The Milling — Diffusion Process of Sugar Cane Juice Extraction and "Naudet" Circulation.

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With notes on Cane Diffusion and on the Sugar Industry in Egypt.

(Mr. G. T. MacDonald in the Chair)

The writer has long felt that Milling — Diffusion of Sugar Cane deserves much wider attention than it has generally received hitherto. Whilst serving in and near Egypt during the late war, the writer was privileged in being allowed to visit all the sugar factories of that country. Personal observations made on the spot and up to date data since kindly furnished from Egypt have further convinced him that the process is remarkedly efficient and well worth further study.

Egypt is certainly the only country where the three chief processes of extraction of sugar cane juice are practised,

(a) Normal Milling with imbibition.

(b) Milling — Diffusion.

(c) Diffusion of cane chips or "cossettes".

The first is universally used and needs no comment. This paper deals with the second process and its modern, extensive application in Egypt.

The third process (c) has been tried in various countries — notably by Prinsen Geerlings and Hamaker in Java — and abandoned. The usual reason was the difficulty encountered in obtaining a suitable and efficient machine for slicing the cane chips. The subsequent diffusion was and is also a lengthy process and the resultant bagasse not easily dried. However, this method has not yet been thoroughly explored in the light of present day knowledge and still offers scope for research. It is carried on at present at only one factory — so far as the writer is aware — that of Cheikh Fadl, Egypt — one of the five sugar factories in that country. The plant still exists and has been used of recent years in the Madeira factory of Wm. C. Hinton & Co. Ltd. (This factory is also unique in that it stands in the centre of a town, cane being fed to the mill over the roof tops by aerial ropeway). It is proposed to devote a little time to a few notes on the Cane Diffusion process because it was this which led to the highly developed Milling — Diffusion method now in use in Egypt. After abortive experiments in Java, Spain, Mauritius and Louisiana, it was given a trial in Egypt, towards the end of the last century. Its success here was only achieved by the perserverance in the face of bitter criticism, of that famous figure in the sugar world of that day, M. Henri Pellet. By 1896, this method was in use at two factories in Egypt, each capable of processing 3,000 tons daily. In practise, the figure averaged 2,500-2,700 tons per day of twenty-three hours. In 1902, the operating data was — Loss in Total Extraction (up to Evaporators) 0.35 to 0.5% only. Diffusion Water 18% on Cane only. Extraction — 96.5%.

