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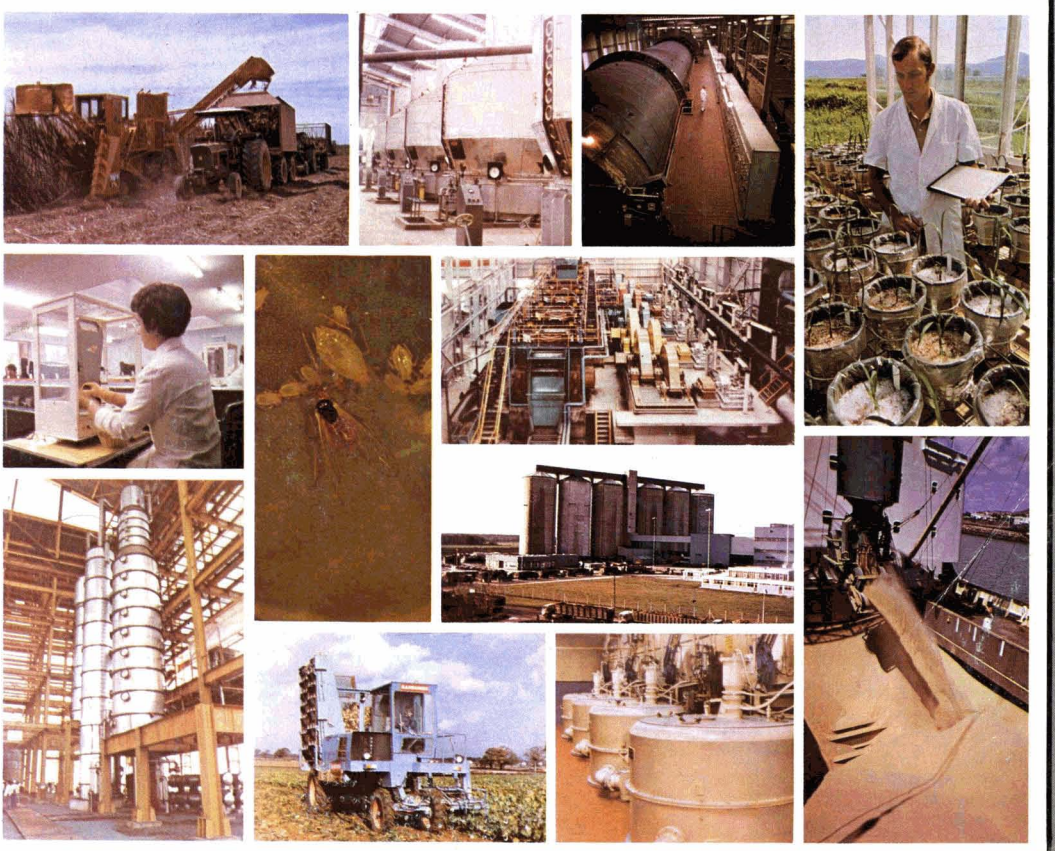

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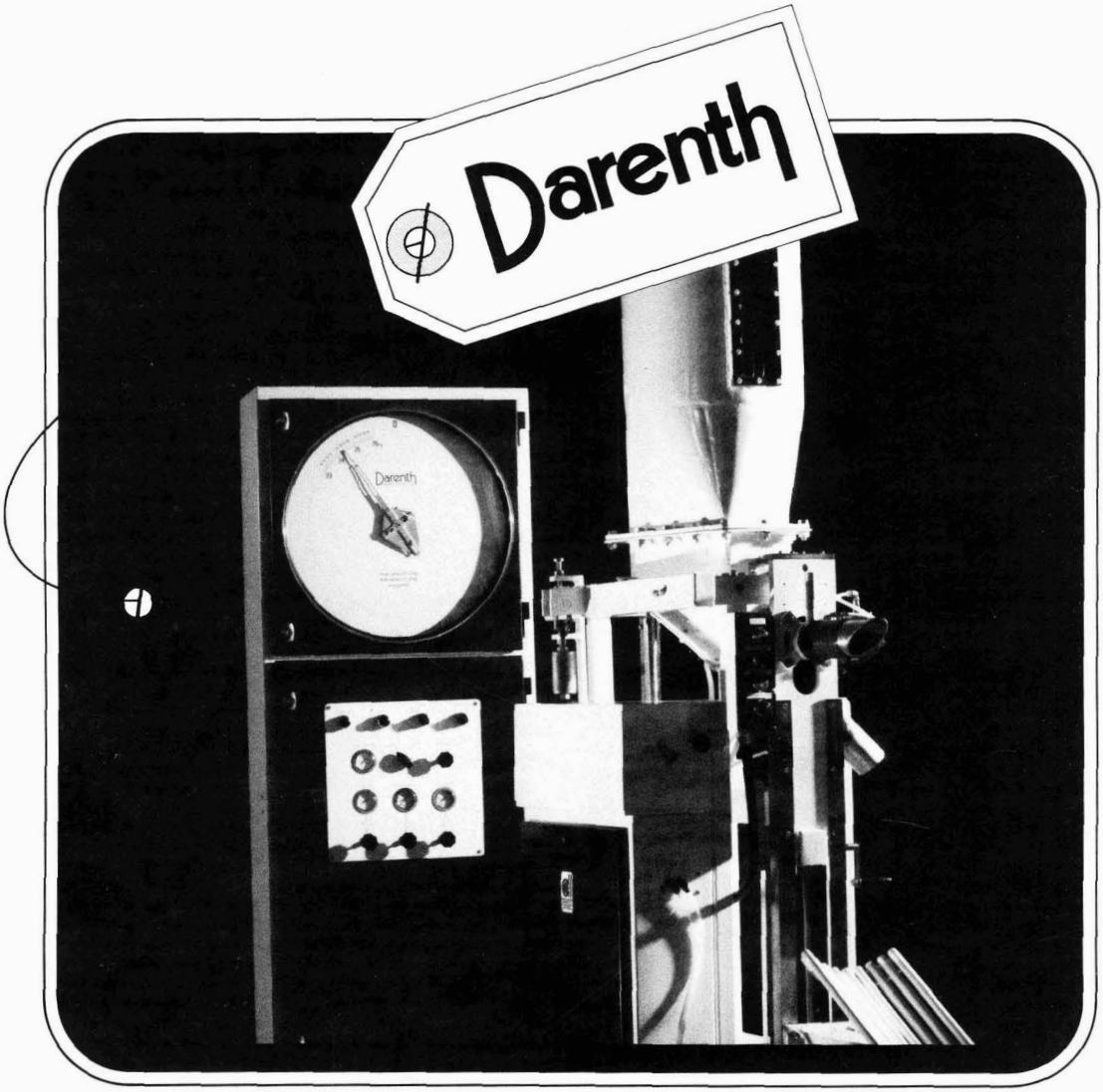

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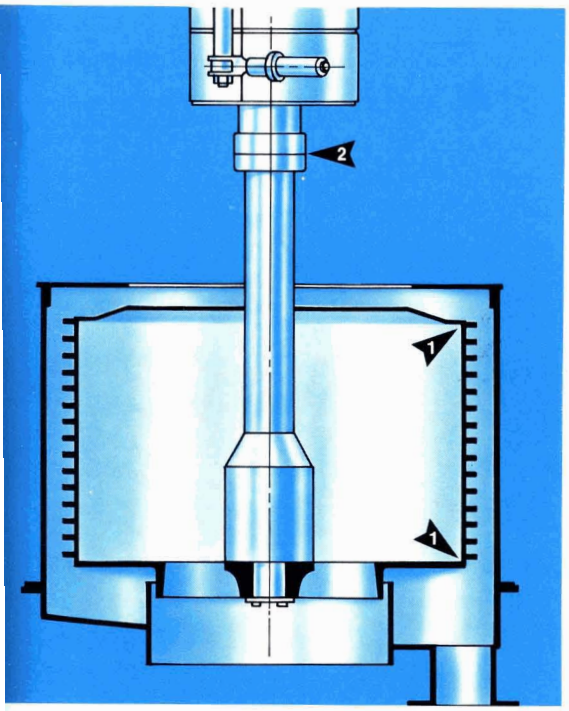

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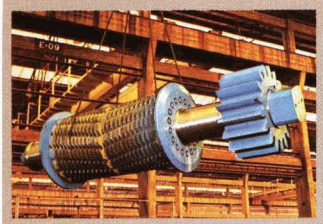

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NOTES AND COMMENTS

World sugar prices

From £248 on April 30, the London Daily Price for raw sugar rose to no less than £346 on May 30 and this represented a fall from the peak of £362 reached on May 28. No dramatic events had given rise to the price increase and it was largely due to speculative interest, fed by reports of purchasing interest by the USSR and actual sales to China, Mexico, Venezuela and other destinations. Moving in parallel with raw sugar prices, the LDP(W) increased during the same period from £257 to £358 per tonne although for most of the month there was a discount against raws instead of the more normal premium. This partly reflects the combination of ready availability of white sugar coupled with a growing awareness of the possibility of world stock levels falling to a critical degree at some time through the 1980/81 crop year.

Bid for British Sugar Corporation Ltd.

S. & W. Berisford Ltd., the international food merchant and commodity trading group, made an offer on May 12 for all the ordinary shares in the British Sugar Corporation not already owned by them. The offer, in cash plus Berisford shares, valued the Corporation at £124 million. Berisford handle up to half of BSC sugar and about one-third of that of Tate & Lyle; the latter responded that, were Berisford's bid to succeed, they would become a rival and Tate & Lyle would have to consider removing their trade from the company.

The Corporation Board unanimously rejected the bid after their meeting on May 13, commenting that there was no commercial logic in union of the two companies since British Sugar is a successful, efficient and well-managed company processing all the sugar beet grown in the UK, in which there is no relevant commercial expertise that Berisford could bring. Berisford's commitment is to international commodity trading while that of British Sugar is to the efficient manufacture and marketing of UK sugar, with all that implies in the future of British agriculture and the consumer.

The bid was halted on June 4 by reference to the Monopolies Commission which is to examine the implications of the proposal and report on its findings within six months. A complication lies in the fact that the UK Government controls 24% of the shares in the Corporation and, while it has been announced in principle that such Government holdings are to be sold, no specific policy in regard to British Sugar has been indicated.

EEC sugar prices

After a series of meetings the Agriculture Ministers of the European Economic Community agreed on a number of measures during their discussions at the end of May including application of a 5% average increase in farm prices for the year commencing July 1, 1980. The quota system which had been due to be replaced after June 30 has been extended for lack of agreement on the terms of its successor.

From July 1, the price of A-quota sugar beet will be raised by 4.0% from 31.83 to 33.10 e.c.u. per tonne, the target price for white sugar will be 4.5% higher at 451.9 e.c.u. against 432.6 e.c.u. per tonne, the intervention price for white sugar will rise by 4.5% from 410.9 to 429.3 e.c.u. per tonne, and the intervention price plus storage levy (the effective minimum price) will be 5.9% higher at 458.2 e.c.u. against 432.66 e.c.u. per tonne.

European sugar beet area, 1980

F. O. Licht GmbH have published details of their second estimate of beet sowings in European countries for the 1980/81 campaign[1]. The total area is expected to be 7,855,000 hectares, which compares with 7,912,000 ha in the previous estimate and the 1979 area of 7,676,000 ha. The new figure represents an increase of 2.33% on last year. The EEC area is set only 6000 ha lower, at 1,781,000 ha, but the beet area for Spain is reduced from 190,000 to 181,000 ha, and in Yugoslavia the beet price offered has been considered unattractive by farmers so that the area has been reduced from 177,000 to 160,000 ha.

The East German area is now set 5000 ha lower at 265,000 ha, the same as in 1979, while the Hungarian area has been raised by 2000 ha to 108,000 ha. The Rumanian area forecast is down from 280,000 to 260,000 ha, while the other estimates for East Europe, including the USSR, are unchanged. Licht points out that the USSR may wish to expand the beet area from the 1979 level (which produced only a poor crop) but considers that there may be difficulties because the flexibility of the Soviet sugar economy is not too great. It has also been reported that some of the beet areas of the Ukraine may be diverted to grain production.

With the area increase set at only 2.33%, European sugar production is not likely to give a marked increase in production, even if weather conditions permitted excellent crops. Average yields would produce a downturn in sugar production, and it has been reported that cold weather delayed sowing and germination in a number of countries.

EEC sugar policy report

A report was published in mid-April by a Select Committee of the House of Lords, the upper house of the UK Parliament, which has been studying EEC sugar policy. On the evidence it had received, the Committee strongly supported the view that the Community should seek membership of the International Sugar Agreement which, it suggested, would bring both political and economic advantages, in view of the need to maintain good relations with third countries, while it would lessen the cost of the present sugar regime.

The Committee urged that production of *C*-sugar should be brought under control, even though it might mean that overall production would be reduced[2]. It also recorded its strong support for the sugar guarantees of the Lomé Convention and went on to state that it accepted the corollary that this implied the maintenance of the British cane refining industry at about its present size. At the same time the Committee supported the EEC Commission in its aims to achieve greater flexibility in the allocation of production quotas so as to encourage specialization of production in the most suitable areas.

Although the Committee could not support the Commission's original production proposals for UK beet, it felt that the revised proposals were about right. It did not feel it would be right for the UK, as a result of its

[1] *International Sugar Rpt.*, 1980, **112**, 215-217.
[2] C. Czarnikow Ltd., *Sugar Review*, 1980, (1488), 78.

imports of ACP sugar and domestic beet sugar production, to emerge as an exporter on the world market. On the other hand it felt that the arrangements for the cane refining margin within the EEC should be examined with a view to attaining a more adequate return.

World free market supply and demand, 1980[1]

Current indications are that the world sugar economy may reach the critical turning point earlier than anticipated. In its report No. 814/80 of February 1980, the World Bank anticipated that production growth will slow down considerably in the years ahead. The Bank added that prices will increase once stocks start to decline measurably. "They may reach a peak somewhere around 1984, causing a new spurt in production in the second half of the 1980's, as well as a new decline in prices".

What the World Bank could not foresee, of course, is that a weather-induced shortfall in production will reduce stocks at the end of 1979/80 by at least 4.8 million tonnes or 16%. F. O. Licht's latest estimate of world sugar balance suggested that stocks will fall to 28.34% of consumption at the end of 1979/80, still above the level of the critical years from 1972 to 1975.

However, there are fears that stocks will be at a very critical level at the end of 1980/81 and these fears will have a growing impact on world prices. Fears of a further draw down of stocks next year are not unfounded as production will have to increase by approximately 6 to 7 million tonnes to cover projected requirements. This will be very hard to achieve as reports from major cane producing areas point to another crop shortfall in 1980/81. Australia and South Africa are plagued by a drought which in the latter case will result in a significant crop shortfall. There are also rumours that the Mauritian crop this year will be lower than anticipated which would contribute to the problems envisaged for 1980/81.

If another production shortfall in the cane sugar sector coincides with below-average yields in Europe, another price explosion like that in 1974 cannot be excluded.

The constant deterioration of production prospects in 1979/80 and the difficulties anticipated for some cane producers in 1980/81 are reflected in the second estimate below of free market supply and demand for calendar year 1980 which also includes a part of the 1980/81 crop. While the previous estimate assumed that there would be a surplus of supply over demand of at least 2.2 million tonnes, mainly in the form of special stocks held under ISA rules, it is now expected that there will be a delicate balance without any surplus stocks at all.

Estimate of free world market supply and demand in calendar year 1980

	New estimate (April 1980)	Previous estimate (January 1980)
	tonnes, raw value	
Net exportable supply of ISA member countries with BET's	14,904,000 (a)	14,895,000 (b)
Net exportable supplies of ISA member countries with small export entitlements	767,000	476,000
Estimated exports under special ISA entitlements:		
German Democratic Republic	60,000 (c)	0
Soviet Union	50,000 (d)	50,000
Total free market availability from member countries	15,781,000	15,421,000
Availability from non-member countries	5,345,000	5,157,000
(of which EEC)	(4,150,000)	(3,800,000)
Total free market export availabilities	21,126,000	20,578,000
Estimated net import requirements	20,354,000	20,312,000
Surplus	+ 772,000	+ 266,000
Assumed Cuban exports to socialist countries under articles 31 (1) and (2) of the ISA		
USSR	2,800,000	3,300,000
other Comecon countries	480,000	400,000
non-Comecon countries	725,000	650,000
	4,005,000	4,350,000

(a) Calculated on the assumption that no special stocks are to be held at the end of 1980
(b) Calculated under consideration of the obligation to hold special stocks
(c) Total export allowance 250,000 tonnes
(d) Total export allowance 100,000 tonnes, white value

International Sugar Agreement

The International Sugar Council met on May 30 in London and agreed to the proposal by its Executive Committee that stock financing fund contributions should commence on July 1 with a fee set at $0.50 per tonne, equivalent to 0.02268 cents/lb, very much lower than the 0.28 cents originally specified in the Agreement. The Council also agreed to invite Zimbabwe to join the Agreement as an exporting member with a basic export tonnage quota of 230,000 tonnes for 1980; for 1981 and 1982 the BET level will be calculated by a formula laid down in the Agreement which is likely to lead to small increases.

Duty-free sugar suppliers to the US

The Generalized System of Preferences (GSP) is a program inaugurated in 1976 to stimulate the economies of countries by offering them tariff preferences on designated export products. In 1979 there were 18 such countries listed as duty-free sugar exporters, supplying 19% of US imports. A further 12 – Argentina, Colombia, Guatemala, Guyana, India, Jamaica, Nicaragua, Panama, Peru, El Salvador, Taiwan and Thailand – supplying 22% of US imports, have been restored to the list after being ineligible in 1979 because in at least one year since 1976 their sugar exports to the US exceeded the maximum value allowed under a GSP formula. They were restored for 1980 because their 1979 supplies were below the value ceiling.

A further five countries – Ecuador, Indonesia, Uganda, Venezuela and Zimbabwe – have been newly designated as GSP beneficiaries. The three principal suppliers to the US – Brazil, Dominican Republic and the Philippines – remain off the list because their shipments in 1979 exceeded the ceiling of $41.9 million. These three countries together accounted for 46.5% of US imports in 1979.

World sugar production

Estimates have recently been published by C. Czarnikow Ltd.[2] and *World Sugar Journal*[3] of sugar production for the crop years 1979/80 and are remarkably similar at 84,647,000 tonnes, raw value and 84,930,000 tonnes, respectively. Both represent falls of more than 5 million tonnes from the previous crops, given as 90,917,000 tonnes and 90,580,000 tonnes, respectively. As noted by other observers, the cause of the decline is a number of poor crops in the USSR, Cuba, India, Peru, Thailand, Brazil, etc.

World Sugar Journal sets consumption for the same period at 91,362,000 tonnes so that production will be 6.4 million tonnes short; Czarnikow sets consumption at 92 million tonnes but believes that high prices and specific shortages in some countries will probably severely curtail this figure. He also notes that, from such indications of the 1980/81 crops as received so far, the position seems likely to be exacerbated next year.

[1] F.O. Licht, *International Sugar Rpt.*, 1980, **112**, 233-240.
[2] *Sugar Review*, 1980, (1494), **107**, 112.
[3] 1980, **2**, (12), 10-13.

Studies on colouring matter produced by contact between quaternary ammonium ion-exchange resin and glucose. Part 1. Its sorption on and desorption from the resin*

By SATOSHI FUJII, ICHIRO SHIBUTANI and MASAHIKO KOMOTO
(Faculty of Agriculture, Kobe University, Kobe, Japan)

Introduction

Since the surface of quaternary ammonium ion-exchange resin in the hydroxyl form is strongly basic, reducing sugars such as glucose and fructose are adsorbed and rapidly decomposed on the resin[1-3]. This results in contamination with organic acids and brown coloured matter produced in the decomposition reaction[2]. When commercial sugar liquor is passed through the resin bed, a similar phenomenon occurs. Because of the strong affinity of the colouring matter for the resin the resin gradually suffers from fouling. A Japanese factory using a reverse system has been confronted with this problem. Kawasaki *et al.*[4] reported a modified restoration method for solving this problem. Furthermore they dealt with a modification of the ordinary reverse system[5].

In order to obtain basic information for development of a reasonable desorption procedure, we have studied the sorption and desorption of the colouring matter produced in a model reaction between Amberlite IRA-900(OH) resin and glucose.

Materials

Resins used were:
(A) Amberlite IRA-900(OH); a strongly basic quaternary ammonium resin, with ca. 8% cross-linking, (B) Amberlite IRA-900(Cl), (C) Amberlite XAD-2, and (D) Browned resin. To prepare (D), 250 cm^3 of resin (A) was added to 500 cm^3 of 10% glucose solution and stirred for 48 hr at 40°C, then separated from the solution, washed with carbonate-free water and allowed to stand for 48 hr at 40°C. This resin was stained brown with colouring matter originating from exhaustive decomposition of the adsorbed glucose.

Colouring matter used included:
(1) CM-(G-R): Browned resin was eluted with 2N sodium chloride solution; the effluent was subjected to high pressure ultrafiltration[6] for eliminating the lower molecular-weight substances until chloride ion could no longer be detected. The resulting brown solution, hereafter referred to as CM-(G-R), was used for the test as such or regenerated after evaporating to dryness and storage.
(2) CM-reverse system (A) and (B): A brine regeneration effluent from a refinery anion-exchange column was ultrafiltered by the use of PM-10 membrane (cut-off MW, 10,000), the permeate and retentate were treated as above and are referred to as (A) and (B), respectively.
(3) CM-decolorizing resin: A brine regeneration effluent from a refinery decolorizing ion-exchange resin column was treated as in CM-(G-R).
(4) CM-molasses (A) and (B): The soluble part of a cane final molasses (Philippines) was treated as in the CM-reverse system; the resulting two parts were referred to as CM-molasses (A) and (B).

