Nominal speed (r.p.m.)	2600	2600	2600	2600	2600	2600

The Chairman, Dr. K. Douwes Dekker, stated that he thought it was a good thing to have results of actual tests of machines at the factories.

Mr. Beesley inquired if Mr. Boyes had any idea of the amount of crystal crushed, as he though it might be possible to separate such crushed sugar in the form of lumps, and return it to process.

He also said that he would have liked to have known the brix at which the molasses viscosity determinations were carried out, as he wished to compare them with figures he had for Illovo molasses.

Mr. Boyes replied that he had the brix figures and they were available to Mr. Beesley. In the determination of viscosity with the Hoeppler instrument there was no difficulty in determining the viscosity of A molasses, but with C molasses which contained a lot of air this was difficult, so it was heated and a vacuum applied to try and draw off as much air as possible. He did not think they were particularly successful in this and the figures were probably not very accurate. The Hoeppler machine was perhaps not the best to use to determine viscosity of molasses. The figures did indicate, however, how viscosity could be reduced by re-heating. As far as crushing was concerned he had shown that a smaller grain size of the sugar put through the continuous centrifugal as compared with the normal type of machine. As the sample sugar was taken avoiding the large slabs it would be appreciated that much of the crushed sugar was not sampled. It was therefore not possible to estimate with accuracy the amount of crushed sugar.

Dr. Van der Pol pointed out that there appeared to be an error where the viscosity of massecuite was given. The Hoeppler apparatus was quite unsuitable for determining this.

Mr. Boyes replied that all viscosity determinations referred to the appropriate molasses.

Mr. Leclezio said that if the C sugar from the continuous machine were used as a footing for A or B massecuites the crushed grain would cause a considerable amount of difficulty in the pans.

Mr. Boyes said that he considered that the crushed grain would cause difficulty, and each footing would have to have this grain dissolved in the pan by feeding on water before boiling could continue.

Dr. Douwes Dekker enquired Mr. Boyes' reason for considering such a machine could be used in the affination stage in the refinery.

Mr. Boyes replied that provided the screen size was such as to prevent loss of crushed crystals and bearing in mind that the fine sugar was almost immediately melted, he considered that the machine has possibilities for affination.

Mr. Elysee said that they had carried out extensive tests at Amatikulu with this machine and could bear out all Mr. Boyes had written about it. He said that various alterations were made to the machine, for instance using a .09 millimeter screen practically no sugar had escaped but with larger holes quite a lot of small crystals got through. However, to sum up, the performance of the machine was not all that could be desired in that the pol was too low and the moisture too high. One point that struck him about the machine was that it was possible to apply water, reducing the molasses brix right down to 70 without any sign of sugar being dissolved. Another striking feature was the machine was run for a period of an hour without any attention whatsoever. He quoted figures for molasses purity and throughput of sugar.

Mr. Thumann said that it was generally accepted that the crushing action was caused by friction of the crystals over the screen and also by the force with which the sugar was ejected from the basket. He wondered if the basket instead of being a plain conical shape were made more parabolic the speed of ejection from the machine might be reduced. He understood that the liners were produced by a photographic process and he wondered if the edges of the slots were not too sharp. He questioned whether the machine had been developed to a really practical stage as yet.

Mr. Lax wanted to know if any indication of the power required was obtained.

Mr. Boyes said he could not state exactly but it appeared to be very low.

Mr. Leclezio asked if any Escher-Wyss machines were in operation in South Africa, and if the users were satisfied with them.

Dr. Douwes Dekker said the machine was in operation at Illovo.

Mr. C. L. Wagner said that the machine was used at Illovo purely on affination.

The Chairman said that as this centrifuge had a number of good points he trusted that the information given by Mr. Boyes would be of value to the manufacturers so that they could eventually develop a machine to the point where it was completely successful.