Each factory had three diffusion batteries, each fed by six cane slicing machines, and eighteen diffusion cells to each battery, making a total of fiftyfour, each 91 H.L. capacity (321.5 cu. ft.). The phenomenon of Osmosis is much slower in cane than in sugar beet, the construction of the cells being entirely different. It follows that the period of contact and number of "mashings" is thus longer, which explains the great size of the diffusion batteries. With good cossettes or slices, of elliptical section and of consistent thickness, the optimum operating figure was 50 Kg. per H.L. of capacity (or 38.9 lbs./cu. ft.) giving 96-98 litres of juice % Kg. of canes (215-22 gallons % tons), with negligible sucrose loss in final bagasse. This process, extracting more juice than any mills then in use, also gave a higher purity juice. At that time the Nag Hamadi factory — the second one so equipped — had been remodelled by French engineers. The factory was completely electrified, including Steffens lone canecutter drives, double carbonation, thin juice sulphitation, a sextuple effect evaporator with seven vessels (one extra as preheater) of the horizontal Littie type — 14,000 tubes and 28,000 rubber joints to dismantle yearly. This factory then produced white sugar. It operated successfully and with various improvements for a few years, but there were many difficulties, which steadily became worse. Drying the bagasse at the nearest suitable place, a piece of desert land of 200 Hectares area (494¼ acres), some Km. (6.2 miles) from the factory, was not the least. No near location was available. Although this factory, technically was twenty years ahead of most others, local conditions and antipathy also helped towards the eventful abandonment of the process. Sucrose total losses were still averaging only .4% as against 1.1-1.2% of milling factories. As other factories became more mechanised and efficient, it was realised that the unsatisfactory and expensive nature of the cane slicing machines was a most undesirable feature. They entailed considerable hand work — canes had to be carefully placed on the feeding tables, in small quantities. Each revolving horizontal slicer carried twelve knife boxes. These had each to be changed for sharpening every four hours. The quality of the steel comb knives varied and caused many a delay. To maintain the knifing gap consistently (between 2 and 2.5mm.) entailed constant supervision, as the gap had to be varied to suit thickness of canes. The slightest relaxation of vigilance here at once had its effect in the diffusion battery. Defecation was carried out in the battery — Milk of Lime being added in the third vessel of each battery. The circulation in the batteries was considered perfect and the formation of reducing sugars was almost nil. One has to realise that the operators of this diffusion were all able, French-trained men, as it had originally been the intention of the company to operate Nag Hamadi and Cheikh Fadl also as beet sugar factories — the beet campaign to follow the cane season. Beets were cultivated with great perseverance but were hopelessly infected by nematode and other worms and it is no longer practicable to grow beet in Egypt. Hence the presence of the diffusion batteries and slicers in the first instance and also the decision of the operating Co. to persist in the cane chips Diffusion process in order to justify their expenditure in a cane beet factory. *A double Decauville rail track removed the bagasse from beneath the diffusion cells at 88-90% moisture. Attempts were made to dry the bagasse in "HUILLARD" vertical towers, fitted with flights. Bagasse fed from the top, cascaded downwards, meeting flue gas, projected up from the base. This was eventually abandoned, as it powdered the bagasse so much as to often render it useless as fuel. Six such towers were required for the bagasse from 2,700 tons cane per day. The drying area too was a source of loss and expense. Some 600-800 men were employed here, turning over the vast expanse of drying trash. During the cold nights of December, January, and February, over 15% of the available bagasse was lost, by being consumed in the many braziers kept going by these men. The bagasse was dried for from seven-fourteen days, depending on climatic conditions and returned to the boiler house at 20% moisture.

When about twenty-five years ago a different cane variety was introduced from Java by M. Henri Naus Bey — POJ 105, although eminently suitable for Egypt, proved too much for the cane slicing machines. Thus, the process was abandoned at Nag Hamadi and was only continued on a reduced scale at Cheikh Fadl, it is still in use. In 1926, Nag Hamadi was completely remodelled for Milling — Diffusion process, and the diffusion batteries enlarged. This will be described later. The capacity of existing Abou Kourgas factory was also increased, working the same process since 1904.

Two Factories in Egypt.

Milling — Diffusion:	*Abou Kourgas*	*Nag Hamadi*
Max. daily capacity (23 hrs.)	5500 tons	3040 tons (long)
Average — last crop (tons of 2240 lbs.)	4315 tons	2847 tons per day

Each factory has two tandems of mills and diffusion batteries.