The colour intensity was expressed as optical density at 420 or 500 nm of the neutralized solution, determination of organic acids produced was carried out according to the method of Kasai *et al.*[7], and the ion-exchange capacity of the resin was measured according to a conventional method[8].

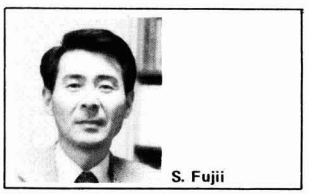
Experimental

I. Change in ion-exchange capacity of Amberlite IRA-900 resin owing to reaction with glucose.

A 200 cm^3 quantity of 10% glucose solution and 50 cm^3 of Amberlite IRA-900(OH) resin were placed in a flask and the atmosphere in the flask was substituted by nitrogen. The flask was allowed to stand at 40°C until adsorption equilibrium was reached (7 days). Adsorption by 1 cm^3 of the resin amounted to 140 glucose. This resin (A) was washed with carbonate-free water and its residual capacity was measured (0.91%). By the regeneration of resin (A) (20 cm^3) with 2N sodium hydroxide solution (250 cm^3) its capacity was recovered up to 89.1%, and 5.35 mg of colouring matter and 0.234 meq (21.10 mg as lactic acid) of organic acid per cm^3 resin, corresponding to 35.3% of the capacity, were released. The regenerated resin was further treated with a mixed solution of 2N sodium hydroxide and 2N sodium perchlorate (1:1, 250 cm^3). By this treatment

*This paper constitutes Part II of the "Studies on Purification of Sugar Liquor with Ion-exchange Resin".

1 Nakamura, Yoshiro & Higure: *Kogyo Kagaku Zasshi*, 1958, **61**, 1150.
2 Fujii, Kawasaki & Komoto: *Nippon Shokuhin Kogyo Gakkai Shi*, 1973, **20**, 449.
3 Maekawa, Kawasaki, Horiki & Saito: *Proc. Research Soc. Japan Sugar Refineries Tech.*, 1978, **28**, 78.
4 Kawasaki, Maekawa & Horiki: *ibid.*, 86.
5 Idem: *Nippon Shokuhin Kogyo Gakkai Shi*, 1978, **25**, 219.
6 Kishihara & Komoto: *Proc. Research Soc. Japan Sugar Refineries Tech.*, 1978, **28**, 61.
7 Kasai, Tanimura & Tamura: *Anal. Chem.*, 1975, **47**, 34.
8 "Seito Binran" (Handbook of sugar manufacture): (Research Society of Japan Sugar Refineries Technologists, Asakura, Tokyo) 1962, p.292.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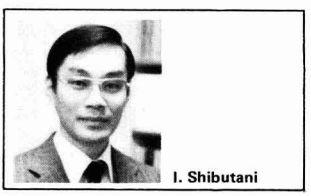
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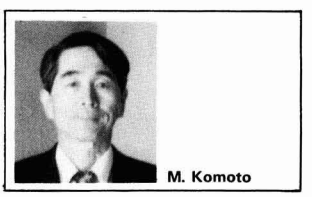
M. Komoto

32.35 mg of colouring matter per cm^3 resin was additionally released, whereas no more organic acid positive to the Barker-Summerson test[9] could be detected in the effluent.

It seems that the larger portion of unrecovered capacity (10.9%) may be occupied by a significant amount of the colouring matter. On the other hand by restoration of residual resin (A) according to the method of Kawasaki *et al.*[4], 10.70 mg of colouring matter was released and 92.4% of the capacity was recovered. The restoration procedure developed at one Japanese refinery adopting a reverse system was unsatisfactory in that it did not effect complete release of the colouring matter. Moreover, it is doubtful whether even perchlorate, which is the most effective desorbent in this system, can completely release all adsorbed colorants. Under the above reaction conditions at least 38.0 mg of colouring matter per cm^3 of resin was released. Thus the persistence of the colouring matter is troublesome for practical operation.

II. Desorbing strength of various kinds of anions for colouring matter on resin.

As shown in I the release or desorption of colouring matter produced in the glucose-resin system from the resin in the usual manner was difficult. In order to find an effective desorbent various kinds of inorganic and organic anions were examined. The sodium ion was adopted as their counter ion. Ten cm^3 of browned resin and 50 cm^3 of 1N salt solution to be tested were placed into a flask and stirred for 24 hr at 40°C. The colour intensity of the resulting coloured solution was measured. Relative strengths of desorbing capacity of the salts are shown in Table I. Perchlorate ion showed the greatest capacity and eluted 3.25 times the colour eluted with sodium chloride, and 81.25 times that with sodium hydroxide. This order agreed with the reverse of the lyotrophic series and was similar to the selectivity order for strongly basic anion-exchange resin (8% cross linking)[10].

Table I. Relative desorbing strengths of various kinds of anions and cations

Anion (Na Salt)	Relative desorbing strength (NaCl = 100)
ClO_4^-	325
I^-	250
Br^-	150
NO_3^-	135
Cl^-	100
$tartrate^{2-}$	41
$formate^-$	27
SO_4^{2-}	26
$citrate^{3-}$	14
$acetate^-$	12
CO_3^{2-}	10
OH^-	4
Cation (Chloride)	
Mg^{2+}	260
Ca^{2+}	235
NH_4^+	103
Na^+	100
K^+	96

Relative amount of colouring matter eluted from 10 cm^3 of browned resin with 50 cm^3 of 2N salt solution.

Fig. 1 shows a relation between the relative selectivity coefficients and the relative desorbing strengths of the anions tested. The relative order of desorbing strengths was proportional to the logarithm of the relative selectivity and this can approximately be expressed by the formula

$$Y = 1.58 \log K - 0.72$$

where Y is relative desorbing strength and K is relative selectivity.

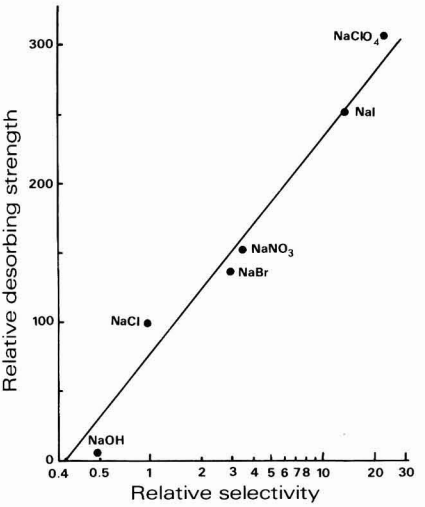

Fig. 1. Relation between relative colour-desorbing strengths of various kinds of anions and their selectivities*

* Data[10] for 8% cross-linking: 10 cm^3 of browned resin and 50 cm^3 of salt solution were stirred for 24 hr at 40°C and the colour intensity of the solution measured.

III. Desorbing strength of various kinds of cations for colouring matter on resin.

Desorbing strengths of various cations were also measured. Under the same conditions as in experiment II above, several cations in chloride form were examined. As shown in Table I the colouring matter could be desorbed by the divalent ions more easily than by the monovalent ions. There were no remarkable differences between individual divalent cations and between individual monovalent ones, respectively. Their order of the desorbing capacity agrees with the lyotrophic series. But the desorbing strengths of divalent cations were about twice those of monovalent ones.

IV. Relation between desorbing strengths and resin-shrinking strengths of various kinds of anions.

The desorption of colouring matter was accompanied by shrinking of the resin. The relative desorbing strength of various desorbents and their shrinking ability were examined. Ten cm^3 of browned resin and 15 cm^3 of 1N solutions of various salts were placed in a 20 cm^3 graduated cylinder. After shaking, the volume of settled resin was read off the graduations of the cylinder. The colour intensity of browned solution was measured as above. The greater the desorbing strength, the larger was the shrinking effect, as shown in Fig. 2. The order of shrinking abilities was also the reverse of the lyotrophic

[9] Barker & Summerson: *J. Biol. Chem.*, 1941, **138**, 535.
[10] "Chromatography" 2nd. Edn., Ed. E. Heftmann. (Reinhold, New York) 1967, p. 300.

series order. Since it is known that the shrinking of resin is ascribed to dehydrating ability of ions, the above relations can be understood.

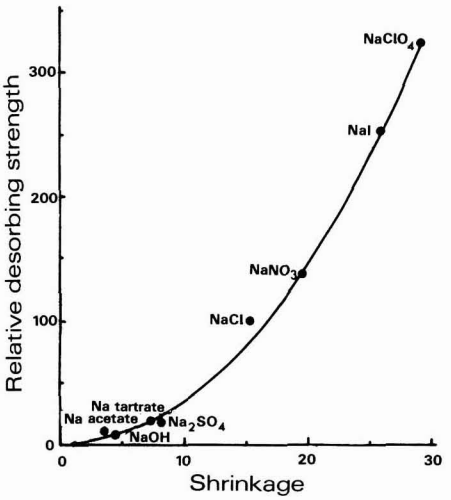

Fig. 2. Relation between relative desorbing strengths of various kinds of anions for colouring matter and their shrinking strengths†

†10 cm^3 of browned resin and 15 cm^3 of N salt solution were placed in a 20 cm^3 graduated cylinder; after shaking, the volume of settled resin was read off and the colour intensity of solution measured.

V. Affinity of colouring matter for Amberlite IRA-900 resin both in OH and Cl form.

Affinity of the colouring matter produced in the glucose-resin reaction for the resins was compared with those of various kinds of colouring matter. Each of the colouring matter solutions (100mg/200 cm^3 water) and 20 cm^3 of Amberlite IRA-900(OH) or (Cl) were placed in a 500 cm^3 Erlenmeyer flask and air in the flask was substituted with nitrogen. The flask was shaken for 4 hr at 40°C. The amount of various kinds of colouring matters sorbed is shown in Table II. CM-(G-R) had the greatest affinity and was sorbed almost 100%. CM-reverse system (A) and (B) may contain both colouring matter like CM(G-R) and colouring matter originating from the technical sugar liquor, hence CM-reverse system (A) and (B) were also largely sorbed. Among the colouring matter from a single source, smaller molecules were more strongly sorbed. It is known that uptake of colouring matter with ion-exchange resin depends on its molecular size[11]. Larger molecules than the pore size of the resin cannot pass through and are not sorbed. CM(G-R) may be passed through PM-10 membrane (cut-off MW, 10,000).

Table II. Sorption of colouring matter eluted from browned resin and of related colouring matters

Colouring matter	Amount sorbed, % OH^--form resin	Cl^--form resin
CM-(G-R)	98.1	100
CM-reverse system A	84.1	88.3
CM-reverse system B	71.3	
CM-decolorizing resin	85.9	
CM-molasses A	77.0	81.3
CM-molasses B	71.3	

Each 100 mg of colouring matter was dissolved in 200 cm^3 of water and stirred with 20 cm^3 of Amberlite IRA-900 resin at 40°C for 24 hr.

The above resins used in the sorption experiment were subjected to desorption. To 10 cm^3 of the resin 50 cm^3 of N sodium hydroxide or chloride solution was added and treated as in II. With sodium chloride, only 20% of the sorbed colouring matter was desorbed, and with sodium hydroxide almost none. Thus this colouring matter had high affinity for the resin. The colouring matter has a carboxyl group[12] and is present as its sodium salt in CM-(G-R). The solution of CM-(G-R) free of sodium ions (24.48mg/20 cm^3 H_2O) and IRA-900(Cl) (50mg) were mixed and stirred for 4 hr. The amount of sorbed colouring matter was 22.89 mg corresponding to 0.0394 meq, while the chloride ion liberated in the solution was 0.0380 meq. The agreement of both values shows that the uptake of this colouring matter was apparently due to ion exchange.

VI. Uptake of colouring matter in the presence of sodium chloride by various kinds of adsorbents

The results obtained in II and V suggested that the uptake of the colouring matter is apparently attributed to an ion-exchange reaction. In order to verify whether or not the uptake depends only on ion-exchange, uptake by IRA-900(Cl) resin, XAD-2 resin or an active carbon in the presence of sodium chloride was examined. In each experiment 100 mg of these adsorbents (48-65 meq) was added to the colouring matter solution (5 cm^3) containing various amounts of sodium chloride, stirring for 4 hr at 40°C. The results of sorption are shown in Fig. 3. As the concentration of sodium chloride increased, the sorption on IRA-900(Cl) decreased, whereas that on XAD-2 resin or active carbon increased. The sorption

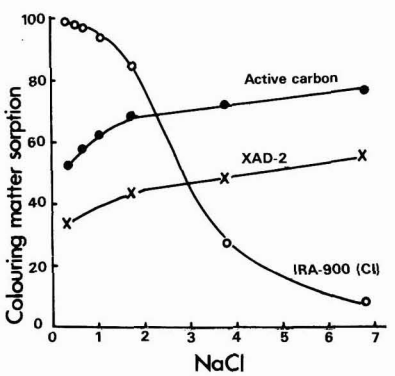

Fig. 3. Effect of sodium chloride on sorption of colouring matter on various kinds of adsorbents‡

‡ Suspensions of granular active carbon, IRA-900 (Cl) resin or XAD-2 resin in 5 cm^3 of CM-(G-R) solution containing various amounts of NaCl were stirred at 40°C for 4 hr.

[11] Abram *et al. Proc. 14th. Gen. Assembly C.I.T.S.*, 1971, 335-349.

[12] Fujii *et al.*: Unpublished data.

curves for the last two adsorbents were parallel to each other.

XAD-2 resin is a highly porous polystyrene-divinylbenzene resin that is physically similar to IRA-900 resin but, because of lack of a polar group, it is very hydrophobic. As the concentration of sodium chloride increased, a "salting-out" effect might have occurred. Hence the sorption on XAD-2 resin and that on active carbon were similar to each other and it seemed that colouring matter was physically (molecularly) adsorbed by both of the adsorbents.

On the contrary, the sorption on IRA-900 resin decreased as the concentration of sodium chloride increased. This is a special feature of ion-exchange. This resin consists of hydrophobic styrenic resin-matrix and hydrophilic anion-attractive trimethyl ammonium groups. It is probable that the sorption occurs in both of the sites, especially so in the absence or presence of only little of the salt.

It is well known that there are two forms of sorption by basic anion-exchange resin, ionic sorption (ion-exchange) and molecular sorption (physical sorption). For example, low molecular-weight carboxylic acids and phenols were sorbed both ionically and molecularly on a quaternary ammonium resin[13] At pH below their pKa values the molecular sorption occurred preferentially and at pH above those ionic sorption occurred The pKa value of the colouring matter was about 4.8[12] and the above sorption experiments were carried out at pH 7.2. The results obtained in II apparently show the occurrence of an ion-exchange phenomenon whereas there is evidence that the colouring matter is sorbed molecularly. The colouring matter was released with methanol in relatively slight amounts from browned resin by similar treatment to that used in the case of XAD-2 resin[14] which had adsorbed the colouring matter from a technical sugar solution. Furthermore, as mentioned above, XAD-2 resin which has no exchangeable group also sorbed the colouring matter.

Accordingly, it seems that the colouring matter was sorbed in both ways. A plausible explanation for this sorption is offered. The colouring matter is a high molecular-weight organic acid; hence it has an ionic carboxyl group and large moiety other than this group. These two parts may be sorbed ionically and molecularly at two different resin sites, respectively. This would explain why the desorption of the colouring matter from the resin is so difficult.

A "salting-in" effect may be an additonal reason for the fact that the desorbing strength of anions (in II) increased in the reverse order of the lyotrophic series.

Summary

When strongly basic anion-exchange resin was exhaustively reacted with glucose, a significant amount of colouring matter and organic acids was produced, and accumulated on the resin. The ion-exchange capacity of the resin was consumed by these substances, and the resin was fouled by the colouring matter which was difficult to desorb.

The desorption of the colouring matter by using various kinds of salts was examined. The order of desorbing strengths of the anions agreed with the reverse of their lyotrophic series and the orders of relative selectivities and shrinking strengths. The perchlorate ion showed the greatest desorbing strength of the anions tested, *viz.* 3.25 times that of chloride and 81.25 times that of hydroxide. The relative desorbing strength of anions is proportional to the logarithm of the relative selectivities. The order of desorbing strengths was in agreement with the lyotrophic series. The strengths of divalent cations were about double those of monovalent cations.

Of the related colouring matter tested, that produced in the glucose-resin system has the greatest affinity for IRA-900 resin. In the uptake of the colouring matter by the resin there was evidence of both ionic and molecular sorption. Concerning the sorption of the colouring matter it was considered that the single molecule of the colouring matter may be sorbed on both hydrophilic ion-exchange group and hydrophobic matrix of the resin.

Etudes concernant la matière colorante produite par contact entre les résines échangeuses d'ions d'ammonium quaternaire et la glucose. 1ère Partie. Sa sorption sur et sa désorption de la résine

Une résine échangeuse d'ions fortement basique étant intensément soumise à réaction avec du glucose; il s'est formé une quantité appréciable de matière colorante et d'acides organiques, qui s'est accumulée sur la résine. La capacité échangeuse de la résine a été consommée par ces substances et la résine a été polluée par la matière colorante, difficile à désorber.

La désorption de la matière colorante par l'emploi de divers sels a été examinée. L 'ordre des forces de désorption des anions concordait avec l'inverse de leurs séries lyotrophiques et de leurs ordres de sélectivités relatives et de leurs forces de contraction. Parmi les ions examinés, l'ion perchlorate révéla la plus grande force de désorption, soit 3,25 fois celle du chlorure et 81,25 fois celle de l'hydroxyde. La force de désorption relative des anions est proportionnelle au logarithme des sélectivités relatives. L'ordre des forces de désorption concordait avec les séries lyotrophiques. Les forces des cations divalents étaient environ le double de celles des cations monovalents.

Parmi les matières colorantes étudiées, celle produite dans le système glucose-résine a le plus d'affinité pour la résine IRA-900. Dans l'accumulation de la matière colorante par la résine il y avait sorption ionique et moléculaire à la fois. En ce qui concerne la sorption de la matière colorante on considère que la molécule individuelle de matière colorante peut être adsorbée à la fois sur le groupement hydrophile échangeur d'ions et sur la matière hydrophobe de la résine.

Studien über Farbstoffe, erzeugt durch Kontakt zwischen quaternärem Ammonium-Ionenaustauscherharz und Glucose. Teil I. Die Sorption und Desorption des Harzes

Wenn man stark basisches Anionenaustauscherharz mit Glucose erschöpfend behandelte, wurde eine signifikante Menge Farbstoff und organische Säuren erzeugt und im Harz angesammelt. Die Ionenaustausch-Kapazität des Harzes wurde durch diese Stoffe aufgebraucht, und das Harz wurde durch den Farbstoff verschmutzt, so daß es schwierig zu desorbieren war.

Die Desorption des Farbstoffes wurde geprüft indem man verschiedene Salze verwendete. Die Rangfolge der desorbierenden Wirkung und Stärke der Anionen stimmt überein mit der Umkehrung der lyotropen Reihe und der Reihenfolge der relativen Selektivitäten und den abnehmenden Kräften. Das Perchloration zeigte die größte desorbierende Kraft der getesteten Anionen, d.h. 3,25 Zeiten derjenigen von Chlorid und 81,25 Zeiten

[13] Fritz & Tateda: *Anal. Chem.*, 1968, **40**, 2115.

[14] Parker & Williams: *Proc. Tech. Session Cane Sugar Refining Research*, 1968, 117.

derjenigen von Hydroxid. Die relative desorbierende Kraft von Anionen ist proportional dem Logarithmus der relativen Selektivitäten. Die Rangfolge der desorbierenden Kräfte stand im Einklang mit den lyotropen Reihen. Die Kraft von bivalenten Kationen war ungefährt doppelt so stark wie diejenige von monovalenten Kationen.

Die geprüften verwandten Farbstoffe, die im Glucose-Harz-System erzeugt wurden, hatten die größte Affinität für das Harz IRA-900. Bei der Aufnahme von Farbstoffen durch das Harz gab es Beweise für ionische sowie für molekulare Sorption. Was die Sorption von Farbstoffen betrifft, so wurde in Betracht gezogen, daß das einzelne Farbstoffmolekül sowohl von der hydrophilen Ionenaustauscher-Gruppe als auch von der hydrophoben Matrix des Harzes sorbiert wird.

Estudios sobre material colorante producido por contacto entre glucosa y resinas para intercambio de iones de forma cuaternario-amónico. Parte I. Su sorción sobre la resina y desorción

Cuando resina fuertamente básica para intercambio de iones se reacciona exhaustivamente con glucosa, una cantidad significante de material colorante y de ácidos orgánicos se produce y se acumula sobre la resina. La capacidad de la resina para intercambio de iones es consumido por estas sustancias, y la resina esta obstruido por el material colorante que es difícil desorber.

La desorción del material colorante por el uso de varios tipos de sal se ha examinado. El ordén de fuerzas de desorción de los aniones estaba en concordancia con el inverso de sus selectividades relativas y sus efectos de encogimiento de la resina. El ion percloruro demuestra la mayor fuerza de desorción de los aniones examinados, es decir, 3,25 veces tanto de cloruro y 81,25 veces tanto de hidroxilo. La fuerza relativa de desorción de aniones es proporcional al logaritmo de sus selectividades relativas. El ordén de fuerzas de desorción estuvo en concordancia con el serie liotrófico. Las fuerzas de cationes divalentes estuvieron casi dos veces tanto de cationes monovalentes.