Diffusion cells, of 90 H.L. (approximately 318 cu. ft.) capacity, are now fitted with hydraulic mechanical discharge doors. The two "pre-diffusion" mills of each tandem are both preceded by revolving knives on the main carriers. Each tandem has two pre-diffusion mills, 900 x 2000 mm (35½" x 78") by CAIL, which crush the cane dry, no imbibition being used or necessary. These mills extract at most 65% of the juice, although no effort is made to maintain or increase this figure, so long as the mills effectively reduce the cane, which is well prepared by the knives and shredders. The bagasse then enters a bucket elevator which takes it up to the rake conveyor feeding the diffusion cells, through chutes in the usual beet factory fashion. Strictly speaking, and as some of the cane cells have already been ruptured in the mills, the process is not 100% diffusion, although diffusion does occur. Lixiviation would be a more suitable term, although "Milling — Diffusion" is the universal appellation which will be also used here. The process in Egypt may be regarded as being extremely efficient, numerous modifications having been embodied and improvements effected. I should mention that the process was first introduced on a large scale at Abou Kourgas in 1904, being entirely remodelled in 1926 at the time of the new installation at Nag Hamadi, in the light of the twenty two years experience obtained in operating it. The initial juice from the mills is measured, tempered with milk of lime, heated and pumped to reception tanks. Both factories have the unique "forced circulation" installation, invented by NAUDET. Each factory has twentyone diffusion cells to each tandem, making fortytwo to each plant. Those at Abou Kourgas are of 90 H.L. (approximately 318 cu. ft.) capacity and at Nag Hamadi 95 H.L. (335.6 cu. ft. approximately). Taking one cell at random in the diffusion battery, its successive operations are as follows. It is filled with bagasse from the first mills, during which operation milk of lime is added in several small doses to temper the juice still contained in the bagasse. Each cell has its own small individual milk of lime tank, fed by ring main from the main tank. When the cell is half full of bagasse, a quantity of juice — already tempered and at high temperature — from the reception tank is admitted and the filling with bagasse completed. This quantity of juice corresponds roughly to that originally extracted from the cane, to which it is now added. Thus, the bagasse and the juice in the cell, as it were, re-constitute integrally their initial amount of cane but in the most ideal form for diffusion. The cell filled, it is closed and juice allowed to flow by gravity from the "compensator tank" into the bottom of the cell and to rise through the column of bagasse until it emerges through a small cock on the lid of the cell, which cock is then shut. The air contained in the bagasse is thus removed. The compensator tank is continually being made up with juice coming from the last cell of the series undergoing ordinary diffusion, the balance of such juice being diverted to the measuring tanks. This "mashing" process completed, the cell is next put on to the "NAUDET" circuit. All parts of this circuit are full of hot juice at the moment the Naudet "forced circulation" starts to operate. A pump takes juice from the compensator tank, forces it through the heaters and then through the cell from top downwards and again into the pump suction. This cycle is repeated for a short time. During this process, the juice passes through the cell several times, each time having been previously heated under pressure to 105°C. (221°F.). The tall column of the bagasse affords a most efficient filtering medium and the juice after its repeated passage finally leaves the cell, bright and

* There are still four Cane/Beet factories in the Malaga area of Spain.

clear. It requires no further treatment and goes direct from the diffusers to the evaporators, passing only over a fine screen to remove entrained bagacillo.

The "Naudet" process completed and juice drawn off, this particular cell is linked to the next in the regular diffusion battery and the next cell newly filled with fresh bagasse is then switched over from diffusion to "Naudet" circulation. In this manner each cell in turn goes through the process prior to forming a unit of the series undergoing diffusion proper. This diffusion is of exactly the same nature as that carried out in a beet sugar factory, each cell being equipped with a caloriser.

The juice coming from the last cell of the regular diffusion series is sent into measuring tanks and thence to the evaporators. The exhausted bagasse is discharged on to a strainer carrier over a concrete pit. The carrier feeds directly the last two mills, in series, used solely for pressing the bagasse to a suitable degree of moisture content, for combustion. The liquid expressed by these mills — "les eaux de moulinage" — together with that collected in and pumped from the strainer and pit below the diffusers is used to make up the diffusion water, while the sediment is screened and settled off, being returned to the land eventually, as or with fertilizer.

It will thus be seen that the "Naudet" process of bagasse diffusion combines the three processes of extraction, filtration and purification of the juice.