De los materiales colorantes afines que se han examinado, éllo producido en la sistema glucosa-resina tuvo la mayor afinidad para resina IRA-900. En la interacción del material colorante con la resina había evidencia de sorciónes iónica y molecular. En la sorción de material colorante, es considerado que moleculas del mismo material colorante puede sorberse por el grupo hidrofílico de intercambio de iones y también en el matriz hidrofóbico de la resina.

Alcohol production from cane molasses
Effect of fermentation conditions on yeast recycling

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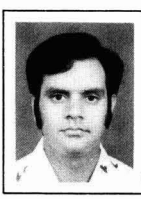
Introduction

Ethanol is gradually emerging as a strong alternative energy source to supplement and/or to replace fossil fuel. This has importance because the raw materials used for ethanol production in India as well as elsewhere in the world are renewable substrates such as cane or beet molasses and other starchy waste materials[1,2]. In recent years, it has been shown that ethanol can replace 15-20% gasoline as a motor fuel. In Brazil, for example, the use of a mixture of 80% gasoline and 20% ethanol has become a common practice[3].

In spite of the great future for ethanol, distilleries the world over are following an age-old batch fermentation process, operating at low efficiency. In order to reduce cost, various innovative techniques have been investigated; adoption of some of these techniques would need complete overhauling of the present set-up of distilleries and require an enormous capital investment. One which does not require much additional investment is the recycling for subsequent rounds of fermentation of yeast recovered either by centrifugation or by natural sedimentation of the wash. If properly worked out, this can benefit the distillers by (i) saving of 5 to 7% of total molasses otherwise used for inoculum preparation, (ii) higher productivity per unit volume of the fermenter, (iii) reduction in the fermentation time cycle, (iv) saving of time and labour spent for the propagation of inoculum with each batch and (v) reduction of the BOD (biological oxygen demand) of distillery effluents because of the removal of the yeast cells.

With a view to improving the ethanol fermentation process, a yeast strain has been developed in this laboratory through extensive selection procedures that can ferment molasses (13-14% reducing sugar) and produces 7.5 to 8.0% ethanol in 24 hr as against the existing 5.0-6.0% ethanol in 40 to 48 hr under conditions operating in distilleries[4]. Furthermore, the process of yeast recycling using centrifugation for the recovery of yeast cells from

1 Lindeman & Rocchiccioli: *Biotechnol. Bioeng.* 1979, **21**, 1107.
2 Chambers, Herendeen, Joyce & Penner: *Science*, 1979, **206**, 789.
3 Anon: *Process Biochem.*, 1979, **13**, 1.
4 Sharma, Dhamija, Dahiya & Bardiya: *Ind. J. Microbiol.*, 1979. In press.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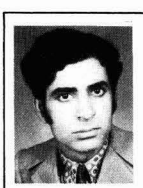
S. S. Dhamija

the wash has been standardized and reported by us[5]. This technique reduces the fermentation cycle to 12 hr with a fermentation efficiency as high as 90-93% when yeast is recovered by centrifugation of 75% of the wash. However, the introduction of centrifugation in distilleries for the recovery of yeast cells requires capital and an alternative method of natural sedimentation has also been attempted[6]. The present communication is an extension of this preliminary study, investigating the effect of various fermentation parameters such as nitrogen status of the wort, pH and temperature of fermentation on the time and efficiency of fermentation.

Materials and methods

Organism: Details of the yeast *Saccharomyces cerevisiae* used in the study have already been reported[4]. It was maintained on GYE agar slopes by regular sub-culturing.

Fermentation media: Diluted cane molasses from The Haryana Cooperative Sugar Mills, Rohtak, India was used as inoculum and production media. The inoculation medium comprised 12° Brix molasses, containing 0.2 kg urea and 0.02 kg phosphoric acid per 100 kg fermentable sugars. The pH was brought to 5.0 and the medium sterilized at 15 psi for 15 min. The unsterilized production medium comprised 21.0-22.0° Brix molasses fortified with urea and phosphoric acid as above, unless otherwise stated.

Inoculum preparation, fermentation and recycling: Inoculum medium (100 cm^3) in a 250 cm^3 flask was seeded with a 24 hr-old yeast slant culture. After 12 hr incubation at 30°C, the contents of the flask were asceptically transferred to 500 cm^3 of medium of the same composition and again incubated for 12 hr. The required amount of inoculum was built up in this manner. 15% of this inoculum was used for initiating the fermentation of 3000 cm^3 of production medium contained in aspirator bottles of 5000 cm^3 capacity. The fermentation was allowed to continue up to 36 hr in the first three rounds while in the next three it was continued only for 24 hr. For the purpose of recycling, after 36/24 hr of fermentation the wash was drained out from the aspirator bottle (through an outlet 2.5 cm above the bottom) leaving behind every time 600 cm^3 of the wash along with the yeast sediment. The next cycle was started by mixing 3000 cm^3 of fresh molasses production medium with the yeast sediment. The fermentation was conducted at 30°C, unless otherwise stated. Samples were withdrawn at 12, 24, 30 and 36 hr of fermentation in the 36 hr cycle and at 12, 18 and 24 hr fermentation in the 24 hr cycle. At the start of each fermentation cycle, i.e. after mixing the fresh medium with the yeast sediment, the viable yeast counts were determined by plating appropriate dilutions on GYE plates. Each experiment was conducted for six rounds.

Analytical procedures: The moisture content, total and unfermentable reducing sugars of molasses were estimated by standard AOAC methods[7]. Total nitrogen content was determined by a micro-Kjeldahl technique[8]. The ethanol content was measured by reduction of potassium dichromate[9] and the fermentation efficiency was calculated by the formula:

$$\text{Fermentation efficiency} = \frac{\text{Actual ethanol recovery } (cm^3)}{\text{Theoretical recovery } (cm^3)} \times 100$$

where theoretical recovery of ethanol (cm^3) = Total fermentable sugar (g) x 0.64*.

Results and discussion

The effect of various parameters on cane molasses fermentation for the production of ethanol has not been worked out in great detail and the information available on these aspects is limited. This is partly because of the fact that cane molasses is a complex mixture and its composition varies from batch to batch[10], from place to place[11] and from factory to factory[12], depending upon the sugar manufacturing process.

The composition of molasses used in the present study is given in Table I. The volatile acidity and the total sulphur dioxide content were estimated because excess of these compounds is known to be harmful to yeast fermentation; they were found to be within acceptable limits.

Table I. Composition of cane molasses used

Moisture	28.20%
Total reducing sugars	51.10%
(a) Fermentable	45.00%
(b) Nonfermentable	6.10%
Total nitrogen	0.36%
Volatile acidity (as acetic acid)	0.18%
Total sulphur dioxide	0.05%

Effect of urea concentration: In general, distilleries do not monitor yeast nutrients carefully. If the yeast biomass is to be recycled it is imperative that it should be rich in viable and active cells. Recycling studies were therefore conducted with three levels of urea. As seen from Table IIa, the ethanol accumulation in the fermenting wort increased with increasing concentration of urea up to 0.2%. Similarly, the initial cell counts were also higher with increasing concentration of urea, which perhaps resulted in a higher fermentation rate. Irrespective of the treatments in a 36 hr cycle, the cell counts and ethanol accumulation were higher in subsequent rounds of fermentation. In the control, however, (no added

Table IIa. Effect of yeast recycling on ethanol production at different concentrations of urea

Cycle	Urea, kg/100 kg fermentable sugars	Initial yeast count (x 10^7)	Ethanol, % (v/v)			
			12 hr	24 hr	30 hr	36 hr
I	Control	2.8	2.7	5.2	6.3	6.7
	0.10	2.7	2.8	6.7	7.3	7.5
	0.20	2.7	3.0	7.5	8.0	8.0
	0.25	2.7	3.0	7.6	8.1	8.0
II	Control	3.5	3.9	6.0	6.9	7.4
	0.10	6.9	6.7	8.0	8.1	8.2
	0.20	7.8	6.9	8.2	8.3	8.3
	0.25	8.0	7.4	8.2	8.3	8.3
III	Control	3.8	3.8	6.0	7.2	7.5
	0.10	6.3	6.3	8.2	8.2	8.2
	0.20	7.4	6.9	8.1	8.2	8.2
	0.25	7.3	7.1	7.9	8.1	8.1

Experimental conditons: Production medium – unsterilized 21.0 to 22.0° Brix molasses containing 0.02 kg phosphoric acid per 100 kg of fermentable sugars, pH 5.0; temp. of fermentation 30°C; scale 3600 cm^3.

* One g glucose, according to the Gay-Lussac equation, gives 0.64 cm^3 of ethanol.

5 Dhamija, Dahiya, Bardiya & Tauro: *Biotechnol. Bioeng.* 1979, (Communicated).

6 Bardiya, Sharma & Tauro: *I.S.J.*, 1980, **82**, 46-47.

7 "Official Methods of Analysis". 12th Ed. (A.O.A.C., Washington, DC) 1975, pp. 577-581.

8 Piper: "Soil and Plant Analysis" (Inter-Science Publishers Inc., New Zealand) 1960, pp. 60-62.

9 Caputi, Ueda & Brown: *Am. J. Enol. Vitic.* 1968, **19**, 60.

10 Hodge & Hildebrand: "Industrial Fermentations". (Chemical Publishing Co. Inc., New York) 1954.

11 Harrison & Graham: "The Yeasts", Vol. III. Ed; Rose & Harrison. (Academic Press, London) 1970, p.283.

nitrogen), the fermentation never reached completion in 36 hr suggesting that the added nitrogen increased the fermentation rates. These observations are consistent with the findings of Hodge & Hildebrand[10] and Chatterjee & Dutt[12].

In the first cycle, the fermentation was over in 36 hr in the treatments with 0.2 and 0.25% urea while in the subsequent cycles it was complete within 24 hr. The higher fermentation rates were observed because of the building up of larger numbers of viable cells in the subsequent rounds. Since fermentation was complete within 24 hr, the next three cycles were operated for 24 hr only (Table IIb). In the last three rounds, the initial cell number started decreasing but the decrease was less in treatments with higher levels of urea. This was perhaps due to the inadequate time given for the sedimentation of yeast cells after the fermentation and/or to the differential cell yields in the media containing different levels of nitrogen. The amount of ethanol produced in the control and 0.1% urea treatments also decreased owing to incomplete fermentation.

Table IIb. Effect of yeast recycling on ethanol production at different concentrations of urea

Cycle	Urea, kg/100 kg fermentable sugars	Initial yeast count ($\times 10^7$)	Ethanol, % (v/v)		
			12 hr	18 hr	24 hr
IV	Control	3.6	3.2	4.6	6.1
	0.10	6.0	5.9	7.4	8.1
	0.20	6.4	6.4	8.1	8.2
	0.25	6.8	6.6	8.0	8.2
V	Control	3.1	2.7	3.7	5.2
	0.10	4.9	5.5	7.0	7.9
	0.20	5.1	6.4	7.5	8.4
	0.25	5.3	6.8	7.9	8.4
VI	Control	2.0	2.4	3.9	4.4
	0.10	3.7	5.2	6.8	7.5
	0.20	4.2	6.4	7.6	8.4
	0.25	4.9	6.8	7.8	8.4

Experimental conditions: same as Table IIa.

On examining the fermentation efficiencies of all the six cycles (Table III), it was found that 0.2 and 0.25% urea treatments gave more or less the same fermentation efficiency in all the six cycles (90-92%), whereas it was only 42% and 77% in the control and 0.1% urea treatments, respectively. There was a cumulative accumulation of residual sugars in the subsequent rounds in these treatments owing to incomplete fermentation which was obviously due to the limiting amount of assimilable nitrogen in the wort. From these data it could be concluded that,for optimum fermentation efficiency

Table III. The comparative performance of recycling at different concentrations of urea

Cycle	Urea, kg/100 kg fermentable sugars	Initial sugar (%)	Residual sugar (%)	Net ethanol % (v/v)	Fermentation efficiency (%)
I	Control	14.4	4.1	6.1	75.6
	0.10	14.4	2.7	6.9	85.6
	0.20	14.4	1.8	7.4	91.8
	0.25	14.4	1.8	7.4	91.8
II	Control	13.8	3.3	6.2	79.5
	0.10	13.6	2.3	6.8	88.5
	0.20	13.3	1.7	6.8	90.9
	0.25	13.3	1.6	6.9	92.2
III	Control	13.9	3.6	6.3	80.7
	0.10	13.7	1.9	6.7	87.2
	0.20	13.4	1.7	6.8	90.9
	0.25	13.4	1.7	6.7	89.5
IV	Control	14.1	4.9	4.9	61.8
	0.10	13.7	2.4	6.6	85.9
	0.20	13.4	1.7	6.8	90.9
	0.25	13.4	1.8	6.8	90.9
V	Control	14.3	7.2	4.2	51.7
	0.10	14.0	4.0	6.4	80.7
	0.20	13.6	1.6	7.0	91.1
	0.25	13.6	1.7	7.0	91.1
VI	Control	14.6	8.3	3.5	42.4
	0.10	14.3	3.6	6.2	76.9
	0.20	13.6	1.8	6.9	90.6
	0.25	13.6	1.7	6.9	90.6

and for proper yeast recycling, a minimum of 0.2% urea is required in the wort.

Effect of temperature: We examined the effect of two temperatures, i.e. 30° and 37°C, on the recycling process. As seen from Table IVa, in the first cycle, fermentation was faster at 37°C than at 30°C, but in

Table IVa. Effect of yeast recycling on ethanol production at different temperatures

Cycle	Temp. (°C)	Initial yeast count ($\times 10^7$)	Ethanol, % (v/v)			
			12 hr	24 hr	30 hr	36 hr
I	30	2.0	3.4	6.5	–	7.6
	37	1.8	3.4	6.9	–	7.5
II	30	4.7	5.5	8.1	8.0	8.1
	37	1.7	2.8	5.0	6.6	7.7
III	30	7.8	6.8	8.1	8.2	8.2
	37	4.2	4.4	6.4	7.5	8.1

Experimental conditions: Production medium – unsterilized 21.0 to 22.0° Brix molasses solution containing 0.2 kg urea and 0.02 kg phosphoric acid per 100 kg of fermentable sugars; pH 5.0; scale 3600 cm^3.

the subsequent cycles this situation was reversed. In all three cycles of 36 hr duration, the cell build-up was slower at 37°C than at 30°C, resulting in a slower fermentation. The low initial counts in subsequent rounds at 37°C were perhaps due to (i) the fact that the optimum temperature for yeast cell multiplication is around 30°C, to (ii) an increased toxic effect of ethanol at 37°C and consequent decrease in cell viability[13] and to (iii) the accumulation of higher amounts of intracellular ethanol at elevated temperatures leading to cell inactivation[14]. When the fermentation cycles were operated for 24 hr (Table IVb), the initial yeast counts decreased in subsequent cycles at both temperatures, but it was more drastic at 37°C, resulting in incomplete fermentation for all three cycles. Although the fermentation was complete at 30°C, the ethanol content in subsequent cycles decreased because of the lower initial sugar content of the wort (Tables IVb and V).

Table IVb. Effect of yeast recycling on ethanol production at different temperatures

Cycle	Temp. (°C)	Initial yeast count ($\times 10^7$)	Ethanol, % (v/v)		
			12 hr	18 hr	24 hr
IV	30	5.7	5.9	6.9	7.9
	37	3.7	4.7	5.9	7.0
V	30	4.9	5.6	6.8	7.6
	37	2.9	4.5	6.2	6.9
VI	30	4.5	5.3	6.4	7.5
	37	2.9	4.1	6.0	6.8

Experimental conditions: same as Table IVa.

The fermentation efficiency (Table V) at 30°C was more or less the same (91-93%) in all the six cycles but at 37°C it was lower. It is therefore concluded that for higher cell build-up, higher fermentation rates and efficiencies, the recycling should be practised at a fermentation temperature of 30°C only.

Effect of pH: Satisfactory yields of ethanol are generally obtained with an initial pH of molasses in the range of 4.5 to 5.5[15]. A pH value lower than 4.0 has been found to slow down fermentation rate considerably[11]. In distilleries, in order to eliminate bacterial contamination, the pH is normally adjusted to between 4.5 and 5.5. To determine the optimum pH for the recycling technique we have examined the effect of three pH values (4.6, 5.0 and 5.4) on the fermentation rate and efficiency. Ethanol accumulation followed closely the

[12] Chatterjee & Dutt: *Sugar News* (India), 1976, **8**, 16.
[13] Troyer: *Mycologia*, 1953, **45**, 20.
[14] Nagodawithana, Castellano & Steinkraus: *Appl. Microbiol.*, 1974, **28**, 383.
[15] Petrov: *Pischch. Prom.*, 1968, **6**, 61.

initial cell counts which Table VIa showed to be higher at pH 5.0 and 5.4. The same trend was also observed in the case of 24 hr fermentation cycles (Table VIb). Although the fermentation rate was lower at pH 4.6 than at 5.0 and 5.4, the net amount of ethanol produced and the overall fermentation efficiency were more or less similar at all the three pH values (Table VII). However, a pH of 5.0 is ideal for prevention of contamination and it also does not involve addition of too much sulphuric acid.

Table V. The comparative performance of recycling at different temperatures

Cycle	Temp. (°C)	Initial sugar (%)	Residual sugar (%)	Net ethanol % (v/v)	Fermentation efficiency (%)
I	30	13.7	1.7	7.0	91.1
	37	13.7	1.8	7.0	91.1
II	30	13.1	1.6	6.8	92.4
	37	13.2	2.0	6.4	86.2
III	30	13.1	1.5	6.9	93.0
	37	13.3	1.6	6.8	90.0
IV	30	12.6	1.5	6.6	92.9
	37	12.6	3.7	5.9	81.6
V	30	11.9	1.3	6.3	92.9
	37	12.3	3.5	5.8	81.9
VI	30	11.8	1.3	6.2	92.2
	37	12.4	3.0	5.7	80.2

Table VIa. Effect of yeast recycling on ethanol production at different pH levels

Cycle	Wort pH	Initial yeast count ($\times 10^7$)	Ethanol, % (v/v) 12 hr	24 hr	30 hr	36 hr
I	4.6	2.0	3.3	6.3	–	7.6
	5.0	2.0	3.4	6.5	–	7.6
	5.4	2.0	3.7	6.7	–	7.8
II	4.6	2.9	5.2	7.7	7.9	8.1
	5.0	4.7	5.5	8.1	8.0	8.1
	5.4	5.4	5.4	8.0	8.0	8.1
III	4.6	7.4	6.5	7.8	8.0	8.1
	5.0	7.8	6.8	8.1	8.2	8.2
	5.4	8.0	6.9	8.1	8.0	8.1

Experimental conditions: Production medium – unsterilized 21.0 to 22.0° Brix molasses solution containing 0.2 kg urea and 0.02 kg phosphoric acid per 100 kg of fermentable sugars; temperature of fermentation 30°C; scale 3600 cm^3.

Table VIb. Effect of yeast recycling on ethanol production at different pH levels

Cycle	Wort pH	Initial yeast count ($\times 10^7$)	Ethanol, % (v/v) 12 hr	18 hr	24 hr
IV	4.6	5.1	5.5	6.5	7.9
	5.0	5.7	5.9	6.9	7.9
	5.4	5.7	5.9	7.1	7.9
V	4.6	3.8	5.1	6.0	7.5
	5.0	4.9	5.6	6.8	7.6
	5.4	4.6	5.5	6.9	7.4
VI	4.6	3.8	5.2	6.2	7.6
	5.0	4.5	5.3	6.4	7.5
	5.4	4.6	5.3	6.4	7.6

Experimental conditions: same as Table VIa.

Conclusion

From these studies it is concluded that for successful implementation of recycling of yeast in cane molasses based distilleries, the fermentation time should be 36 hr for the first two to three rounds to allow proper settling and higher cell build-up. In subsequent rounds, the fermentation time could be reduced to 24 hr without loss in fermentation efficiency. This period includes the time allowed for settling and this reduced the fermentation time by 10-12 hr. The ratio of lees volume to fresh production medium should be maintained between 1:5 and 1:6. The optimum parameters for efficient recycling were found to be 0.2% urea, a pH around 5.0 and a fermentation temperature of 30°C. If the optimum fermentation parameters are not maintained in the recycling technique there would be accumulation of unfermented sugar in the subsequent cycles thereby resulting in the net loss of valuable substrate. Recycling of yeast mass collected by mere sedimentation can easily be practised in existing distilleries without any need for investment. This would realize higher fermentation efficiency and save 5-7% of the molasses normally used in the inoculum. Our studies have been on a laboratory scale and only up to six cycles; a full-scale trial in a distillery is to be reported in due course.

Table VII. The comparative performance of yeast recycling at different pH

Cycle	Wort pH	Initial sugar (%)	Residual sugar (%)	Net ethanol % (v/v)	Fermentation efficiency (%)
I	4.6	13.8	1.7	7.0	90.4
	5.0	13.7	1.7	7.0	91.1
	5.4	13.8	1.8	7.1	91.7
II	4.6	13.0	1.6	6.7	91.9
	5.0	13.1	1.7	6.6	89.6
	5.4	13.1	1.6	6.6	89.6
III	4.6	13.1	1.6	6.6	88.9
	5.0	13.1	1.5	6.7	90.2
	5.4	13.0	1.6	6.7	91.0
IV	4.6	12.5	1.5	6.4	90.9
	5.0	12.6	1.5	6.5	91.5
	5.4	12.6	1.6	6.4	90.2
V	4.6	11.8	1.4	6.1	90.7
	5.0	11.6	1.3	6.1	92.5
	5.4	11.6	1.4	6.0	91.0
VI	4.6	11.7	1.4	6.1	91.7
	5.0	11.8	1.3	6.1	90.7
	5.4	11.9	1.4	6.1	90.0

Summary

The effects of different urea addition rates, temperatures and pH on fermentation cycle times and efficiency with yeast recycling have been studied on the laboratory scale.

La production de l'alcohol à partir de mélasses à canne. Effet des conditions de fermentation sur le recyclage de la levure

On a étudiée sur l'échelle de laboratoire les effets de différents taux d'addition de l'urée, de différentes températures et valeurs de pH sur des temps de cycles de fermentation et sur l'efficacité avec le recyclage de la levure.

Alkoholherstellung aus Rohrmelassen. Einfluss der Gärbedingungen auf Heferückführung

Die Einwirkungen von verschiedenen Harnstoffzugabemengen, Temperaturen und pH-Werten auf Gärzyklenzeiten und Gärleistung bei Heferückführung wurden im Laboratoriumsmassstabe untersucht.

Producción de alcohol de melaza de caña. Efecto de condiciones de fermentación en reciclo de levadura

Los efectos de diferentes niveles de adición de urea, temperaturas y pH sobre tiempos de ciclos de fermentación y su eficiencia con reciclo de levadura se han estudiado al escala de laboratorio.

Analysis of interactions - a neglected tool in applied research

By GEORGE ARCENEAUX
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Widespread use of statistical methods in the wake of pioneer contributions by Fisher and others of the English group has greatly enhanced the accuracy and efficiency of applied research. Nowhere has the impact been greater than in agricultural investigations, but it should be mentioned that attention to problems of design and interpretation has been focused largely on individual experiments with less consideration given to possibilities of combining results from a number of related experiments to provide a more inclusive base for interpretation.

Limitations of comparisons based on a single generalized error were recognized by Stadler[1] who pointed out the importance of "seasonal error" in determining the relative value of varieties or treatments. This view is also expressed in a report[2] of the Committee on Experimental Technique of the ISSCT as follows: "Investigators have determined, with hair-splitting precision, the statistical limitation of their data in individual experiments but have given much less attention to the more important question of developing a measure of the limitations of current and past yield comparisons as a basis for predicting future relationships."

Immer *et al.*[3] proposed the use of errors based on appropriate interaction variance in comparing varieties for: (a) superiority at all of a series of locations (variety x location) and (b) in predicting superiority in future comparisons (variety x year).

One aspect of the "fine tuning" of our research apparatus for greater precision in individual experiments involves the separation of overall variance into its different components. The residual variance for calculating a generalized error can usually be reduced by sacrificing the appropriate number of "degrees of freedom". However in some cases components of the variance thus separated contain, in themselves, important information. This applies especially to variance attributable to primary interactions.

Methods and practical application of interaction analysis are illustrated in a previous publication[4] covering results of tests of six sugar cane varieties at four stations in Louisiana over a four-year period, 1937-1940 inclusive. The analysis of variance given in the publication includes the following item which is pertinent here:

Interaction	DF	SS	MS	F	σ
Variety x year	15	902.04	60.136	12.81**	
Error	320	1,501.89	4.693	–	2.1663

G. Arceneaux

The generalised variety (V) x year (Y) interaction involving 15 degrees of freedom was resolved to specific terms shown below by use of the equation: Interaction V x Y = varietal yield of cane observed in the year plus general mean of all varieties minus mean of the variety minus mean of all varieties for the year[4]. Linear regression values shown are also taken from the 1943 report[4].

A statistical analysis of interaction terms and of constants derived from them is complicated by the fact that values from which they are derived are not independent. As shown earlier[4] applicable values of standard deviation (SD) are computed as follows in the case under consideration:

$$\text{SD: Interaction V x Y} = \sigma\sqrt{K}\sqrt{\frac{(m-1)(n-1)}{mn}} = 8.39$$

$$\text{SD: Linear regression of interaction V x Y} = \sigma\sqrt{K}\sqrt{\frac{20(m-1)}{m}} = 43.33$$

where $\sigma = 2.16663$; $K = 24$; $m = 6$; $n = 4$.

The interaction of a given variety with year denotes its performance in relation to the group as a whole during that particular year as compared with its corresponding performance in each of the other years. It is expressed as a plus or a minus with a varietal summation of zero. Minor departures from zero in Table I are due to "rounding-off".

Highly significant values of V x Y regression ranging from + 278 to – 245 must be interpreted as corresponding changes in varietal productivity over the 4-year period. Positive regression values indicating enhancements in relative position within the group cannot be interpreted as actual improvements in productive capacity. There is no reason to assume that a sugar cane variety improves with age, hence it is more logical to conclude that such varieties have lost less productive capacity, if any, than the group as a whole.

Therefore CP 29-116, showing the highest positive regression value, can serve as a "bench-mark" from which to measure loss of productive capacity in other varieties. With CP 29-116 as a base, other varieties showed linear drops in relative productivity with differences reaching significance in 4 out of 5 comparisons. Such a loss in yield capacity has been commonly observed with sugar cane varieties, and for lack of a better term is referred to as "varietal yield decline". A build-up of disease infection within the clone is generally accepted as probably the most important factor. Under conditions of vegetative propagation sugar cane, with a fixed genetic constitution, is at a disadvantage against disease pathogens that have genetic variability and hence ability to produce new forms of increased aggressiveness and virulence.

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1 *Proc. Int. Conf. Plant Science,* 1926, (I), 107-135.
2 Arceneaux: *Proc. 6th Congr. ISSCT,* 1938, 387-390.
3 *J. Amer. Soc. Agron.,* 1934, **26**, 403-419.
4 Arceneaux & Hebert: *ibid.*, 1943, **35**, 148-160.

Analysis of interactions

Table I

Variety	Variety x year interaction 1937 (Y_1)	1938 (Y_2)	1939 (Y_3)	1940 (Y_4)	Linear regression of interaction value on year (LRI)	Difference in LRI as compared with CP 29-116
CP 29-116	-55.3**	1.4	24.5**	29.7**	278.1**	0
Co 281	2.9	-52.8**	12.1	37.9**	169.9**	-108.2
CP 28-11	-9.8	5.3	-37.2**	42.0**	112.9*	-165.2*
CP 28-19	7.6	17.3*	-21.6*	-3.0	-70.7	-348.8**
Co 290	17.9*	31.2**	6.1	-55.1**	-244.1**	-522.2**
CP 29-320	36.8**	-2.1	16.6*	-51.2**	-245.3**	-523.4**

* Significant at 0.05 probability.
** Significant at 0.01 probability.

The history of sugar cane mosaic in Louisiana with new strains appearing from time to time is well known. CP 29-116 was resistant to mosaic while the other varieties were susceptible. Therefore, the disease no doubt played a part, but was kept under some sort of control through roguing and use of seed material from rogued sources.

There was also another disease, ratoon stunting (RSD), not known to be present at the time. The latter, when discovered by Abbott[5] in 1952 was already widely distributed, a circumstance which led Schexnayder to conclude from a later study[6] that RSD had probably been present in Louisiana "for a long long time". It was presumably present and spreading at the time of this study without any sort of control. CP 29-116 has proved highly resistant to RSD[6], while other varieties are susceptible to various degrees. Calculated varietal losses in relative production conform fairly well to regression values of V x Y interaction as compared with CP 29-116.

It is interesting to note here that the presumed increasing impact of RSD occurred at a time when mechanization was rapidly replacing hand cutting in Louisiana. Elsewhere circumstantial evidence is cited as indicating that harvesting machines are more effective vectors of RSD than machetes[7].

Analysis of interactions as presented above not only provides evidence of the relation between disease spread and varietal "yield decline" in sugar cane, but also illustrates a valid statistical approach to a quantitive measurement of the phenomenon in individual varieties.

Date of harvest in relation to varietal "yield curve"

Procedures followed at Central Romana Division of Gulf + Western Americas Corporation provide features permitting recovery of valuable information from operational data. The latter can be readily computerized and fed into agricultural research activities. This is particularly true of the system followed with cane deliveries at the factory. The information as recorded on each delivery of approximately 30 tonnes includes: weight of cane, variety, source (specific field of known area), crusher juice analysis, and indicated sugar recovery. Such massive information on varietal performance including rendement after VCF adjustments[8] provides a very useful supplement for meaningful comparisons with results of replicated field-plot experiments and other investigations.

In the Caribbean area sugar cane is commonly harvested at the age of approximately 12 months. The actual length of the harvest period will depend on milling capacity in relation to tonnage of the supply zone. At Central Romana, in the Dominican Republic, a milling season of 6 to 7 months is fairly representative. Timing of the harvest period within the calendar year ordinarily provides climatic conditions which will favour: (a) ripening, thus resulting initially in a progressive increase in sugar content of the cane and (b) eventual resumption of vegetative growth with a progressive decrease in sugar content. Hence, a peak is reached at some point near mid-harvest which is preceded and followed by yields that are relatively lower. This is known as the "yield curve" for the crop. The obvious strategy is to time harvest operations within a period when the overall reduction in yield from early-plus-late milling will be a minimum.

The purpose of this study was to determine differences in "yield curves" between different varieties over the grinding period; also to estimate possible gains in total sugar recovery that might be realised through appropriate regulation in timing the harvest of individual varieties.

Available for analysis were comparative data on yield of sugar % cane obtained over three grinding seasons from each of six varieties supplying the bulk of sugar cane milled at Central Romana. Included were individual car lot determinations on nearly 8 million tonnes of cane in which each variety was substantially represented in each semi-monthly period of each season. We thus had for analysis results of approximately 250,000 determinations in a well-balanced distribution among variables involved.

For the purpose of this study the cane of each variety was divided into four periods of delivery (quarters) as follows:

Quarter 1 — Milled prior to Feb. 15 (Total, 1,807,959 tonnes)
" 2 — Milled between Feb. 16 and March 31 (2,046,506 tonnes)
" 3 — Milled between April 1 and May 15 (1,782,960 tonnes)
" 4 — Milled between May 16 and end of season (2,113,572 tonnes)

Table II, taken from an unpublished internal report of Central Romana, gives the rendement of each variety during each quarter of each of three seasons together with a statistical analysis. The weighted average yields of sugar % cane over the 3-year period were as follows:

Quarter 1 — 11.55
Quarter 2 — 12.65
Quarter 3 — 12.96
Quarter 4 — 11.35

The above shows good timing for the crop as a whole but the significant V x Q interaction indicates that we are dealing with varieties of different yield curves within the delivery period, hence some gain in sugar recovery might be realized from a change in the order of harvesting individual varieties.

The 15 degrees of freedom for V x Q interaction shown in Table II were converted to specific terms from quarterly sugar yield values given in Table IIIA as follows: Interaction V x Q = value observed in a given quarter plus general mean minus mean for the variety minus mean of all varieties for the quarter. For instance, inter-

[5] *Sugar Bull.*, 1953, **31**, 116-120.
[6] *ibid.*, 1956, **34**, 349-356.
[7] Arceneaux: *Sugar J.*, 1979, **41**, (11), 10-12.
[8] Idem: *ibid.*, 1975, **37**, (10), 23-27.

Table II. Varietal values for yield of sugar % cane in each quarter during each of three grinding seasons

Variety	Season	Yield of sugar % cane Q1	Q2	Q3	Q4
B 4362	1977	11.85	12.47	13.42	13.11
"	1978	10.71	11.40	12.06	11.11
"	1979*	11.60	13.17	13.40	12.25
PR 980	1977	12.14	12.65	13.36	12.30
"	1978	10.19	11.43	12.22	10.91
"	1979	11.74	13.23	13.32	11.14
CB 44-105	1977	11.76	12.23	13.69	13.05
"	1978	10.19	11.87	11.93	11.39
"	1979	11.86	13.38	13.67	11.56
CR 6101	1977	11.58	12.24	12.49	11.72
"	1978	10.28	11.87	11.87	10.65
"	1979	11.02	12.90	12.73	10.06
CP 5243	1977	12.65	13.18	13.96	12.85
"	1978	11.54	12.20	12.21	11.13
"	1979	12.39	13.79	13.34	11.22
B 42231	1977	11.96	12.52	13.25	12.18
"	1978	10.85	11.06	11.99	10.83
"	1979	11.49	13.22	13.18	10.84

* 1979 season started in late December 1978

Analysis of Variance

Source	D.F.	S.S.	M.S.	F	σ
Varieties	5	5.7421			
Years	2	22.1504			
Quarters	3	27.1828			
Int. V x Y	10	0.8591			
V x Q	15	3.9874	0.2658	11.8	
Q x Y	6	4.6721			
Error	30	0.6773	0.0226		0.1506
Total	71	65.2712			

action of B 4362 on Q.1 = 11.346 plus 12.056 minus 12.129 minus 11.379 = -0.106. Table IIB gives V x Q interactions for each of the six varieties. Probability levels shown are based on generalized σ given in Table II converted to a value applicable to interactions.

Table III. Varietal yields of sugar % cane and computed values of V x Q interaction

(A) yield of 96° sugar % cane

Variety	Q 1	Q 2	Q 3	Q 4	M(a)
B 4362	11.346	12.251	13.014	11.907	12.129
PR 980	11.335	12.447	12.946	11.431	12.040
CB 44-105	11.108	12.549	13.107	11.898	12.165
CR 6101	10.873	12.424	12.403	10.541	11.560
CP 5243	12.210	13.123	13.215	11.591	12.535
B 42231	11.403	12.303	12.812	11.110	11.907
M(a)	11.379	12.516	12.916	11.413	12.056

(B) Computed values of V x Q interaction

Variety	Q 1	Q 2	Q 3	Q 4
B 4362	-.106(b)	-.338*	+.025	+.421**
PR 980	-.028	-.053	+.046	+.034
CB 44-105	-.380**	-.076	+.082	+.376**
CR 6101	-.010	+.404**	-.017	-.376**
CP 5243	+.352**	+.128	-.180*	-.301**
B 42231	+.173*	-.064	+.045	-.154

(a) Simple averages (b) 11.346 + 12.056 - 12.129 - 11.379 = -0.106

* Significant at 0.05 probability.
** Significant at 0.01 probability.

Analysis of interactions

Here it may be useful to point out that the algebraic value of an interaction term as computed does not indicate relative sugar production potential for the variety per se in the particular period of harvest. Instead it shows in the overall context where varietal priorities are to be placed in each quarter for maximum production of sugar from the group as a whole. A high negative interaction value in a given quarter indicates that the tonnage of the particular variety could have been milled to better advantage in an earlier or later quarter. It may thus be assumed that contrasting trends in different varieties offer the opportunity for a favourable varietal shift in tonnage of cane between quarters.

A hypothetical redistribution of varietal tonnages was made as indicated by interaction values shown in IIIB. In the case of "high interaction" varieties such as CP 52-43, deliveries were moved from high minus to high plus quarters. Then the tonnage of the low interaction PR 980 was redistributed to bring the tonnage of each quarter to the same as actually harvested. Thus tonnage totals for each variety and each quarter were the same as in the actual harvest. Only the timing of varietal deliveries was different. The hypothetical timing of varietal deliveries provides a model for a presumed increase in sugar recovery to be expected from combined results with the six varieties.

Table IVA shows a production of 938,715.77 tonnes of sugar from 7,750,997 tonnes of cane as actually harvested. According to figures shown in Table IVB the same tonnage of cane would have produced 954,046.19 tonnes of sugar or an increase of more than 15,000 tonnes by timing of deliveries in accordance with the model derived from V x Q interactions. This is not to say that the indicated gain could have been realized by simply changing the timing of varietal deliveries with the cane as actually found in the fields over the 3-year period. Crops as then constituted would not have provided the tonnage of appropriate age to supply varietal requirements for each quarter. However, through careful planning and reaping operations in the future it would be possible to establish eventually a condition whereby each variety will supply the required tonnage in each quarter to permit the most advantageous timing of varietal harvest.

In conclusion it is considered pertinent to mention that, in some cases at least, observed varietal

Table IV. Hypothetical increase in sugar production from a redistribution of varietal tonnages by quarters as per model indicated by V x Q interaction for yield of sugar % cane

(A) Varietal tonnages as actually harvested

Variety	Cane tonnage 3-yr period	% distribution of deliveries Q 1	Q 2	Q 3	Q 4	Tonnes of sugar recovered
B 4362	999,257	17.38	31.90	29.33	21.39	122,344.96
PR 980	1,312,570	18.07	26.40	25.74	29.79	158,446.33
CB 44-105	619,969	26.75	28.73	19.56	24.76	75,068.80
B 42231	96,542	28.47	24.51	18.93	28.09	114,024.84
CR 6101	1,216,886	26.94	17.96	21.50	33.59	138,348.32
CP 5243	2,636,673	23.79	28.36	22.24	25.61	330,482.52
Total	7,750,997					938,715.77

(B) Harvested as per model indicated by V x Q interactions

Variety	Cane tonnage 3-yr period	% distribution of deliveries Q 1	Q 2	Q 3	Q 4	Tonnes of sugar recoverable
B 4362	999,257	0	0	17.38	82.62	120,902.25
PR 980	1,312,570	0	6.45	35.15	58.40	157,884.01
CB 44-105	619,969	0	8.06	18.89	73.05	75,497.35
B 42231	96,542	49.47	14.15	29.29	7.10	115,128.44
CR 6101	1,216,886	10.50	67.99	21.50	0	149,150.84
CP 52-43	2,636,673	45.61	35.94	18.45	0	335,483.32
Total	7,750,997					954,046.21

interaction values can be attributed to known varietal characters. The poor showing of CP 52-43 in the latter part of the harvest period (Q4) was probably due to extensive development of side-shoots after heavy arrowing. CR 6101 is not basically an early maturing variety but the poor showing made in Q3 and Q4 deliveries was due in part at least to damage from stem rots commonly suffered during those periods. And finally, the massive background of evidence brought to bear on the problem indicates that differences in varietal yield curves as measured by V x Q interactions are real, and of basic importance.

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Summary

Components of the variance due to interactions are usually shown in general terms. Cases are cited where information of significant importance was revealed by resolving primary interactions to specific terms. Results of sugar cane variety tests at several stations in Louisiana over a 4-year period showed a highly significant interaction of variety x year. Varietal values of V x Y interaction revealed obvious secular trends which, when resolved to linear regression, gave values ranging from highly significant plus to highly significant minus. The logical interpretation is that the variety showing the highest positive regression had lost the least if any in productive capacity and hence could serve as a "bench mark" to measure loss in productive capacity suffered by each of the other varieties. Several years later ratoon stunting disease (RSD) was discovered in Louisiana and, because of its widespread distribution at the time, was assumed to have been present in the area for a long time. CP 29-116, showing the highest positive regression in V x Y interaction, also shows the highest resistance to RSD. In the case of other varieties their relative linear regression bore a relatively good correlation with the order of damage suffered from RSD. Spread of RSD within individual clones is therefore assumed to have been the major factor in loss of productive capacity. Use of V x Y interaction analysis is proposed as a possible approach to the problem of detecting and measuring yield decline in sugar cane varieties. In the Caribbean area sugar cane is ordinarily farmed as a 12-month crop. The period of harvest, usually lasting from 5 to 7 months, is timed with a view to maximizing sugar recovery, but for practical reasons it is impossible to harvest the entire crop within the relatively short period of maximum sugar content. Lower recoveries prior to and following the period of peak recovery give rise to what has become known as the "yield curve". From a statistical analysis of rendement records of sugar cane deliveries at Central Romana during a 3-year period it was shown that the six varieties supplying the bulk of the tonnage differed significantly in their respective yield curves. Hypothetical timing of varietal harvest according to a model developed from interactions of individual varieties on date of harvest indicates a substantial potential increase in sugar recovery.

L'analyse des interactions — un outil négligé en recherche appliquée

Les composantes de la variance due à des interactions sont généralement exprimées en termes généraux. Des cas sont cités où de l'information d'importance significative a été révélée en convertissant des interactions primaires en termes spécifiques. Les résultats d'essais de variétés de canne à sucre de plusieurs stations en Louisiane, portant sur une période de 4 ans, indiquaient une interaction hautement significative de variété x année. Les valeurs variétales de l'interaction V x A révélaient visiblement des tendances séculaires qui, résolues en régression linéaire, ont donné des valeurs allant de hautement significatif positif à hautement significatif négatif. L'interprétation logique en est que la variété révélant la régression positive la plus élevée a perdu le moins — si elle en a perdu — de capacité productive et pourrait dès lors servir de "repère" permettant de mesurer la perte de capacité productive encourue par chacune des autres variétés. Quelques années plus tard la maladie des rejetons (RSD) fut découverte en Louisiane et, vu l'étendue de son apparition à ce moment, il fut admis qu'elle était présente dans la région depuis longtemps. CP 29-116, qui possède la régression positive la plus élevée en interaction V x Y, offre également la plus grande résistance à la RSD. Dans le cas des autres variétés, leur régression linéaire relative

révéla une corrélation relativement bonne avec le degré de dégât encouru de la part de la RSD. La propagation de la RSD endéans des clones individuels est très lors supposée avoir été le facteur principal de perte de capacité productive. L'emploi de l'analyse d'interaction V x A est proposé comme approche possible du problème de la détection et de la mesure de la baisse de rendement des variétés de canne à sucre.