It is obvious that the process entails a Milling — Diffusion house of considerable length, from rough estimation by the writer on the spot, about twice the length of the average milling house for a normal milling factory of like capacity. Width however, was no greater than that of a factory operating two milling tandems of 36" x 84" mills, bearing in mind that Abou Kourgas and Nag Hamadi each operate two tandems of mills and diffusion batteries. This inordinate length of mill house however, is well compensated for by the fact that this process entirely dispenses with Defecators, settling tanks or subsiders, clarifiers of all types, filter presses — with their attendant troubles and expense of cloth etc. — rotary or vacuum and other forms of filters or sulphitation plant. The process may sound somewhat complicated, but in practice it works quite smoothly, as in a beet sugar factory. Normally the juice can be circulated through the entire battery, including "Naudet" treatment, three times in 7-8 minutes. Filtration is considered perfect during the process — after many years experience of it — also the losses, known and unknown, inseparable to the other stations necessarily interposed between mills and exaporators in a normal factory, are avoided. To obtain similar results from a normal milling factory would, of course, require an abnormal and uneconomical number of mills in the train, high imbibition rate with lower purity final mixed juice.

The double, strictly controlled liming employed works out at 1 Kg. of Lime per long ton of cane or 0.98% on cane. From crusher(s) to first body of evaporators requires average time of thirty minutes.

Details of the Industry and Factories in Egypt.

For many years, the present company — Societe Generale Des Sucreries et de la Raffinerie d'Egypte has been permitted by government to enjoy the monopoly of sugar manufacture in that country.

There are five factories and one refinery, particulars being as follows:—

All five factories are situated well down the Nile, in the flat, fertile cane growing areas of upper Egypt. Irrigation is universal.

Type.	Name.	Max. Daily Capacity.
Milling—)	Abou Kourgas	5500 long tons 2 tandems.
Diffusion)	Nag Hamadi	4315 long tons 2 tandems.
Normal)	Komombo	5310 long tons 2 double crushers
Milling)		2 tandems of 15 roller mills.
Factories)	Ermant	4350 long tons Double crusher 15 roll mill.
Cane Chips)	Cheikh Fadl	*1500 long tons 12 cutting mills.
Diffusion)	Total available cap.	20795 long tons per day.

Abou Kourgas and Komombo have double two-roll crushers with Maxwell Shredders to each tandem i.e., four at each factory. The others have single two-roll crusers also with Maxwell Shredders. All are of Krajewski pattern. MacNeil patent grooving on all mill rollers. All mills — except primary mills at Nag Hamadi one of which dates from 1868 — are of modern design and all are electrically driven. 90% of all drives in the factories are electrified. Mills are of CAIL or FIVES-LILLE (French) manufacture.

Averages final bagasse 49% moisture.

A significant factor in favour of Milling — Diffusion is in Horsepower required. Milling factories require 0.48 H.P. per ton cane.

Evaporators are modern in design and application, pre-evaporators supplying steam to 1st. pans are in use. Most evaporators made by Fives-Lille, some by Cail & Gilain. Nearly all the remainder of the plant in each factory is by Cail or Fives-Lille. Watson-Laidlaw electrically driven centrifugals, were seen in one factory, also crystallisers and other units by Skoda-Verk, Prague.

Distillery plant (mostly alcohol) is largely by Pingris-Mollet-Fontaine, Fives-Lille or Cail. Raw sugar is loaded direct into Nile feluccas or into E.S.R. box cars, as convenient.

All the factories are well and spaciously laid out. Tiled floors abound in sugar houses and elsewhere.

* This capacity of Cheikh Fadl is not fully utilised.

Considering the type of labour available, the factories are clean, sanitary and well kept, with pleasing surrounds and housing estates.

Maximum grinding rates for 1948 Crop, were as follows:—

Abou Kourgas	230 tons per hour)	(tons of 2240 lbs.)
Nag Hamadi	187 „ „ „)	Milling-Diffusion process
Komombo	216 „ „ „)	Milling factories
Ermant	180 „ „ „)	

Messchaert groves used in all mills.

At Abou Kourgas, the two subsequent "pressing mills" of each train or tandem, following the diffuser, are of Cail manufacture, 900 x 2000 mm. (35½" x 78¾") dating from 1868, but modernised as to hydraulic loading in plase of toggles. These are each followed by a Fulton 36" x 84" mill, both of which were installed in 1944, by special arrangement with the U.K. and U.S.A. governments as to export, import and shipping. This set-up is entirely satisfactory, yielding a final bagasse of average 50-52% moisture, which, is excellent for combustion and compares well with bagasse from a normal straight milling train. Actually, the writer was informed, this is the most desirable figure of moisture content, the bagasse being somewhat finer than that from the usual train of mills. Hence, it is inclined to become powdery if drier, and to clog if wetter. It consistently produces an average of 20 Kg. of steam per square metre of heating surface (or 4.1 pounds steam per square foot of H.S.).

Laboratory figures, averages for 1947-1948 Crop.

Abou Kourgas Factory:

Average daily grinding and diffusion rate — 211 long tons/hr. % sucrose in cane — 12.7, fibre % 11.2, purity 83.7. Diffusion draft (soutirage) — 107 litres % Kg. cane or 241 gallons per ton cane — 107% on cane.

Juice Analyses.	Brix.	Sucrose	Purity
Mill juice (1st. & 2nd. Mill)	20.2	16.91	83.7
Diffusion juice	14.7	12.35	84.0
Concentrated juice	53.7	44.81	83.44

Bagasse Analyses.	% Sucrose	% Fibre
Bagasse, after 2nd. pre-diffusion Mill	7.4	33.0
Bagasse, after Diffusion	.84	15.5
Bagasse, after 1st. post diffusion Mill	.74	39.6
Bagasse, after 2nd. post diffusion Mill	.66	45.2

Analyses of "Mill Waters".	% Sucrose
Mill waters ex both post-diffusion Mills	0.66
Losses in Milling-Diffusion process, up to Evaporators, — "Waters" from Mills and cells (not recirculated)	.04
Exhausted Bagasse	.14
Sediment from decantation of "Waters"	.08
Total Losses:—	0.26

Production Figures.	Raw Sugar 1947	Av. 96° — Long tons. 1948
Abou Kourgas	48,800	50,840
Nag Hamadi	43,000	45,000
Komombo	45,800	47,600
Ermant	38,500	40,200
Cheikh Fadl	11,660	12,160
Total 1947 Crop	187,760 tons	195,800 tons 1948 Crop.

Apart from small local sales of 96° Raw and 99° "plantation white" the bulk of this raw production is shipped to the company's refinery, El Hawamdieh, located on the Nile near Cairo, almost opposite Memphis, site of historic tombs and remains. This production could be even higher, but it must be borne in mind that 20-25% of the cane grown is not processed for sugar, but used in small syrup factories, by the growers directly, or sold in the streets by vendors from hand carts. Thus in most towns and villages during crop time, the pavements are littered with rejected bagasse, since every other fellahin (Arab peasantry) one encounters seems to be chewing cane, so purchased. Large quantities are sold for this purpose even in Cairo, far from the cane fields. It is transported there in Arab feluccas, on the Nile. Much of the raw sugar is shipped thus, also and it is a common sight, to see a 100 year old felucca with its huge triangular single sail and clumsy construction, so laden down with sugar as to have only 3" of freeboard.

The refinery is a large, well laid out plant, on clean and modern lines. It is capable of melting about 1,000 long tons per day and runs for 126 hours per working week. Bone Char clarification is used, also double carbonation and sulphitation for certain lower grade sugars. Cube sugar, "coffee cube" — tablet, old fashioned brown, soft, confectioners are some of the many grades of sugar produced, packetted and wrapped.

Refined production in 1948 was 216,500 long tons and in 1948 was 225,520 long tons in which year 29,720 tons of raw sugar were imported and refined also. Most of the refinery plant and machinery is of French and some Belgian origin. The writer did observe, however, two — "Mirrlees" streamflow vacuum pans, also one battery of Watson-Laidlaw centrifugals. Others were by Fives-Lille and Skoda.