Dans la région des Caraïbes, la canne à sucre est habituellement traitée comme culture de 12 mois. La période de récolte, qui dure généralement de 5 à 7 mois, est planifiée de façon à maximaliser la production de sucre, mais pour des raisons pratiques il est impossible de récolter la totalité de la récolte endéans la période relativement courte de teneur maximale en sucre. Les productions inférieures qui précèdent et celles qui suivent la période de récupération maximum donnent lieu à ce qu'on a appelé la "courbe de production". L'analyse statistique des enregistrements du rendement des fournitures de canne à sucre à Central Romana au cours d'une période de 3 ans révèle que les six variétés qui constituent le gros du tonnage différaient de façon significative dans leurs courbes de production respectives. La planification hypothétique de la récolte par variété d'après un modèle tracé à partir des interactions des variétés individuelles avec la date de récolte indique un accroissement potentiel substanciel en sucre produit.

Analyse der Wechselwirkungen — ein vernachläßigtes Hilfsmittel in der angewandten Forschung

Die Komponenten der Varianz, die auf Wechselwirkungen beruhen, werden gewöhnlich in allgemeinen Ausdrücken dargestellt. Es werden Fälle zitiert, in denen eine Information von signifikanter Bedeutung durch Auflösen der primären Wechselwirkungen in spezifische Ausdrücke erhalten worden war. Die Ergebnisse der Zuckerrohr-Sortenversuche verschiedener Stationen in Louisiana während einer 4-Jahresperiode zeigten hochsignifikante Wechselwirkungen von Sorte (V) mal Jahr (Y). Die Sortenwerte von V x Y-Wechselwirkungen ergaben offensichtliche Säkularschwankungen, die, wenn man sie linear regressiv auflöste, zu Ergebnissen führten, die zwischen hochsignifikant plus und hochsignifikant minus schwankten. Die logische Interpretation ist, daß die Sorte, die die höchste positive Regression hatte, am wenigsten, wenn überhaupt, an produktiver Kapazität verloren hat und daher als "Fixpunkt" dienen konnte, um den Verlust an produktiver Kapazität, der bei anderen Sorten eintrat, zu messen. Einige Jahre später wurde die Ratoon Stunting-Krankheit (RSD) in Louisiana entdeckt, und wegen ihrer damaligen weiten Verbreitung wurde angenommen, daß sie in dieser Gegend schon seit langer Zeit vorhanden gewesen sein muß. CP 29-116, die die höchste Regression in der V x Y-Wechselwirkung zeigte, hat auch die höchste Resistenz gegenüber RSD. Bei den anderen Sorten hatte deren relative lineare Regression eine verhältnismäßig gute Korrelation mit der Höhe des Schadens durch RSD. Die Verbreitung von RSD in einzelnen Klonen wird daher als Hauptfaktor für den Verlust an produktiver Kapazität angenommen. Die Anwendung der Analyse der V x Y-Wechselwirkung wird daher als mögliche Annäherung an das Problem der Feststellung und Messung der Ertragsabnahme von Zuckerrohrsorten vorgeschlagen.

In der Karibik wird Zuckerrohr normalerweise als 12-Monatskultur angebaut. Die Ernteperiode dauert normalerweise 5 bis 7 Monate und wird so gewählt, daß eine maximale Zuckerausbeute erzielt wird, aber aus praktischen Gründen ist es unmöglich, das gesamte Zuckerrohr innerhalb des kurzen Zeitraumes des höchsten Zuckergehaltes zu ernten. Geringere Ausbeuten vor und nach der Periode der höchsten Ausbeute ergeben die sogenannte "Ertragskurve". Durch eine statistische Analyse des Rendements von Zuckerrohrlieferungen an die Central Romana innerhalb einer Dreijahresperiode konnte gezeigt werden, daß die sechs Sorten, die den größten Anteil an den Lieferungen hatten, sich signifikant in ihren jeweiligen Ertragskurven unterschieden. Das Ernten der Sorten zu verschiedenen Zeitpunkten nach einem Modell, das aufgrund der Wechselwirkungen der einzelnen Sorten beruht, hat ein substantielles Potential für die Erhöhung der Zuckerausbeute.

Análisis de interacciones — un instrumento descuidado en investigación aplicada

Componentes de la variación debido a interacciones se indican usualmente in términos generales. Se citan casos donde información de importancia signifiante se reveló por resolución de interacciones primarias en términos específicos. Resultas de ensayos de variedades de caña de azúcar en Louisiana en un período de cuatro años demuestran una interacción muy significante entre variedad y año. Valores varietales de la interacción V x Y revelaron evidentes tendencias seculares que, cuando se resolveron a regresión linear, dieron valores colocando de un positivo de alta significancia a un negativo de alta significancia. La interpretación lógica es que la variedad que demuestra la regresión positiva la más alta había perdido lo menos, si cualquier, en capacidad productiva y, por ésto, podía servir como una norma para medir perdida de capacidad productiva sufrido por cada una de las otras variedades. Después de algunos años, se ha descubrido el raquitismo en Louisiana y, a causa de su distribución amplia en eso año, esa enfermidad se ha considerado presente en el área desde hace mucho tiempo. La variedad CP 29-116, que tiene la regresión positiva la más alta en interacción V x Y, tiene también la resistancia la más alta al raquitismo. En el caso de otras variedades, su regresión linear relativa tiene una corelación relativamente buena con el ordén de daño causado por el raquitismo. Difusión de esta enfermidad entre clones individuales es por consiguiente presumido de ha sido el mayor factor en la pérdida de capacidad productiva. Uso de análisis de la interacción V x Y se propone como un camino potencial a la problema de descubrimiento y medida de declinación de rendimiento en variedades de caña de azúcar.

En el área del Caribe, caña de azúcar se cultiva normalmente como una cosecha de 12 meses. El período de cosecha, que dura normalmente 5 a 7 meses, se establece en vista de hacer máxima la recuperación de azúcar pero, a causa de factores prácticos, no es posible cosechar toda la caña dentro el período relativamente corto de contenido máximo de azúcar. Recuperaciones menores antes y después del pico dan origen a la "curva de rendimiento". De un análisis estatístico de registros de rendimiento de entregas de caña de azúcar en Central Romana durante un período de tres años se ha demostrado que las seis variedades que forman la mayoría del tonelaje se diferencian significantemente en sus curvas de rendimiento respectivas. Colocación hipotética de la cosecha varietal en conformidad con un modelo desarrollado del la interacciones de variedades individuales a la fecha de cosecha indica un significante aumento potencial en recuperación de azúcar.

SUGAR CANE AGRONOMY

Ecological studies on the main weed species in cane fields of Taiwan. J. T. Wang, L. T. Twu and S. Y. Peng. *Rpt. Taiwan Sugar Research Inst.*, 1978, (81), 1-10 *(Chinese)*. – The numbers and weights of seed produced by 35 species of annual weeds found in Taiwan have been studied and reported. Germination from seeds and vegetative parts of the principal weight weeds has been examined; these include the annual broad-leafed weeds *Amaranthus spinosus, Eleusine indica, Ageratum conyzoides* and *A. houstianum*, the annual grass *Solanum nigrum,* the perennial grasses *Cynodon dactylon* and *Panicum repens*, and nutgrass, *Cyperus rotundus.* Annual seeds germinated readily at any month of the year from a depth of 0.5 cm in soil. Apparently depending on the size of fragmented rhizome, stolon or tuber, ready germination could be obtained at any time from 0.5 to 20 cm deep in soil. The period required for emergence of all species was 4-6 days from planting in the rainy season and 1 month in dry months. The life cycle was 1½-2 months for all annuals. Competition effects on cane elongation and juice Brix increased with the ratio of weed plants to cane plant in pot trials.

Studies on the increase of phosphorus fertilizer availability in red soils. S. C. Yang and Y. C. Wang. *Rpt. Taiwan Sugar Research Inst.*, 1978, (81), 11-23 *(Chinese)*. The effects were determined of subsequent green manuring, application of a microbial propagator and mixture with calcium silicate on the availability of phosphorus from applied fertilizer. Trials occupied three years and both plant and ratoon crops in each year. The cane and sugar yields were increased by all three treatments, the increases being greater with the second treatment and with ratoon crops than with plant cane. Available phosphorus in the soil was significantly increased by the first and third treatments.

Fertilization with vinasse at Usina Santa Adelaide. J. T. Coleti. *Brasil Açuc.*, 1978, **92**, 294-306 *(Portuguese)*. In 1977/78 the distillery capacity at Usina Sta. Adelaide was tripled; whereas the vinasse had been previously applied to the soil near the cane field but without much control, the larger amount from 1977/78 required more systematic application. Some vinasse is applied direct while the remainder is stored and either pumped from store to the fields or taken by tank truck for dispersal. Weekly analyses are made of the "direct" and "stored" vinasse in respect of N, P, K, Ca, Mg and pH. Costs of application are discussed and compared with those of conventional fertilization.

Post-harvest deterioration of three sugar cane varieties at different harvesting practices. F. E. Mercado, R. E. Tapay and H. M. Miayo. *Sugarland*, 1978, **15**, (4), 10-11, 16. Post-harvest deterioration of cane was found to be dependent on variety and on the harvesting practice employed. The recoverable sugar in cane fell with passage of time, greatest losses being with burning-and-cutting and topping-and-burning. Topping of cane and leaving it standing tended to increase cane yield. Cane yield falls with delay before milling to a greater extent than sugar recovery because of the stalk weight reduction due to moisture loss.

Towards increasing efficiency of the use of fertilizers. W. G. Espada. *Sugarland*, 1978, **15**, (4), 12-13. – The optimum fertilizer application cannot be determined by soil or tissue analysis since the effects are subject to a wide range of factors related to the soil, climate, variety, etc., and the best guide to fertilizer effectiveness is the growth of the cane itself. The farmer should know very well the characteristics affecting his cane in order to formulate a sound and efficient fertilizer program.

Calcium, magnesium trials in North Queensland. Anon. *Cane Growers' Quarterly Bull.*, 1979, **42**, 65-66. – Strip trials with application of lime, cement and magnesium as Epsom salts or MgO in areas where orange freckle disease and soil and leaf analysis betrayed Mg deficiency are reported. The lime treatments did not prevent freckling but gave a growth response similar to that of Mg treatment which cured the freckling. Addition of both lime and Mg gave best results.

No cane yield increase from dual-row planting. A. Hurney. *Cane Growers' Quarterly Bull.*, 1979, **42**, 67-71. – Trials in a number of areas of Queensland showed that little yield advantage arises from the dual-row system of planting and, while row spacings can be increased without a sacrifice in yield, the reduction in time and cost of cultivation must be balanced against the cost of machinery modification.

The effect of long-term application of hog wastes on the soil properties of TSC's sugar cane fields. C. C. Wang and I. J. Fang. *Taiwan Sugar*, 1978, **25**, 196-204. – Among its other activities, the Taiwan Sugar Corporation operates 24 piggeries, and the manure produced could all be disposed of on cane lands. Only a small amount is used in this way, however, and a study has been made to determine changes to the soil which would result from cumulative effects in the long term. The manure composition varies with the type and age of animal, kind of feed, climate, etc., so that the soil property changes varied greatly. Generally, however, soil pH was slightly increased, soil organic matter changes depended on the nature of the soil and on the manure organic matter, soil N was increased, especially in the topsoil, soil electrical conductivity was raised, as were exchangeable K and Zn, and available P and extractable Cu in acid red soil and sandstone alluvial soil. The pig manure could increase cane yield if properly managed.

Computers – a valuable modern aid. C. L. Toohey. *Cane Growers' Quarterly Bull.*, 1979, **42**, 82-83. – A description is given of the application of a computer, fed with level readings over a cane farm, to indicate the areas requiring earth moving to provide drainage/irrigation efficiency, calculation of the cost involved, etc.

Compaction in sandy cane growing soil. P. R. Downs. *Cane Growers' Quarterly Bull.*, 1979, **42**, 86-87. – Digging of test holes for a seepage drainage system resulted in notably better cane growth; examination of the fields concerned showed that a hard pan existed over the remainder of the field as a result of soil compaction. This prevented root penetration and limited yields. Breaking up the compacted soil was estimated to raise cane yield by 70 tonnes.ha^{-1}.

CANE PESTS AND DISEASES

Infructuous attack of the sugar cane top borer, *Tryporyza nivella* **F.** A. N. Kalra and M. Prasad. *Indian Sugar Crops J.*, 1978, **5**, 37-39. – The title name is given to attack when the borer enters the cane stalk through the mid-rib of the first open leaf on the top but dies within it and fails to reach the growing point. The cane continues normal growth and little injury is caused. As with borer resistance, the incidence of infructuous attack is a varietal characteristic but is also favoured by higher N fertilizer rates and split rather than single doses. Sett treatment with hot water or hot air reduced borer attack in general but increased infructuous attack. Reasons are suggested for this behaviour.

Eye spot disease of sugar cane – some observations on its outbreak in Mandya district. S. Kumarswamy and S. D. Urs. *Indian Sugar Crops J.*, 1978, **5**, 40-42. – Eye spot disease was observed in the Mandya district of India and symptoms are described. Conditions favouring the disease are noted, *i.e.* it occurred in Co 419 cane with severe attacks on cane up to 7 months old. Water-logging of soil favoured infection as did decrease in soil pH and K content and increase in N and P content. Incidence was greatest in a period when there had been continuous cloud and drizzle for 18-20 days, with 85-90% R.H., at the beginning of the winter season with short day length, low night temperatures and heavy dew deposits. The cane was sprayed with a 0.2% a.i. copper oxychloride solution at 18-20 day intervals and severely affected leaves removed and burnt. This permitted recovery, but the following year the disease occurred severely on the ratoon crop. Recommendations are made to avoid further recurrence.

Rust in northern areas unlikely to cause heavy losses in yields. Anon. *Producers' Rev.*, 1978, **68**, (12), 49. – A new and more active strain of rust disease, probably that found in Africa and Asia, has been observed in susceptible varieties of cane in the far north of Queensland. Farmers are urged to report its incidence, but it is not expected that yield reductions of more than 5% will result from the disease.

Height of flight, time of flight and influence of lunar phases on the capture of adults of *Diatraea saccharalis* **Fabr., 1974 by means of light traps.** A. C. Mendes, P. S. M. Botelho and N. Maceo. *Brasil Açuc.*, 1978, **92**, 277-289 *(Portuguese)*. – Trials conducted at the Araras experiment station of Planalsucar showed that greatest numbers of the moth borers were captured when the trap touched the surface of the crop; when the crop was not present, the best height was 1 metre from the soil (of positions between 1 and 6 m high). The preferred time of flight is between 7 p.m. and 4 a.m., with two peak periods between 10 and 11 p.m. and from midnight to 1 a.m. Higher numbers of adults were collected during the waning and new moons than during the periods of increasing and full moons.

The study of physiological races in *Ustilago scitaminea* **Syd.** V. V. Shingte, D. G. Hapase, M. B. Bachchhav and S. S. Lambhate. *Indian Sugar*, 1978, **28**, 329-331. Strains of smut fungus were isolated from four infected varieties and used to cross-infect healthy cane of the other varieties and a fifth. The strain isolated from one source proved much more virulent than the others, indicating that the fungal strain is an important factor in infection.

Biology, behaviour and fecundity of *Epipyrops melanoleuca* **Fletcher (Lepidoptera:Epipyropidae), an ecto-parasite of the sugar cane leafhopper (*Pyrilla* spp.).** J. Chandra and N. K. Tewari. *Indian Sugar*, 1978, **28**, 333-335. – Observations are reported on the behaviour of the title moths with special reference to time of emergence (between 10 p.m. and 10 a.m. with 79% between midnight and 6 a.m.), mating (females immediately after emergence, males only after 2 hr), oviposition (in rows, at variable rates and within 2-4 hours), and fecundity (shown to be directly correlated with the cocoon length of the female, r = 0.7118).

Sugar cane smut in Florida and Belize. S. Flores C. *Sugar y Azúcar*, 1978, **73**, (12), 19-21. – A brief account is given of the history, symptoms and transmission of smut, and the spread from Guyana in 1975 through the Caribbean to Florida in 1978 is described. The varieties grown in the state and their relative susceptibility are tabulated. Diseased cane was also found in Belize, apparently introduced in seed cane from Jamaica in 1974. Control methods adopted are listed, as are precautions taken in Mexico to prevent introduction of the disease in that country if at all possible.

A new rust disease in North Queensland. B. T. Egan and C. C. Ryan. *Cane Growers' Quarterly Bull.*, 1979, **42**, 60-62. – A rust disease observed in North Queensland is not caused by the milder *Puccinia kuehnia* and may be due to *P. erianthi* which may itself be identical with *P. melanocephala*. Observations on the susceptibility of a number of varieties are reported; Q 57, A 75, Q 77 and Q 78 appear to be resistant while Q 99 shows some resistance. Trials are to be set up to quantify losses due to the disease and a monitoring system to follow the spread southwards by wind-borne spores.

New chemicals for nematode control in cane. B. Hitchcock. *Cane Growers' Quarterly Bull.*, 1979, **42**, 62-65. Trials have been conducted in North Queensland and in the Bundaberg area over several years with Temik and Mocap water-soluble granular nematicides which are more convenient to use than the fumigants which needed to be injected. Positive benefits were obtained with both plant and ratoon cane, and double treatment showed additive effects. Soil moisture was most important and rainfall or irrigation after application was necessary for maximum benefit. Temik produced higher yields in general than Mocap.

Greybacks back in Burdekin. I. T. Freshwater. *Cane Growers' Quarterly Bull.*, 1979, **42**, 77-78. – Incidence of the greyback grub *Dermolepida albohirtum* in the Burdekin district was greater in 1977 than for several years and it was found that growers were applying BHC in an incorrect manner, which did little to control the pest. Two alternative effective methods are described.

Program to reduce leaf scald in Burdekin. H. L. Boyle. *Cane Growers' Quarterly Bull.*, 1979, **42**, 78-79. – From discovery in 1976, 351 of the Burdekin district's 840

farms were diseased by 1978. Elimination of Q 63 and its replacement with Q 99 is expected to get rid of the disease from most farms by 1982.

Smut in Florida and Belize – a serious threat to the Mexican sugar industry. S. Flores. *Sugarcane Pathol. Newsletter*, 1978, (21), 1-2. – Occurrence of smut in Florida and Belize has been reported and the measures taken by Mexico are described. Mexican varieties are to be tested for resistance to the strains and consultations taken with technologists from infected and uninfected areas.

Smut in Belize. A. L. Fors. *Sugarcane Pathol. Newsletter*, 1978, (21), 3. – The history of the recent occurrence of the disease in Belize (it was first observed in July 1978) is described as well as the opportunities which have been taken to test locally planted and promising varieties for resistance as well as the Mexican varieties mentioned in the previous abstract.

Epidemic of smut (*Ustilago scitaminea* Syd.) in Okinawa and its control. S. Yamauchi. *Sugarcane Pathol. Newsletter*, 1978, (21), 4-5. – After a lapse of 40 years, smut was found in May 1972 at Ishigaki and on the main island of Okinawa. From an area of 84 ha, it had spread to 5453 ha (25.5%) of the total cane area by 1976, increasing slightly in 1977 and then decreasing to 5159 ha (22.0%) in 1978. Control measures include roguing (after wrapping the whip in a nylon bag to stop spore dispersal), use of healthy seed cane at planting and for replacement of infected plants, covering with about 7 cm of soil at planting and earthing-up in April or May, and adoption of resistant varieties; RK 65-37 and IRK-67-1 are being propagated for replacement of the susceptible N:Co 310, the resistant N:Co 376 being unsuitable because of its low Brix and poor ratooning.

Leaf scald disease in sugar cane variety Co 7301 in Punjab (India). K. S. Waraitch and K. Singh. *Sugarcane Pathol. Newsletter*, 1978, (21), 6. – Leaf scald occurs on a number of varieties in different Indian states. It was observed in the Punjab at Jullundur on Co 7301 cane which was severely affected (58% of clumps affected). The disease occurred to a mild but chronic degree in 30 other varieties.

A rapid technique for confirming leaf scald diagnosis. C. Ricaud, S. Félix and P. Ferré. *Sugarcane Pathol. Newsletter*, 1978, (21), 7-8. – A sero-agglutination technique which is suitable for use by pathologists, disease inspectors or agronomists, for the rapid confirmation of the diagnosis of the disease in doubtful cases, is described. Tissue from suspected cane stalks is sliced into thin transverse sections. Stripe symptoms in the leaves are torn off from the green lamina and cut transversely into thin ribbons. The tissues are kept in distilled water in small vials for 2 hr to allow exudation of bacterial cells; the issue:water volume ratio is approx. 1:1. The exudate is strained through muslin, centrifuged at 2000 *g* for 1 min to eliminate cell debris and then at 20,000 *g* for 20 min to collect bacterial cells. The sediment is re-suspended in 0.5-1 cm^3 of phosphate-buffered saline solution at pH 7.0 and centrifuged at about 250 *g* for 30 sec. The supernatant is tested by micro-agglutination of a 1-drop sample against 1 drop of an appropriate antiserum specific to *Xanthomonas albilineans* on clean cavity slides or ordinary glass plates at room temperature. Readings are taken after 3-5 min with side illumination against a dark background so as to see the fine agglutination clearly. Control tests should be run simultaneously with healthy plant material, a pure culture of the bacterium and normal serum. In reliability tests the disease was confirmed in 90% of stalks showing doubtful symptoms, while 93% of stalks showing typical symptoms gave positive agglutination.

A note on hot water treatment followed by aseptic culture of excised buds to improve the phtyosanitary aspects of sugar cane importation. R. P. Kahn. *Sugarcane Pathol. Newsletter*, 1978, (21), 9. – Reference is made to the paper by Waterworth & Kahn[1] on the production of plants testing negatively to mosaic virus from plants known to be infected. The technique is described and a request made that results obtained by its use be communicated to the author for assessment of its applicability as a routine quarantine precaution with imported canes.