Stoving and cutting arrangements for cube sugar were conducted on modern and hygenic lines. In fact the whole refinery plant was a credit to its owners, the more so in a country where working conditions, industrially and otherwise are generally deplorable. Boilers at the refinery are oil fired Stirlings, each apparently of about 30,000 lbs./hour evaporation.

Skilled labour is scarce among the Egyptian Arabs, who are by no means a mechanically mined race. Technicians and factory managers were of French or Belgian origin. Chemists, draughtsmen and the like were of Maltese, Italian or Greek origin. Trade Unions are either non-existent, or completely ineffective. In other respects however, the industry seemed to be on modern thriving lines. Large sums are spent on research, the company having a large and well equipped research laboratory at El Hawamdieh refinery, also excellent drawing office and general engineering facilities both here and at the four chief factories. The writer was very impressed with the efficiency, smoothness of operation and operating results of the Milling — diffusion process. In conclusion, whilst not suggesting that this process could be economically embodied in any existing factory, it is certainly worthy of being given every serious consideration by any concern proposing to extend its factory or to erect a new plant. Its many advantages have already been dwelt upon — such as high extraction, no equipment required between last mill and evaporators and so on.

The term "diffusion" will at once produce objections on the score of vast quantities of water required per ton cane being less than in many maceration factories in Hawaii and less than any Queensland factory using maceration baths between the mills. In all fairness, certain disadvantages have to be allowed for. The somewhat complicated pipe work and valve system requires careful training of the operators, by staff fully conversant with and having experience of diffusion work. It is also questionable whether it would be an economical project to build such a plant at present, no item of engineering equipment having risen so inordinately in price as valves and pipe fittings since 1939 (300 to 550%). Despite this, the weight of steel involved in a diffusion battery is considerably less than that used in the equivalent number of mills; cost is less also, there being but a fraction of the amount of machining and fitting work involved — other than piping and vessels. The results being consistently obtained in Egypt — I venture to suggest — certainly indicate that intensive research on a small or pilot scale should be put in hand at once, by all parties interested in furthering the efficiency, extraction rate and future of our industry.

Even if such research did not result in the immediate decision to embody this process, it would possibly provide an anwser to that oft-repeated question, which this subject provokes, i:e:, "is it economically sound to adopt longer and longer and heavier milling trains while ignoring the obvious inefficiency of imbibition as generally practised?"

Four milling units with Naudet process and diffusion are achieving superior results at high capacities as the longest of milling trains in use anywhere and, coupled with this are the great advantages of abolishing completely all the plant normally necessary between mills (juice) and evaporators.

This research could easily be undertaken on a modest inexpensive or laboratory scale, plenty of data being already available, from sources known to the writer.

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DISCUSSION.

Mr. Shannon stated that Mr. Buck claimed that there was little equipment comparable to the ordinary milling between the mills and the evaporator. He felt, however, that the diffusion batteries were probably just as expensive and occupied as much space as would be required by the rotary filter station and continuous clarifier stations used in the normal milling plant.

Mr. Buck stated that the milling house in the milling diffusion process admittedly was much longer than in the ordinary process. The diffusion battery did not take much space and was not particularly expensive. The biggest cost with the process under discussion was for valves and piping, the cost of the former having increased up to three times that of pre-war values. In Egypt, as they were dealing with the plant established before the war, when valves and piping were at normal cost they considered they were operating a cheap process. Because of the inflated values it would hardly be fair to compare the processes at present. As far as space was concerned it should be remembered that the buildings for a milling diffusion plant did not require the same number of stories as would an ordinary milling process plant. Consequently there was economy of space from this point of view.

Mr. Shannon felt that one disadvantage of the diffusion clarification was that no filter press mud was available for return to the fields, whereas with the normal milling the filter press mud was considered to be a valuable fertilizer.

Mr. Buck agreed that this was so in that the mud was burnt in the furnaces with the bagasse. However, 70% of the wash water from the post-diffusion mills containing a considerable amount of suspended matter was returned to the fields through the irrigation channels and was considered to be of considerable benefit to the cultivation.

Mr. J. G. Davies asked whether there was no detrimental effect on the quality of the juice when the hot limed juice was filtered over the bagasse.

Mr. Buck said that there was apparently no such effect as the juice entering the evaporators was clear and limpid.

Mr. Davies said that the reason he had asked this question was that in normal milling with continuous liming at the mills the juice was badly affected if the bagacillo had not been previously screened off. The effect of hot limed juice on the bagacillo normally resulted in a breakdown process with the formation of pectins and pentosans which led to trouble later on in the boiling house. The difference between juice from which the bagacillo had been removed and from which the bagacillo had not been removed was remarkable. In the former case, the resulting juice was pale and clear and in the latter case was dark and had a much higher viscosity.

Mr. Buck said that no such effect was apparent with the milling diffusion process and probably the Naudet system of clarification was responsible for this. The juice emerging from a diffusion cell before Naudet circulation was dark grey in colour, but after the Naudet circulation and screening of bagacillo it was sufficiently well processed to be sent direct to the evaporators.

Mr. J. G. Davies said that he felt that the Naudet process was a perfect one for transferring cane wax from the rind of the cane into the juice and consequently into the boiling house and vacuum pans. This would have a detrimental effect on subsequent work and especially sugar boiling and curing.

Mr. Buck stated that he had brought up this point but had been assured that this was not the case. On the other hand the boiling house in the Milling Diffusion process was much slower than in the ordinary sugar factory and a much larger pan capacity was required. It was quite likely that this could be attributed to wax in the juice. It took much longer to boil both "A" and "C" sugars in the milling diffusion process.

Mr. J. G. Davies stated that Mr. Buck claimed that the mill extraction was much higher than in the normal milling plant. He would like to know how the Boiling House Recovery compared for the two processes.

Mr. Buck stated that as far as he could ascertain there was little to choose between the BHR for the two processes.

Mr. J. G. Davies asked if this were the case, what were the advantages gained by the excellent clarification.

Mr. Buck stated that the advantages claimed were higher extraction together with smaller maintenance and operating costs. There was much less wear on the mills than with the normal process, as they relied mainly on the diffusion process to obtain their higher extraction, and the diffusion made up largely for any milling deficiences.

Mr. H. A. Thompson asked whether there was surplus bagasse or whether additional fuel had to be used.

Mr. Buck stated that surplus bagasse was available both from the milling diffusion and the cane chipping processes. This was so in the latter case, even when there were quite large losses from the drying of bagasse in the deserts as referred to in the paper. He had been assured by the factory staffs that only 75% of bagasse manufactured was required for fuel purposes, and by the operating company that their heat balance and fuel economy were better than any other type of sugar cane processing.

Mr. Thompson asked whether, due to the fact that cane was shipped in feluccas to the mill, the cane was old when it arrived.

Mr. Buck stated that he had been assured that the maximum age of cane was three days from the date of cutting.

Mr. D. Aitken asked whether waste water to be disposed of from the factory gave any trouble.

Mr. Buck stated that a considerable amount of water was expressed from the post-diffusion mills for the purpose of drying out the bagasse and that after screening, 30% might be returned to the preliminary diffusion process the remaining 70% being flumed into the irrigation channels; and claims were made that this was of considerable benefit to the field. There was no effluent problem as even the waste from washing out of diffusion process was re-circulated through the diffusion cells. The amount of water used was claimed to be less than in the Queensland mills using the maceration bath process and also less than in some factories in Hawaii where large quantities of imbition waters were used.

Mr. Nurse asked whether the milling diffusion process resulted in difficult scale forming properties of juice in so far as evaporators and pans were concerned.