Evaluating reaction of American cane varieties to *Ustilago scitaminea* in Brazil. W. M. da Silva and A. Sanguino. *Sugarcane Pathol. Newsletter*, 1978, (21), 10-11. – Seed pieces cut from 276 varieties of the CI, CP and H series were dipped in a suspension of spores of the Brazilian strain of the smut causal organism, planted, and the occurrence of whips counted after 90 and 180 days. Shoots with 1-5% of whips were classified as resistant, 5.1-10% as "averagely" resistant, 10.1-15% as moderately resistant, 15.1-30% as susceptible and more than 30.1% as highly susceptible. The 86 varieties which proved susceptible or highly susceptible are listed; the remainder are being further tested.

An improved technique of negative staining for detection of sugar cane mosaic virus particles in Puerto Rico. L. J. Liu. *Sugarcane Pathol. Newsletter*, 1978, (21), 12-13. – Bunches of rod-shaped virus particles have been observed under the electron microscope in negatively stained juice obtained from mosaic-infected plants of CP 31-294 using a modification of the Kitajima negative staining method[2]. Leaves are surface sterilized with 70% ethanol and cut into small pieces with a sterile knife. They are then chopped vertically on a 3 x 3 in plate of dental wax with a sterile razor blade in a sterile Petri dish containing 100 cm^3 of double-distilled water. The suspension is poured into a test tube, a drop of 0.5% sucrose solution added and the suspension stained with a 1.5% solution of phosphotungstic acid. A carbon-coated grid was left floating on the surface of the suspension for approx. 10-15 min, excess water removed with a piece of filter paper and the grid examined under the electron microscope.

Screening of sugar cane clones for field resistance to grassy shoot disease. S. Vir and M. S. Beniwal. *Sugarcane Pathol. Newsletter*, 1978, (21), 13-15. – Grassy shoot disease incidence was recorded twice in fields of 1st ratoons of 150 cane clones undergoing yield evaluation trials at Haryana Agricultural University, Hissar, and the average incidences are tabulated. Co 1148, Co 6905, Co 7217, Co 7318, N:Co 310, S 1-72, S 45-74 and S 81-72 were graded as resistant, 36 as moderately resistant and the remainder as susceptible or moderately or highly so.

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[1] *Plant Disease Reporter*, 1978. **62**, 772-776.
[2] *J. Electron Microscopy*, 1965, **14**, (2), 119-121.

SUGAR BEET AGRONOMY

Experiences in 1978 with post-emergence herbicides in sugar beet. H. von Olfers. *Die Zuckerrube*, 1979, **28**, (2), 36 *(German)*. — Mention is made of Fervin, a leaf contact herbicide which has proved successful against a number of grasses, including wild oats, *Panicum* spp. and *Alopecurus* spp. at 1.75 $kg.ha^{-1}$; optimum time of application is between the 2- and 6-leaf stage. Fervin + Betanal (at 1.25 or 1.5 $kg.ha^{-1}$ + 6 $litres.ha^{-1}$, according to weed) has also proved successful, the activity of both herbicides being independent of soil type and moisture content.

Inter-seed spacing. A. Vigoureux. *Le Betteravier*, 1979, **13**, (129), 14-15 *(French)*. — Advice is given on beet seed spacing to provide optimum final plant population; in 1978, it is pointed out, the highest yields of sugar per ha were obtained in Belgium with a seed spacing of 17 cm where the beet was drilled to stand, and 12.5 cm where manual thinning was applied.

Dynamics of leaf growth and development in sugar beets. E. A. Clark and R. S. Loomis. *J. Amer. Soc. Sugar Beet Tech.*, 1978, **20**, 97-113. — Beet seeds were planted and the resultant seedlings thinned to hexagonal patterns for equidistant spacing. Four levels of plant density (3, 6, 12 and 24 per m^2) were examined and the rates of growth of leaf numbers and size measured weekly on 5 plants from each group. At first leaf appearance, the rate was greatest for the lowest density, but after 80 days the rates were the same. Leaf areas grew at different rates, the highest being with the lowest density and with leaves growing at the start of measurement (53 days after sowing); leaves starting to grow on day 102 had area expansion rates which were closer for the different densities. Specific leaf areas ($cm^2.g^{-1}$) were lower for the lower plant densities and highest for the highest densities, the blade and petiole dry weights being higher at low densities and vice versa.

Bolting, fresh root yield and soluble solids of sugar beets as affected by sowing data and gibberellin treatment. D. Papakosta-Tasopoulou and A. G. Sficas. *J. Amer. Soc. Sugar Beet Tech.*, 1978, **20**, 115-126. — A number of varieties of beet were sown at intervals between December 8 and March 14 in one season and between November 22 and March 27 in the next, the second season plants also being treated with a foliar spray of the potassium salt of gibberellic acid. Bolters ranged from 4.7 to 34.5% of the December-sown beet in the first season and up to 3.6% of the January-sown beet. All bolters set seed. In the second season, the November-sown beets showed 17.3 to 62.4% bolters but only 11.7-34.7% set seed. Bolting in the December- and later-sown beet was less than in the first season and only a proportion set seed. January and February sowing were agronomically more suitable than earlier dates for sowing. Sowing date did not affect total soluble solids %. Varietal differences with regard to bolting became more marked as the thermal induction period increased. Plants did not bolt when exposed to temperatures of 2-12°C for less than 40 days but increased linearly with the number of days more than 40 at a mean temperature between 2 and 12°C. Bolting resistance was positively related to number of days from sowing to germination and to cold resistance of young plants, but negatively related to earliness of bolting and % soluble solids. Gibberellin complemented the cold stimulus and masked varietal differences in bolting but did not affect the % of bolters setting seed. Although gibberellin increased root yield and soluble solids, the increases were too small to be of practical consequence, while it interacted with sowing date for bolting, root yield and soluble solids.

Regression techniques for estimating % crown removed in scalping sugar beet roots. D. F. Cole and G. J. Seiler. *J. Amer. Soc. Sugar Beet Tech.*, 1978, **20**, 127-132. A multiple regression equation ($\log y = 0.0176 + 0.06527x - 0.000268x^2 - 0.932 \log x$) was developed to relate the amount of crown removed to the diameter of the cut surface at a right angle to the longitudinal root axis. A correlation coefficient of 0.82 was obtained between the actual and predicted amounts removed by two random cuts through crowns of 100 roots selected at random. The equation was thus suitable for estimation under conditions in the area concerned, although the coefficients may not apply elsewhere.

Response of sugar beet (*Beta vulgaris*) and annual weeds to Mefluidide. E. E. Schweizer and Y. Eshel. *J. Amer. Soc. Sugar Beet Tech.*, 1978, **20**, 147-165. — Greenhouse and field trials showed that the title herbicide suppressed the height of a number of annual weeds between 48 and 84%. It also reduced root and sucrose yields in sugar beet treated at the 8-leaf stage by suppression of foliar growth, but tolerance of beet increased with age; yield decreases were not significant with plants treated at the 4- and 12-leaf stages.

Weed control in sugar beets: efficacy of preplant Nortron + Hoelon and other mixtures, 1975-77. E. F. Sullivan and S. L. Downing. *J. Amer. Soc. Sugar Beet Tech.*, 1978, **20**, 175-191. — Trials have shown Hoelon, Nortron and their mixtures to be very effective preplant herbicides for sugar beet. Hoelon gives almost complete control of grasses and improves crop selectivity and broad-spectrum weed control in mixtures with Nortron. The mixtures may improve residual weed control and crop production potential.

Effect of harvest injury on respiration and sucrose loss in sugar beet roots during storage. R. Wyse. *J. Amer. Soc. Sugar Beet Tech.*, 1978, **20**, 193-202. — Injury during harvesting results in increased respiration rate and encouragement of mould growth, although the latter can be minimized by use of fungicides and the former by maintenance of low temperatures. Crown removal in harvesting is practised to eliminate the non-sugars that result in lower yields; however, crown removal is a harvesting injury which can cause storage losses and, since the majority of beets grown in the USA are stored for at least 30 days before processing, it may be time to re-evaluate the desirability of crown removal.

Various types of destruction at beet emergence. L. van Steyvoort. *Le Betteravier*, 1979, **13**, (130), 11 *(French)*. Sources of injury to emerging seedlings are briefly discussed, including frost, heavy rain (which causes mechanical damage) and pests. Possible preventive means are given.

CANE SUGAR MANUFACTURE

Odour and effluent impounding. J. C. P. Chen. *Sugar J.*, 1978, **41**, (7), 25. – Impounded wastes cause corrosion in handling equipment because of their acidity and are a nuisance because of their odour. Trials were made in three seasons at a Louisiana factory on addition of a chemical formulation called 3EF, containing α-alkyl (C_{10}-C_{18})-ω-hydroxy-polyoxyethylene, *n*-undecylbenzene sulphonic acid, a dialkanolamine, triethanolamine, ethylene glycol monobutyl ether, oleic acid, ethanolamine, and tetrasodium ethylene diamine tetra-acetate. Application at a low rate (11 ppm) for the last ten days of the crop reduced the odour problem, and use of 16 ppm for the last twenty days of the two subsequent crops almost completely eliminated it.

Compound imbibition in cane milling: a model. F. Szklaruk Chaet. *Control Cibernética y Automatización* (Cuba), 1976, **10**, (1), 26-35; through *S.I.A.*, 1979, **41**, Abs. 79-449. – Using Hugot's macroscopic analysis (intermediate between the purely theoretical and empirical treatments), a mathematical model of compound imbibition is developed which permits quantitative prediction of mass transfer and explanation of practical anomalies. The model is based on four fundamental parameters: water added/unit fibre; preferential extraction of recycled juice rather than cell-fixed juice; decrease in juice purity across the mill tandem; and residual juice/unit fibre in bagasse. The second of these factors explains why excessive imbibition can cause lower extraction.

Consumption of water in the sugar industry. M. Rodríguez G. *ATAC*, 1978, **37**, (3), 55-65 *(Spanish)*. – Water entering a sugar factory includes raw water from wells, etc. and "vegetable water" entering as part of the cane and itself being of two types – contaminated and uncontamined. In order to minimize the necessity and cost of using well water, it is essential to maximize the use of "vegetable water" and minimize wastage. A balance is given for a sugar factory of 100,000 arrobas/day capacity, and aspects of improving water utilization efficiency are discussed. A case is described where installation of closed-circuit systems, etc. for improved efficiency have been planned so as to reduce make-up water requirements by more than three-quarters.

Incidence of different amounts of dry trash on sugar cane quality. F. A. Fogliata, H. G. Ayala and C. A. Gargiulo. *La Ind. Azuc.*, 1978, **85**, 315-320, 335-340 *(Spanish)*. – Clean cane was mixed with eight levels of dry trash up to 20% and the mixtures passed through a laboratory mill, the experiments being repeated three times. The juice was analysed and its recoverable sugar content calculated, while from the fibre and pol in bagasse and cane the bagasse % cane was calculated. The results are tabulated and discussed. Extraction fell only slightly with up to 5.66% trash but was appreciably lower above this. This purity also fell in a similar way and recovery dropped from 10.56% with clean cane to 9.45% at 5.66% trash and 9.15% with 20% trash. Reducing sugars increased with higher trash content, but gums reached a maximum at 7.40% trash and then fell, the contents with the highest trash levels being lower than those in juice from clean cane. Regression curves are drawn relating extraction, juice purity, recovery, true purity, bagasse % cane, fibre % cane and Java ratio with the trash content, and juice extraction and Java ratio with fibre % cane, as well as Java ratio with extraction, pol loss in bagasse with trash content and with bagasse % cane. A final graph relates the value per tonne with the trash content.

Factory research and development in South Africa. Anon. *Ann. Rpt. Sugar Milling Research Inst.*, 1978.

Extraneous matter in cane and its effect on mill performance: Determination of ash in prepared cane and bagasse as a measure of field soil showed that the proportion of ash in cane which finds its way into bagasse depends on the type of extraction plant and is higher for a diffuser and lower for milling tandems, although no statistically significant correlation could be found between ash in cane and ash in bagasse for the various types of plant. Similarly, no significant correlation has been found between ash in cane and wear of preparation equipment (determined by weighing shredder hammers and knives every time they were replaced), nor between ash in bagasse and wear of aluminium rods placed in last mill bagasse chutes. In investigation of the effects of cane trash content (which averaged 7.5% for burnt cane and 12.2% for trashed cane), the lower trash content increased the payload of the Hilo trailer supplying to the factory by about 8% and increased mill capacity by about 15%, although fibre throughput remained unchanged. Extraction was higher with burnt cane (97.16%) than with unburnt cane (96.69%) as a direct result of the lower cane fibre content. Pol % bagasse and corrected extraction were also lower with burnt cane. Power consumption by preparation equipment was higher for trashed than for burnt cane as a consequence of the additional weight of fibre. In the case of diffusion, an average 20% increase in throughput resulted from a 5% reduction in trash with burnt cane, while power consumption by preparation equipment followed the same trend as with the milling tandem.

Cane yard survey: A survey of cane yard operations showed that most yards have considerable spare capacity, so that in many cases inefficient labour utilization resulted. Delivery of cane in chained bundles affects yard operation costs: the chains carry high capital and maintenance costs, while the labour requirements are higher for handling chained bundles than loose cane. Yard operation is adversely affected by the need to stockpile cane from each grower separately to permit sampling. Where the weekend stockpile requirements and the amount of cane delivered in small bundles are high, operations are governed by sampling requirements, which can lead to high inefficiency. The most efficient yards were those having minimal weekend stockpile requirements and receiving all the cane loose, allowing it to be spilled directly from truck to feed table and the small stockpile to be handled by a Cameco stacker. It is also important that the yard have a single cane handling system where possible, without spillers, gantries and tipper, which lead to inefficient labour use.

Use of conductivity profiles as indicators of diffuser performance: Since Brix measurement is time-consuming and labour-intensive, the possibility of replacing Brix profiles by conductivity profiles as indicators of diffuser

performance was investigated (it being possible to measure conductivity continuously at low instrumentation cost). Comparison of average Brix and conductivity curves for a De Smet diffuser showed similar shapes, although the decline in conductivity along the diffuser was less steep than that of the Brix. Laboratory investigations showed that use of temperature-compensating electrodes or correction of readings to a standard eliminated any influence of temperature variation on conductivity, and pH in the range 5-8 caused no significant change in conductivity readings. On the other hand, juice ash content, which is dependent on cane quality, determines the conductivity measurement; since it is not feasible to control it, its direct influence on the conductivity profile must be eliminated. It is shown that this could be achieved by relating the "actual" to an "ideal" curve, the highest value on the curve being taken as 100% and all other measurements being expressed as a percentage of it; any decrease in the "ideal" percentage between any two stages will indicate the performance.

Mill torque measurement: The power split between pressure feeder and a Walker cane mill was measured at Sezela, displacement transducers being used to measure the angle of twist over a given distance on the tailbar. A chart depicting torque (deflection) *vs.* time for the 1st mill clearly demonstrates the cyclic variation and non-uniformity of the torque loading; the measured power split between pressure feeder and mill was about 1:5. Torque loading on the last mill was far more uniform than on the 1st, but the cyclic variation was still very evident; the measured power split between pressure feeder and mill was about 1:12. Gearbox loss for the measurements, determined by subtracting absorbed power from developed power, was 15-20%.

Magnesium oxide as a clarifying agent: Whereas earlier investigations[1] had shown that magnesite ($MgCO_3$) can be activated to caustic MgO provided the calcining temperature does not exceed 650°C, laboratory tests on magnesite samples from additional sources have shown that temperatures up to 900°C do not cause dead-burning, the difference in behaviour between types of magnesite being attributed to the silica content. Although activated MgO on its own was inferior to lime in laboratory clarification tests, a 70:30 CaO:MgO mixture gave almost the same results as did CaO on its own. A high silica content in the magnesite (12.43%) was insoluble (had it been in soluble form it could have had adverse effects on the quality of sugar produced), so that the concentration of soluble silica in clarified juice was the same with both lime and lime:magnesite as clarifying agents.

Evaporator malfunctions: Investigations to establish causes of failure to maintain an adequate vapour pressure after the 1st effect in a quadruple-effect evaporator showed that the problem was caused by improper cleaning of tubes, a high degree of superheat in the exhaust steam to the 1st effect, and inadequate vacuum in the last effect. Use of a multi-point temperature recorder combined with Brix readings between vessels can give a rapid indication of problem areas, as in the case of continuous low syrup Brix, which resulted from choking of the centrifugal-type entrainment separator with crystallized sugar and hence considerable temperature difference between the last two vessels in a quintuple-effect evaporator as well as erratic temperature control of the exhaust system.

Colour in sugar of different grain sizes: Colour of sugar produced toward the end of the crushing season often tends to increase, and an investigation was undertaken to establish whether a reduction in sugar colour could be obtained by boiling slightly smaller grains. Colour analysis on sub-samples after screening of sugar obtained from one centrifugal basket load showed that any decrease in colour with finer-grain was only marginal.

Non-sucrose balance and molasses formation: Statistical analysis of figures from a number of factories showed that high non-sucrose ratios in juice not only led to increased molasses formation because of the additional quantity of non-sucrose passing into products, but also probably caused a fall in the reducing sugar:ash ratio in the molasses because of increased ash, so that target purities rose. Clarification studies showed that the non-sucrose ratio appeared to increase with fall in retention time.

Condensers: Low-cost conversion of cascade-type condensers to rain-type condensers was followed by performance tests, in which all of the condensers showed improved efficiencies, giving approach temperatures in the range 1-4°C at a controlled injection water flow rate. A new rain-type condenser of small diameter was also tested. When operated at the designed absolute pressure of 13.5 kPa, it gave a 3°C approach temperature; however, when operated at slightly better than design conditions, it occasionally gave some inexplicable temperature recordings which are to be investigated.

Chain study: Preliminary findings from investigations of problems with conveyor chains indicated that the problems were mainly a result of poor quality control exercised by the manufacturers, who argue that good quality control, particularly in the case of roller chain, is expensive and time-consuming and would therefore add to the price as well as delivery times; moreover, greater standardization on the part of the factory operators would allow the manufacturers to carry out greater production runs and simplify stock requirements, both of which would tend to lower prices. The SMRI is to draw up specifications for various types of roller chain in collaboration with factory operators and chain manufacturers.

Experience in storage and transportation of raw sugar in Cuba. P. V. Poltorak, A. F. Zaborsin, V. P. Mondzelevskii, N. V. Kostenko, J. Lodos, S. Ortega, J. Perez and E. Casanova. *Nauch.-Tekh. Ref. Sbornik Sakhar. Prom.*, 1976, (7), 1-12 *(Russian)*. — A survey is given of bulk storage, transportation and handling of raw sugar in Cuba, with descriptions of specific installations at the ports of Cienfuegos and Matanzas, at Hector Molina and Caracas factories and José Antonio Echeverría refinery. Details are given of the new Miconaz design of silo and of adaptation of old bagged sugar silos to bulk storage.

Need for improved sugar crop planning to ensure continued higher sugar production. S. N. Pandit. *Indian Sugar Crops J.*, 1979, **6**, 1-3. — In northern India, cane is economically processed from mid-November to mid-April, after which there is a sharp deterioration in cane quality, so that factories are reluctant to continue operation beyond the optimum period. To enable the factories to use their capacity to the full, it is therefore suggested that sugar beet be grown as well as cane; the beet could be processed after the cane, and residual bagasse could be used as fuel. While beet processing would solve the problem, it would also bring in extra revenue in the form of molasses, for which the pharmaceutical industry pays about 20 times more than it does for cane molasses. Carbonatation factories could be adapted to beet-cum-cane processing, while diffusion plant is usable for both crops.

[1] *I.S.J.*, 1979, **81**, 214.

BEET SUGAR MANUFACTURE

Some processing problems in the operation of a DDS-20 diffuser. A. M. Grebenyuk. *Sakhar. Prom.*, 1979, (4), 25-27 *(Russian)*. — Problems that arose when the rotary speed of the scrolls in a DDS-20 diffuser was increased from the nominal 0.8 rpm to 1.0-1.2 rpm in order to increase throughput are discussed.

Intensification of and improvement in 1st carbonatation juice settling. I. G. Chugunov, L. S. Pokutnev and V. A. Kholodov. *Sakhar. Prom.*, 1979, (4), 31-35 *(Russian)*. The need to increase 1st carbonatation juice clarification rates is discussed, and descriptions are given of the Enviro-Clear rapid clarifier as well as recent BMA and Dorr-Oliver designs. Details are given of a 5-tray rising-stream clarifier developed in the USSR and tested at two factories; it has a rated daily throughput equivalent to 1750 tonnes of beet, and a juice residence time of 60 min. Performance data are given, showing that even without use of flocculant, clear juice turbidity did not exceed 1 g.litre^{-1} at a throughput equivalent to 2000 tonnes of beet.day^{-1} (50 min retention). A 8-tray model is being designed to handle juice from 3000 tonnes of beet.day^{-1} without use of flocculant.

Automation of liquid-spray sulphiters. V. G. Drynov, Yu. V. Trikhleb, V. A. Oksimets and E. A. Koval'chuk. *Sakhar. Prom.*, 1979, (4), 40-43 *(Russian)*. — Details are given of a scheme for automatic control of juice pH in Soviet-designed liquid-spray sulphiters.