Mr. Buck stated that so far as he could determine there was not much trouble in this connection, the normal processes of cleaning being used both for pan and evaporator. He pointed out that the factories operated a 23 hour day, one hour being devoted to cleaning. The scale normally was soft but if allowed to stay too long in between cleanings it definitely did harden and gave trouble. There was however, he understood, a form of crystallization causing scaling of pipe line between the diffusion cells, the evaporators, and these pipelines were at one time replaced annually. This trouble had to some extent been overcome by the use of copper piping. He understood that some scale troubles had been encountered in factories using POJ and CO canes which had refractory juices.

Mr. Nurse stated that it might be possible that the use of bagasse as a filtering medium in normal milling sugar houses might help to eliminate excess lime in juice and reduce scale formation.

Mr. Innes wanted to know in what part of Egypt these sugar factories were situated.

Mr. Buck stated that they were all located some miles down the Nile valley and on the delta of that river. The reason for this was that they were dependent on irrigation.

Mr. Innes said that the reason for his question was that some Egyptian soils in the Nile delta were noted for their high salinity and this in turn might be the reason for the need for large boiling house capacity in the factories under discussion.

Mr. Buck stated that this was quite plausible reasoning but he would not commit himself on this point.

Mr. Floro referring to Mr. Nurse's remarks stated that bagasse as a filtering medium would not eliminate excess lime from the juice so long as this was in solution. Bagasse could only be used as a filtering medium for the removal of suspended matter and as such had been used at one time in Louisiana for bagacillo and other suspended material.

Mr. Suberan stated that the disadvantage of using bagasse as a filtering medium might be that its breakdown products with hot juice and lime might be similar to those from the breakdown of bagacillo. He had noticed that the juice figures quoted showed a decrease in purity of juice from the front to back end of the process and that this decrease in purity might be due to bagacillo breakdown products.

Mr. Shannon made reference to the claim that the milling diffusion process had a much higher extraction than the normal milling process. He gave figures to show, however, that a Hawaiian factory some years ago having four more rollers but no Maxwell shredder and a less amount of dilution water gave very comparable extraction figures to those quoted for the milling diffusion process. He then stated that as far as fuel surplus was concerned this was probably due to the installation of air preheaters and to the elaborate system of bleeding the evaporators and other measures of heat economy. It was quite possible that the cost of installation and operation of this heat economy equipment might more than offset the value of any additional sugar recovered, as compared to a normal milling plant. He referred to the Madeira factory quoted in Mr. Buck's paper, and stated that his most recent information was that this factory had given up the milling diffusion process some 3 years ago and the reason for this was that they had to use too much coal to make up for the deficiency of bagasse for the furnaces. The factory was a small one and due to its situation was unable to expand in area and consequently could probably not afford either the space or the money to install elaborate heat economy equipment, to give it the proper heat balance required.

Mr. MacDonald in closing the discussion thanked Mr. Buck for his very interesting paper. As he had stated previously the paper was of personal interest to him as he had a long time ago taken off one crop in the Nag Hamadi factory. He was very glad to know that in the intervening 18 years this factory had improved its efficiency so much. When he was there the Superintendent of Manufacture had had considerable trouble, as they did not strain the bagacillo and the juice deteriorated rapidly due to the action of the hot lime juice on the bagacillo. In the old days also, they had had a lot of trouble in getting sufficient steam from the bagasse available. He made reference to the labour difficulties which were present in those days but which had apparently been overcome to a great extent by the time of Mr. Buck's visit. He wished to thank Mr. Buck very much for producing such an interesting paper and it was obvious from the numerous questions that had been asked that although there are many disadvantages to the mill diffusion process it was one which gave a lot of food for thought and it might be that in time we in Jamaica might again have to consider the investigation of such a process.

The President thanked Mr. Buck for contributing his first paper to the J.A.S.T. meetings and also thanked Mr. MacDonald for so ably carrying out his duties as Chairman.