Investigation of the design parameters of feed devices for continuous centrifugals. V. F. Kolomiets, V. G. Andreev, K. I. Tobvin and E. E. Egiseryan. *Nauch.-Tekh. Ref. Sbornik Sakhar. Prom.*, 1976, (1), 1-4 *(Russian)*. — Investigations are reported on optimization of the angle of slope of massecuite feeders for continuous centrifugals. The results, obtained with an experimental model with interchangeable feeders adjustable to an angle of slope of 0.45° from the vertical, showed that 8-10° was optimum for a massecuite having a mother liquor viscosity of 0.2-0.3 Pa.sec^{-1}, and 12-14° for a viscosity of 3.5-4.0 Pa. sec^{-1}.

Removal of bound moisture. A. F. Zaborsin, L. K. Krsek, A. P. Fedorov, K. U. Burliev, F. B. Bakhriev and G. N. Avetisyan. *Nauch.-Tekh. Ref. Sbornik Sakhar. Prom.*, 1976, (2), 6-8 *(Russian)*. — Investigations were carried out to determine optimum parameters for raw sugar conditioning before prolonged bulk storage. Results showed: that the conditioning temperature should not exceed 30°C to avoid darkening of the sugar crystals; that the R.H. of the air need not be particularly low (as long as air conditioners operating in winter have drying means); that the volume of air should be as high as possible in order to remove a maximum of moisture, but without causing dust entrainment, crystal size reduction or fluidization; and that air recirculation is desirable from both an economic and a hygienic point of view. After 4 days' conditioning, sugar had practically no moisture, whereas the moisture content of unconditioned sugar doubled in 10 days.

Softening of 2nd carbonatation juice with ion exchange resin in sodium form. L. I. Ryazantseva. *Nauch.-Tekh. Ref. Sbornik Sakhar. Prom.*, 1976, (2), 14-16 *(Russian)*. Treatment of second carbonatation juice with KU-2-8 cation exchanger in Na^+ form followed by sulphitation with Na_2SO_3 gave best results in terms of purity, invert sugar content, colour, lime salts, ash and total N and provided greatest thermal stability on heating for 25 hr. Slightly poorer results were obtained by sulphitation before ion exchange treatment, while sulphitation on its own gave only slightly better results than no further treatment after carbonatation.

Calculation of the intensity of white sugar drying in a fluidized bed with pulsating fluidization by air. A. A. Dmitryuk. *Nauch.-Tekh. Ref. Sbornik Sakhar. Prom.*, 1976 (3), 21-22 *(Russian)*. — Pulsation of the hot air flow for drying of white sugar has the advantage of intensifying removal of moisture from the crystals without channelling, so that the process is more regular. However, the pulsation frequency differs according to the quantity of sugar and the rate of air flow. Experiments were conducted on drying of 55-312 kg of sugar per m^2 of distribution grid, with a bed height of 0.03-0.06 m, a flow rate of 0.5-2.5 m.sec^{-1}, and a frequency of 0.6-3.67 Hz. By means of a quadratic regression equation, the mass transfer coefficient was calculated in terms of the various parameters and found to have values in the range 1.07-4.5 x 10^{-4} m.sec^{-1}.

Calculation of a filter-thickener operating in a pulsating system. E. I. Vorob'ev, I. M. Fedotkin and Yu. V. Anikeev. *Nauch.-Tekh. Ref. Sbornik Sakhar. Prom.*, 1976, (4), 1-9 *(Russian)*. — In filtration of 1st carbonatation juice, pressure pulsation can be used (i) to intensify the process by loosening the cake and thus reduce resistance or (ii) to release the cake from the elements at regular intervals (this being possible only with filters having inclined or vertical elements). The pulsation frequency is in the range 0.1-100.min^{-1}. Parameters relevant to operation on system (ii) were calculated. Earlier studies showed that, whereas the filtration rate falls from e.g. an initial 26-28 litres.m^{-2}.min^{-1} to 10-12 litres.m^{-2}.min^{-1} under normal conditions of filter operation, with pulsation the rate remains considerably higher as a result of constant regeneration of the filtration surface and mud discharge. On the other hand, the pulsation system demands very durable cloths of high retention properties but finer pores than for normal operation, which leads to a filtration rate lower than the theoretical, although it is still equivalent to 1300-1500 m^3 per day compared with 960 m^3 in normal operation. At a pressure difference of 1.25 bar, it is calculated that the cake can be released from a Terylene-type cloth in 5 sec, for which 0.005 m^3 of filtrate is needed per m^2 surface. The increased throughput permits all the 1st carbonatation juice at a factory slicing 6000 tonnes of beet per day to be handled by 6-7 instead of 9 filter-thickeners.

The effect of low-grade massecuite stirring on the crystallization rate. A. I. Gromkovskii, V. M. Fursov, V. S. Bogdanchikova and V. E. Apasov. *Nauch.-Tekh. Ref. Sbornik Sakhar. Prom.*, 1976, (4), 9-12 *(Russian)*. A 1:5 scale crystallizer with rotating tubular surface was used in low-grade crystallization studies. The speed was

varied from 3 to 50 rpm, permitting studies to be carried out at Reynolds' numbers of 0.6-90. The rate of cooling was $1.5^{\circ}C.hr^{-1}$ from an initial 75°C. The crystallization rate was determined in the temperature range 70-60°C where it is governed by convective diffusion of sucrose. The results indicated that in a battery of crystallizers, increasing the stirring velocity in the end vessels does not increase the crystallization rate, the Reynolds number being 0.5-0.6 by comparison with 3-4 in the first vessel (at which the rate does increase). Hence, in the end vessels it is advisable to reduce the stirring velocity and allow the increase in crystal content to provide accelerated molasses exhaustion and reduce its purity.

Requirements of plant for sugar dust separation. A. F. Zaborsin and K. U. Burliev. *Nauch.-Tekh. Ref. Sbornik Sakhar. Prom.*, 1976, (4), 12-14 *(Russian)*. – Guidance is given on selection and use of sugar dust separators in the USSR.

The relationship between raw juice and 2nd carbonatation juice purities. I. A. Oleinik. *Nauch.-Tekh. Ref. Sbornik Sakhar. Prom.*, 1976, (4), 20-22 *(Russian)*. – In an attempt to derive a relationship between the purities of the two juices, linearity was found for two distinct raw juice purity ranges: 83-87 and 87-91. Calculated values of 2nd carbonatation juice purity X obtained from empirical equations for the two ranges were in satisfactory agreement with factory values. The expressions are: $X = 23.429 + 0.784x$ for the 1st range and $X = 40.392 + 0.583x$ for the 2nd, where x is raw juice purity.

pH change during heating of thick juices with different sodium sulphite doses. A. R. Sapronov, L. I. Ryazantseva and A. Yu. Gadzhiev. *Nauch.-Tekh. Ref. Sbornik Sakhar. Prom.*, 1976, (4), 22-26 *(Russian)*. – Although sulphitation of juice from beet of high reducing sugars and N content has been effective in reducing colour formation during evaporation, it does not provide an alkaline thick juice unless 2nd carbonatation is stopped at pH_{20} 9.5-9.8 and sulphitation at pH_{20} 9.0-9.5, thereby giving a thick juice of pH_{20} 8.5. Sodium sulphite was added in various dosages to thick juice obtained in an experimental plant, to give a pH of 7.5. The juice, of 60°Bx, was then heated for 35 hr and the pH measured at 20° and 90°C at various time intervals. With increase in the dosage rate, the pH of the juices fell much less than in unsulphited juices, so that after heating the pOH had altered by 0.0019 unit as a result of addition of 0.02 $mole.litre^{-1}$ sulphite by comparison with 0.0148 unit in untreated juice. Thus, addition of sodium sulphite does impart thermal stability.

Methods and means of sugar dust separation and their evaluation. A. F. Zaborsin and K. U. Burliev. *Nauch.-Tekh. Ref. Sbornik Sakhar. Prom.*, 1976, (5), 1-9 *(Russian)*. – A survey is presented of sugar dedusters, with comparison of their performances, space requirements and relative installation and running costs.

Investigation of continuous centrifugalling with creation of a drop in air pressure across the screen. V. F. Kolomiets, V. G. Andreev, S. M. Grebenyuk and E. E. Egiseryan. *Nauch.-Tekh. Ref. Sbornik Sakhar. Prom.*, 1976, (6), 1-6 *(Russian)*. – The effect of the angle of slope of the conical basket on the performance of a continuous centrifugal operating under vacuum was investigated; baskets having slopes of 26-44° were used, with mother liquor viscosities of 0.2 and 3.5 $Pa.sec^{-1}$ and a spun sugar moisture content of 2.0 and 1.5%. Graphed results showed that throughput increased with increase in the basket slope up to a maximum after which it fell. The optimum slope for the lower viscosity massecuite was 32-33° and for the higher viscosity, 35-36°; these values compared with 29-31° and 32-33°, respectively, where no vacuum was used. Hence, massecuite throughput under these circumstances is increased.

A doser for unammoniated double superphosphate. A. P. Lapin and A. A. Kucheryavenko. *Nauch.-Tekh. Ref. Sbornik Sakhar. Prom.*, 1976, (6), 7-8 *(Russian)*. Treatment of diffusion water with $Ca(H_2PO_4)_2$ improves diffusion in a number of ways, and details are given of a dosing system installed for the DDS-30 diffuser at the authors' sugar factory.

A multi-channel pneumatic conveyor for white sugar. R. Tazhiev and A. P. Fedorov. *Nauch.-Tekh. Ref. Sbornik Sakhar. Prom.*, 1976, (6), 9-12 *(Russian)*. Trials are reported with a multi-channel system at Tagotin experimental factory. Pipes of 1 m diameter and 3.5 m long were located at angles in the range 0-90° from the horizontal and the throughput ($kg.min^{-1}$) of white sugar of 0.17% moisture content determined. Results are tabulated.

Effect of system factors on the equilibrium of scale formers in the system solution-deposit. A. T. Bogorosh, N. A. Arkhhipovich, I. S. Gulyi and I. M. Fedotkin. *Nauch.-Tekh. Ref. Sbornik Sakhar. Prom.*, 1976, (6), 12-24 *(Russian)*.–In a study of scale formation, various process parameters have been found to affect the change in quantity of scale-forming ions in solution and in solid scale. Addition of a small quantity of CO_2 (up to 1 $m^3/100\ m^3$ solution) creates turbulence and alters both solution and scale composition. Analysis of scale in a carbonatation juice heater showed that calcium carbonate was the main component and existed as both calcite and aragonite. At 400-600°C rhombic crystals of aragonite change to trigonal calcite (an endothermic process). Heating under gas-liquid conditions (with bubble flow) trebles the CO_3^{--} content in the juice, leading to a considerable reduction in Ca^{++} and Mg^{++} concentrations; moreover, increase in the heat exchange rate resulting from the turbulent flow reduces the HCO_3^- content, so that the soluble bicarbonate content is also reduced, as is the pectin content. The effect of similar heating conditions on raw juice are also indicated. A nomogram is presented for calculation of optimum conditions of gas-liquid heating.

Installation of gates on flumes in the beet yard. A. P. Lapin and A. A. Kucheryavenko. *Nauch.-Tekh. Ref. Sbornik Sakhar. Prom.*, 1976, (8), 1-3 *(Russian)*. – After the depth of the flumes had been increased to 3 m at the authors' factory, problems arose with regularization of beet feeding to the factory; beets frequently accumulated at the slide gate and underwent marked deterioration as a result of inadequate water flow and rubbing along the wall. The problem was overcome by installing concrete weirs with pivoting grids set in them; these allowed water to flow in reverse direction while the beets were held pending their feeding from the branch flume to the main flume and thence to process.

New equipment in the sugar industry. V. A. Kanygova. *Nauch.-Tekh. Ref. Sbornik Sakhar. Prom.*, 1976, (9), 1-4 *(Russian)*. – Descriptions are given of two pieces of equipment of Polish design: a plate filter intended for 2nd carbonatation juice, and a thin-film evaporator.

SUGAR REFINING

The evaluation of ion exchange resins for sugar decolorization. W. Fries and R. W. Walker. *Proc. Tech. Session Cane Sugar Refining Res.*, 1978, 37-45. – A system which is described and illustrated has been developed for operation during 168 hours a week, with little attention or maintenance, for continuous cycling of a decolorizing resin bed used to treat sugar liquor. This permits study of individual resins and comparisons as well as research of individual parameters affecting the process.

Dextran problems in sugar production. E. E. Coll, M. A. Clarke and E. J. Roberts. *Proc. Tech. Session Cane Sugar Refining Res.*, 1978, 92-106. – Analyses of sugars from different origins and of sugar factory products during a season indicated wide variations. Dextran can arise from deterioration of cane after harvesting and also as a consequence of poor house-keeping in the factory. It causes problems in the refinery and it seems advisable for establishment of a routine check program for dextran; a modified haze test method is described which would be suitable.

Minimum energy for refining sugar. F. G. Carpenter. *Proc. Tech. Session Cane Sugar Refining Res.*, 1978, 172-182. – Energy requirements for the various stages of the refining process are derived theoretically and the minimum calculated as 680 B.Th.U. per lb of sugar melted. A more realistic figure for a real refinery is 800, while the average for US refineries is 3000, the world average is 2000 and consumption at Thames refinery is 1000 B.Th.U./lb. The largest use is for evaporation in vacuum pans, so that, if a double-effect system could be devised, this would achieve a considerable saving.

Treatment of recovery massecuites at a refinery. V. N. Sheina and G. N. Mikhatova. *Nauch.-Tekh. Ref. Sbornik Sakhar. Prom.*, 1976, (1), 5-12 *(Russian)*. – At the Krasnopresnenskii refinery in Moscow, raw and wash run-offs from recovery massecuites were of much lower Brix than the mother liquors of the corresponding massecuites, indicating that some wash syrup was being mixed with raw syrup or that too much wash water was being added during spinning. A detailed mass balance was drawn up for all three recovery massecuites and corresponding run-offs and sugar, and a number of conclusions were drawn. Recommendations made to remedy the situation include hot pre-spinning of massecuite (the run-off from which is then sent to the crystallizer handling the massecuite) and installation of water dosimeters on the centrifugals.

Use of a vacuum filter with moving cloth for raw sugar processing. N. G. Lila, B. I. Eibozhenko and K. K. Kovalenok. *Nauch.-Tekh. Ref. Sbornik Sakhar. Prom.*, 1976, (2), 1-6 *(Russian)*. – FD-80 disc filters are used at a number of Soviet factories for sweetening-off mud from carbonatation liquor during post-campaign refining of cane raw sugar. However, sometimes mud becomes detached from the disc, allowing wash water to pass through the gap and reduce performance. To avoid this, the sugar factory at Korenovskaya is provided with a battery of eight disc filters for carbonatation liquor; after filtration, a suspension made up of some of the mud and partially filtered liquor is handled by a further battery of three disc filters; the mud from these is sweetened-off by spraying with condenser water to give a 10-15°Bx suspension which is then filtered on a moving-cloth vacuum filter, the mud from which is sweetened-off with hot condenser water at 10 $m^3.hr^{-1}$. Cake losses are 0.07% on raw sugar, 500 tonnes of which is refined daily.

Sugar dust separation at Primorskii sugar combine. V. N. Zharskii and T. Ya. Kravchenko. *Nauch.-Tekh. Ref. Sbornik Sakhar. Prom.*, 1976, (2), 9-11 *(Russian)*. Details are given of a wet deduster installed in the packaging section of the title refinery.

Transportation, reception and storage of raw sugar at Primorskii sugar combine. V. N. Zharskii, A. T. Kosyachenko, M. M. Druyan and V. U. Zaporozhets. *Nauch.-Tekh. Ref. Sbornik Sakhar. Prom.*, 1976, (3), 1-4 *(Russian)*. – The combine processes only Cuban raw sugar, which is transported to the refinery from Vladivostok in trucks. Diagrams illustrate the system used for piling the sugar in the 40,000 tonne bulk silo and for its retrieval. A second silo, of the same capacity, was to be built to allow the annual processing capacity of the combine to be increased to 200,000 tonnes.

Polish decolorization by means of a styrene-base resin. Anon. *Ann. Rpt. Sugar Milling Research Inst.*, 1978. While residual colour in the fine liquor obtained in melt decolorization could not be removed by recirculation through acrylic-base resins, laboratory experiments showed that further decolorization was possible by passing the liquor through a styrene-base resin (which is less expensive) to give a very low residual colour; the colour of carbonatation liquor treated by acrylic resin was reduced from 230 to 70 ICUMSA units by subsequent treatment with styrene-base resin. However, pilot plant trials, in which the first of two decolorizing columns contained acrylic resin (already used in previous experiments) while the second column contained fresh styrene-base resin, showed that the latter resin had a shorter service life than the former; even when regenerated with sodium hypochlorite after 60 and 78 cycles, its improvement in decolorizing performance was inadequate, and 45 cycles (when fine liquor colour reaches an index of 450) is considered the practical maximum. On the other hand, styrene-base resin is suitable for use, after fine liquor treatment with two beds of acrylic-base resin, to give a low residual colour; the lower colour load would increase the life of the resin.

Liquid sugar by chromatographic molasses desugarization process. H. J. Hongisto. *Proc. 38th Ann. Meeting Sugar Ind. Technol.*, 1979, 22-38. – See *I.S.J.*, 1979, **81**, 133.

The design, start-up and operation of a continuous liquid sugar manufacturing facility. D. E. Webster. *Proc. 38th Ann. Meeting Sugar Ind. Technol.*, 1979, 48-101. – See *I.S.J.*, 1979, **81**, 134.

The effects of raw sugar quality on the refining process. J. V. López-Oña, D. M. Humm, L. G. Sansaricq, S. J. F. Winn and W. R. Tuson. *Proc. 38th Ann. Meeting Sugar Ind. Technol.*, 1979, 124-181. – See *I.S.J.*, 1979, **81**, 135.

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LABORATORY STUDIES

Titrimetric determination of reducing sugars with copper (II) sulphate. T. H. Khan. *Analyst*, 1979, **104**, 261-265. Details of modifications to the Lane & Eynon method of reducing sugar determination to minimize error and variability are described: as well as a constant boiling time, the time required to reach boiling point should also be constant; boiling the reaction mixture of sugar and Fehling's solution for 5 minutes before addition of the methylene blue indicator caused the cuprous oxide to settle to the bottom of the flask, leaving a clear supernatant instead of one which was red or orange, owing to the presence of coagulated oxide; this also yielded a colourless end-point, and disappearance of the last trace of blue colour could be seen; only 1 drop of 0.1% methylene blue solution was needed as indicator, and this gave a sharp colour change at the end-point. Increasing the reaction time from 1 to 3 min avoids errors caused by excess of sugar solution, while use of a 200 cm^3 Erlenmeyer flask instead of a 300 or 400 cm^3 flask gives a greater height of liquid layer and so improves detection of the end-point. By allowing the Fehling's solution to stand overnight, the tedious filtration of the solutions through treated asbestos becomes unnecessary.

Establishment of the technological value of sugar beet on the basis of cell juice purity. S. Zagrodzki. *Zuckerind.*, 1979, **104**, 206-209 *(German)*. — A correlation was obtained between purity of cell juice (obtained by centrifuging brei at 2800 rpm) and purity of raw and carbonatation juice (also obtained in the laboratory) at a sugar loss in exhausted cossettes of 0.3% on beet. From the relationship and the quantity of non-sucrose formed during evaporation and boiling (0.02-0.12% on beet), the total quantity of non-sucrose occurring in molasses was established. A graph expressing the effect of beet cell juice purity on molasses sugar content, at a molasses purity in the range 60-62, beet sugar contents of 12, 14, 16 and 18% and a pulp sugar content of 0.3%, indicates the dominant effect of pulp sugar content and amount of non-sucrose formed during processing on molasses non-sucrose content, from which it is shown that white sugar yield can be calculated from the beet sugar content. For reasons stated, high molasses purities are not considered.

The role of ammonia and amides in the formation of colouring matter. I. F. Bugaenko. *Nauch.-Tekh. Ref. Sbornik Sakhar. Prom.*, 1976, (1), 12-16 *(Russian)*. A study was made of colour formation in model solutions heated at 100°C for 1-4 hr. The solutions were 0.05M invert sugar with and without 0.025M nitrogenous compounds (glutamic acid, glutamine, ammonium chloride, aspartic acid and asparagine — ammonium chloride also being added with the glutamic and aspartic acids). Gel chromatography on Sephadex G-10 and spectrophotometry were used in the investigations. In all cases, optical density rose with time of heating at pH 8 and 9; but at pH 12 there was little difference between the values for each solution with time. The results are interpreted.

The effect of sucrose caramelization products on the viscosity of saturated sugar solutions. A. P. Moldyrev, I. P. Orobinskii and R. I. Tyulyakova. *Nauch.-Tekh. Ref. Sbornik Sakhar. Prom.*, 1976, (2), 12-14 *(Russian)*. Studies showed that, at a concentration of 0.050 g/g water, the title products caused the viscosity of a saturated solution obtained from low-grade massecuite to fall below that of a pure solution. The same applied to Brix. In the presence of > 0.075 g/g caramelization products, viscosity rose to above that of a pure solution. In both types of solution, viscosity was greater at 30° than at 40°C.

Effect of decolorization method on the amino-acid composition of thick juices. L. I. Ryazantseva, G. V. Ovchinnikova, P. E. Shepetnev and A. R. Sapronov. *Nauch.-Tekh. Ref. Sbornik Sakhar. Prom.*, 1976, (2), 17-21 *(Russian)*. — Unsulphited thick juice was treated with active carbon and anion exchange resin in Cl^- form, respectively, adjusted to pH 7.5 and 60°Bx and heated for 25 hr. Amino-acids were isolated on a cation exchanger in H^+ form and eluted with 2N NH_4OH solution, after which the eluates were evaporated and the solid residue dissolved in a citrate buffer. Comparison was made between the amino-acid concentrations in both carbon- and ion exchange-treated thick juices as well as in sulphited and unsulphited thick juices not subjected to decolorization, and for each sample before and after heating. Results are tabulated, and indicate that all amino-acids and amides took an active part in the formation of colouring matter, the quantity of total and individual amino-acids being governed by the decolorizing method used; in all cases, heating caused a marked increase in the amino-acid concentrations. The highest free amino-acid concentration occurred in the non-decolorized sulphited juice; the sulphite blocked the aldehyde and ketone groups and thus inhibited melanoidin accumulation.

Ebulliometry of pure aqueous solutions of sucrose. V. I. Tuzhilkin and A. A. Slavyanskii. *Nauch.-Tekh. Ref. Sbornik Sakhar. Prom.*, 1976, (3), 4-11 *(Russian)*. Raoult's first law, whereby the fall in vapour pressure of a solvent is proportional to the concentration of the solute, is not valid for sucrose solutions since it does not allow for boiling point elevation (BPE). The Gibbs-Duhem equation demonstrates the dependence of sucrose activity in solution on both concentration and temperature. By Raoult's second law, BPE is proportional to solute concentration but not its nature. Experimental data for dilute sucrose solutions obtained at an accuracy of ± 0.00001°C demonstrate the validity of the second law at concentrations up to 0.327 mole/100 g. However, while the BPE of undiluted solutions alters according to a linear law, the linearity is different from that of Raoult's law, the divergence increasing with concentration. The values of BPE obtained by four authors are compared for sugar concentrations of 60-90%, and calculation of supersaturation as a function of BPE is discussed. The use of an ebulliometric method demands high precision in the measurement of BPE, since supersaturation will alter by ± 0.05 for every 0.1°C error in the measurement. Conflicting data have been obtained on the effect of crystal content on BPE.

Pressure depression also affects BPE, but this effect falls with increase in circulation, so that where a pan is provided with a massecuite stirrer, the BPE will be practically constant throughout boiling.

Application of a method of thin-layer chromatography to determination of organochlorine pesticides in molasses and pulp. A. Z. Usmentseva and A. Ya. Zagorul'ko. *Nauch.-Tekh. Ref. Sbornik Sakhar. Prom.*, 1976, (3), 12-17 *(Russian)*. — A method for determination of organochlorine pesticides (Heptachlor, polychloropinene, γ-BHC, DDT and its metabolites, DDD and DDE) in beet pulp and molasses is described. For extraction of the pesticides, best results were given by petroleum ether or *n*-hexane (85-96% extraction from molasses and 80-90% from pulp). Extract purification was carried out by adsorption on columns of various adsorbents, most of the co-extracted impurities being colorants. Best results were obtained with Magnesil, Florisil, AV-17-2P and EDE-10p anion exchange resins, Sephadex A-25 and MR-200 active carbon; MgO, KAD active carbon and cellulose adsorbed too much pesticide. TLC on silica gel or alumina, with *n*-hexane as mobile solvent and silver nitrate as spot developer, was followed by U.V. irradiation of the chromatogram, permitting detection of as little as 0.1 μg pesticide.

Chromatographic determination of small quantities of Phosphamide and Methylmercaptophos in sugar. A. Z. Usmentseva. *Nauch.-Tekh. Ref. Sbornik Sakhar. Prom.*, 1976, (3), 18-20 *(Russian)*. — The title insecticides (toxic to humans) were extracted from 50 g sugar three times with chloroform (30 cm^3 each time), the extracts then combined and passed through anhydrous sodium sulphate, followed by evaporation almost to dryness under vacuum on a hot water bath at $\geq 40°C$ and spotting on a plate of KSK silica gel finer than 100 mesh and bonded with starch. After the solvent front had risen 10 cm, the plate was treated with an indicator (0.05 g bromophenol blue in 10 cm^3 acetone), made up to 100 cm^3 with a solution of 0.5% silver nitrate in 3:1 aqueous acetone. The blue background was eliminated with 5-10% acetic acid, and the plate dried for 10-15 min at 35°C . Acetone was used as mobile solvent for Methylmercaptophos, and 2:3 *n*hexane:acetone for Phosphamide; R_f values for the former pesticide were 0.71-0.75, and for the latter pesticide 0.61-0.65. Recovery was in the range 88.595.1%, limits of detection being 0.07 ppm for the former and 0.03-0.04 ppm for the latter pesticide.

Methods of purifying extracts of sugar-containing food products in the determination of micro-quantities of pesticides. A. Z. Usmentseva, L. D. Lokantsova, M. A. Klisenko and D. B. Girenko. *Nauch.-Tekh. Ref. Sbornik Sakhar. Prom.*, 1976, (4), 14-19 *(Russian)*. — More than 25 adsorbents were tested for elimination of colorants, waxes and lipids from extracts obtained from sugar or molasses[1] in the determination of pesticides. Results are given for the 14 found to be the most suitable in column adsorption.

The kinetics of sucrose decomposition in concentrated solutions. M. Muro, L. P. Reva and A. P. Kozyavkin. *Nauch.-Tekh. Ref. Sbornik Sakhar. Prom.*, 1976, (12), 7-12 *(Russian)*. — Model buffered solutions having an initial sucrose content of about 59% were heated at 70, 80 and 90°C for varying periods. The initial pH (ranging from 3.97 to 10.20) varied by no more than ± 0.2 during heating. The quantity of sugar decomposed was determined by subtraction of final from initial concentrations, and hence the decomposition rate constant K established. An empirical equation was derived whereby $K =$

$$10^{10.04 - \frac{3797}{T} - pH} + 10^{17.55 - \frac{8829}{T} - 0.017T + 0.6pH}$$

where T is temperature. For pure solutions, $10^{10.04}$ becomes $10^{9.96}$, and $10^{17.55}$ becomes $10^{17.47}$. The pH at which sucrose decomposition is minimum ranged from 9.05 at 30°C to 7.85 at 100°C . Comparison was made between experimental and calculated values of K.

Determination of sucrose by the isotope dilution method. I. Isolation of sucrose from molasses. L. Skála and M. Friml. *Listy Cukr.*, 1979, **95**, 64-70 *(Czech)*. Methods of isolating sucrose from molasses for determination by isotope dilution were compared, and the best found to be that in which 6 g of ^{14}C-sucrose was added to 12 g of molasses diluted with 30 cm^3 of water at 60°C; 48 cm^3 of 99% acetic acid was then added, followed by thorough mixing, and the mixture allowed to stand at a low temperature for 48 hours. The crystalline mass was then filtered off, washed with 99% acetic acid and ethyl alcohol and dried at 60-70°C. Sucrose yield was approx. 62% and its ash content 0.0001%.

Indicators of non-sugar removal during raw juice purification. M. Wachowicz. *Gaz. Cukr.*, 1979, **86**, 54-55 *(Polish)*. — The three indices proposed by Vukov[2] as criteria of juice purification efficiency in terms of non-sugar removal (the non-sugar index, alkali ash index and lime salts index) were applied to juices from two Polish factories, and the values compared with threshold values established by Vukov to show where performance was satisfactory or unsatisfactory. Details are also tabulated of raw, thin and thick juice parameters from the two factories. The findings are discussed.

Non-sucrose changes during sugar processing. P. G. Morel du Boil and K. J. Schäffler. *Proc. Tech. Session Cane Sugar Refining Res.*, 1978, 107-135. — Analyses of syrup and molasses weekly composite samples were made over a 9-month season for Brix, pol, reducing substances, non-fermentable reducing substances, sucrose (by Lane & Eynon titration after hydrolysis and by gas chromatography), dextrose and levulose (by oximation, silylation and gas chromatography), chloride and amino-nitrogen. Reducing sugars other than dextrose and levulose are formed during boiling, and increases in the levulose:dextrose ratio are shown to be due mainly to loss of dextrose. There was no apparent seasonal trend in amino-N levels, but a significant decrease was found between syrup and molasses. The influence of the major optically active impurities on pol measurement is discussed and a correlation established between pol and the three sugars sucrose, dextrose and levulose. There is a slight increase in optically active substances between syrup and molasses. Part of this increase is apparent and due to the effect of dry lead acetate on the pol analysis.

[1] See Usmentseva & Zagorul'ko on this page
[2] *Zucker*, 1974, **27**, 23-26.

BY-PRODUCTS

The distribution of distillery slops in São Paulo, Brazil. F. O. Brieger. *Sugar y Azúcar*, 1979, **74**, (1), 42-43, 46-47, 49. — Vinasse contains plant nutrients originating from the cane and subsequent processing, and it must be analysed to determine its applicability for agricultural purposes. The value of vinasse as a fertilizer has been recognized in Brazil since 1950, and studies made on this application are briefly surveyed. Distribution by gravity through furrows is discussed and its drawbacks pointed out. A distribution tank truck designed by Santal is described and an account given of the economics of vinasse disposal. Use of vinasse as fertilizer affects the composition of juice in the cane grown on the soil concerned, as is explained, particularly in respect of a higher ash and starch content, which affects the quality of the white sugar produced. The cane yield is increased, however, and trials are needed to determine, for each area, the optimum level of vinasse to apply.

Trace elements in carbonatation mud and their practical use. A. Kubiak, J. Stachowiak and E. Foremska. *Gaz. Cukr.*, 1979, **86**, 56-57 *(Polish)*. — The macro- and micro-element composition of carbonatation mud is indicated and the contents of each element compared with the requirements of cattle. The values for iron and zinc differ considerably between 1975/76 and 1977/78, while those for copper, manganese, molybdenum and cobalt are only slightly different. However, in all cases the maximum values tabulated are below the toxic level, although in most cases they are above the optimum range. However, it is considered that carbonatation mud can be a valuable source of the elements for cattle.

Production of citric acid from cane molasses on a semi-pilot scale. F. A. Hamissa and A. Radwan. *J. Gen. Appl. Microbiology*, 1977, **23**, 325-330; through *S.I.A.*, 1979, **41**, Abs. 79-364. — *Aspergillus niger* NRRL 599 was cultured on media based on molasses from three Egyptian cane sugar factories and one refinery. The molasses were diluted, clarified by centrifuging, brought to a sugar concentration of 15% and supplemented with 0.2% NH_4NO_3. Yields of citric acid up to 59.7% on total sugars and up to 69.0% on sugars consumed were obtained. Yields were improved by addition of ethanol or methanol, especially the latter, the optimum methanol concentration being 2.5 vol.%. Addition of $K_4Fe(CN)_6$ in the presence of 2.5% methanol did not increase the citric acid yield, but, in the absence of methanol, addition of 0.15 weight % $K_4Fe(CN)_6$ doubled the yield.

Effect of new granulated organic-mineral fertilizer on sugar beet yield. E. G. Ivashchenko, V. I. Gudim, L. M. Kozak *et al. Visnyk Sil's'kogospodars'koi Nauki*, 1976, (8), 9-14; through *S.I.A.*, 1979, **41**, Abs. 79-371. Vinasse from yeast manufacture was slurried with superphosphate at a dry solids ratio of 0.6:1 or 1:1 and heated to 80°C, forming a series of organophosphorus and K-P compounds; the mixture was granulated and tested as fertilizer for beet in three regions for three years. Tabulated results show its effect; with extra N, yields were similar to those with conventional N-P-K fertilizer.

Regimes for conveying (beet) pulp along pipelines. L. I. Grachova and M. M. Shumlyak. *Visnyk Sil's'kogospodars'koi Nauki*, 1976, (4), 81-84; through *S.I.A.*, 1979, **41**, Abs. 79-448. — A study on the hydrodynamic behaviour of mixtures comprising 10-60% fresh beet pulp in water is reported. Results include the effect of pipeline diameter and speed of mixture on pressure loss (for various mixtures and pipeline materials) and extent of abrasion. It is concluded that wide pipelines (20-30 cm in diameter) should be used, pressure being generated by centrifugal or screw pumps which do not decrease the particle size; particle size reduction appears inevitable if the mixture contains > 60% pulp, with difficulty in subsequent separation from water, but high pulp concentration is advisable to avoid the transfer of unnecessary water. It is recommended that the velocity should be 10% above that for which pressure loss is minimum for the particular mixture; pipelines should be rotated through 120° occasionally in order to equalize abrasion.

Economic aspects of the industrialization of bagasse. H. Noa S. *ATAC*, 1978, **37**, (3), 16-26 *(Spanish)*. — Cane sugar factories are generally designed with boiler efficiency such that they are self-sufficient in fuel with bagasse only and do not need to use supplementary fuel. This still represents only about 60-80% efficiency, however, and more efficient combustion could release quantities of bagasse for conversion to pulp and paper, etc. The investment required in plants for manufacture of pulp, artificial wood, furfural and activated carbon are tabulated; the last two require least capital and can operate economically with smaller amounts of bagasse. The various types of product which can be made from bagasse are described, and the quantities of bagasse which should be available from factories of different sizes are tabulated. As the price of oil increases, so the economics of bagasse utilization projects improve.

Power alcohol in the Sudan: a case study. O. M. R. Brown. *Paper presented at UNIDO Fermentation Alcohol Workshop*, 1979, 12 pp. — The feasibility of producing alcohol from cane molasses at distilleries erected adjacent to Sennar and Kenana sugar factories and using it in a 80-90:20-10 gasoline:alcohol blend is discussed. Economic factors involved in such a program are discussed.

Agrochemistry comes of age. Fermentation alcohol as basic raw material for a chemical industry. P. Yakovleff and M. Goharel. *Paper presented at UNIDO Fermentation Alcohol Workshop*, 1979, 26 pp. — The practicality of producing polyethylene and polyvinyl chloride from ethylene obtained via ethanol from cane molasses is discussed, and diagrams illustrating this and production of ethanol derivatives by dehydration, dehydrogenation and oxidation are reproduced. Economic factors are considered.

The ethanol-based chemical industry in Brazil. F. A. Ribeiro. *Paper presented at UNIDO Fermentation Alcohol Workshop*, 1979, 68 pp. — The development of the ethanol-based chemical industry in Brazil from 1920

to 1974 is traced, and the National Alcohol Plan (PRO-ALCOOL) instituted in November 1975 is described. The various alternative raw materials available in Brazil for alcohol production are examined, including sugar cane, and prospects of new ethanol-based chemical projects are discussed. The main derivatives and processes used in the title industry are described with the aid of diagrams, and the economics are indicated.

Use of ethyl alcohol as chemical feedstock. A. Yamazoe. *Paper presented at UNIDO Fermentation Alcohol Workshop*, 1979, 39 pp. – Advantages of alcohol over petroleum as chemical feedstock are discussed, and factors to be considered in production of fermentation alcohol from, e.g., sugar cane, are examined. The main derivatives of ethanol itself as well as ethylene and acetaldehyde are indicated. The economics are also discussed.

Fuel alcohol from crops by continuous fermentation. R. G. H. Prince and D. J. McCann. *Paper presented at UNIDO Fermentation Alcohol Workshop,* 1979, 20 pp. The possibility of producing fermentation alcohol from sugar cane, sugar beet, fodder beet or cassava is discussed, and a continuous process described[1]. The economics of alcohol production from each raw material (except fodder beet) are compared.

Power alcohol industry for Thailand: potential and prospect. T. Vicharangsan. *Paper presented at UNIDO Fermentation Alcohol Workshop*, 1979, 18 pp. – The possibility of establishing an alcohol production program in Thailand with the aim of using gasoline:alcohol blends as motor fuel is examined. Three types of distillery are envisaged: (i) attached to a sugar factory, (ii) using surplus cane from the sugar industry and cane grown especially for alcohol production and provided with cane crushing and diffusion equipment as well as distillation plant, and (iii) producing alcohol from both cane and cassava (the latter crop not being restricted to any particular harvest season). An outline is given of sugar cane and cassava production in Thailand.

Present status of the alcohol and alcohol-based chemicals industry in India. K. D. Sharma. *Paper presented at UNIDO Fermentation Alcohol Workshop*, 1979, 10 pp. The production of alcohol from cane molasses in India is beset with the problem of reduced molasses availability resulting from use of sugar cane for jaggery, etc.; this factor, plus the need to raise alcohol production efficiency, the need to improve pollution control, a call for greater financial returns on alcohol, and transport difficulties, has caused irregularity in alcohol supplies as feedstock for chemicals manufacture. The economics of alcohol and petroleum as chemical feedstock for a number of derivatives are compared; it is suggested that it may be more economical to use alcohol as feedstock and propylene only for the production of polypropylene.

The fermentation alcohol industry in Egypt in the last three decades. A. G. Madi. *Paper presented at UNIDO Fermentation Alcohol Workshop*, 1979, 10 pp. – The production of cane molasses and its use as starting material for production of animal fodder, yeast and alcohol in Egypt is outlined, and the chemical composition of the molasses presented. By the end of the present decade, more than 500,000 tonnes of molasses (beet and cane) is expected to be produced annually. Of the alcohol produced from cane molasses in straight-run distillation in plants owned by the Egyptian Sugar & Distillation Co., 80% is pure ethanol. The market distribution of pure and denatured alcohol is indicated. The fermentation technique used to produce alcohol and fodder yeast in a single process is briefly described, and scaling and descaling of the mash columns discussed. Also described is the problem of yeast flocculation and its remedy, purification of CO_2 produced during molasses fermentation by *Saccharomyces cerevisiae* (the impurities were mainly acetaldehyde and butyraldehyde), and the problem of fermenter cooling under tropical conditions. Possible means of treating 1500 $m^3.day^{-1}$ vinasse of high BOD are discussed; of the methods, the most suitable is considered to be fodder yeast production.

The interaction between energy accounting and cost accounting in the production of liquid fuels from biological materials. P. F. Greenfield and D. J. Nicklin. *Paper presented at UNIDO Fermentation Alcohol Workshop*, 1979, 8 pp. – In a discussion of the economics of liquid fuel synthesis (such as ethanol production from cane in Brazil), the authors stress the need to allow for the energy required in operation of the plant when calculating both the capacity of the plant and the production economics. Otherwise, where the cost of synthetic fuel is high relative to the market price and the net energy gain is small, massive errors can arise in estimating the cost of the fuel.

Experience with the Brazilian power alcohol plants. O. Prado, G. Costa Coimbra and G. Anderle. *Paper presented at UNIDO Fermentation Alcohol Workshop*, 1979, 13 pp. – The National Alcohol Program in Brazil is described, and its goals outlined. Reasons for the choice of sugar cane as raw material for fermentation alcohol production are listed, and points considered in evaluating new distillery projects are enumerated. Future trends and prospects are indicated.

New developments in continuous alcoholic fermentation: intensification – simplification – economization. J. Meyrath. *Paper presented at UNIDO Fermentation Alcohol Workshop*, 1979, 8 pp. – Major factors governing the economics of alcoholic fermentation of molasses are given as: yield per unit fermentable sugar, alcohol concentration in the mash, fermentation time, necessity for aseptic operation, reliability and ease of operation. The first three are discussed in turn, followed by consideration of biomass recirculating systems. Practice has shown that the high costs of centrifuges make a fermentation time of less than 8 hours uneconomical; however, with 8 hours' fermentation the separation plant required may cost some half of the entire plant. In view of the high capital and running costs of centrifugal separators and the fact that they are unsuitable for some developing countries (because of the need for maintenance and careful handling), a simple, cheap fermentation process has been developed which does not use centrifuges but involves extremely short fermentation periods. With low-grade molasses of 40-42% fermentable sugar content, 1.3-1.5 hours gives an alcohol concentration of 7.2-7.5% (by volume) and 95% of theoretical maximum yield (higher concentrations of 9.5-10.0% being obtainable with a two-stage process); 1 hour's fermentation of molasses containing at least 52% fermentable sugar will give 7.3% by volume alcohol in the wash, with 95% theoretical yield (12.5-13.0% being obtainable in 11.5-12.0 hours). Advantages of the process are listed.

[1] *I.S.J.* 1980, **82**, 44-45.

PATENTS

UNITED STATES

Centrifugal drum. W. Dietzel, S. Matusch and V. Hentschel, of Braunschweig, Germany, *assrs.* Braunschweigische Maschinenbauanstalt. **3,993,243.** March 25, 1975; November 23, 1976. – See UK Patent 1,474,003[1].

Cane ripening. L. G. Nickell, *assr.* Hawaiian Sugar Planters' Association, of Honolulu, HI, USA. (A) **3,994,712.** June 6, 1975; November 30, 1976. (B) **3,994,715.** April 17, 1975; November 30, 1976. – The sugar content of cane is increased by application (A) 2 – 10 (3 – 8) weeks before harvest of 1 – 80 (1–40) lb.acre^{-1} of 2-chlorobenzoic acid, 3-hydroxybenzoic acid, 3-cyanobenzoic acid or 4-methoxybenzoic acid or a mixture of these, or (B) 2-10 weeks before harvest of 1-4 lb.acre^{-1} of vanillin, ethyl vanillin or acetovanillin, in a water carrier containing 0.1 – 2% of a (non-ionic) surfactant.

Clarification and treatment of sugar (cane) juice. L. E. Paley, of Aurora, IL, USA. **3,994,743.** November 19, 1973; November 30, 1976. – Raw unheated cane juice is (centrifuged and) treated with an aqueous slurry of pH 6.8 – 8.5, comprising (a) lime, NaOH or a mixture of these, (b) powdered active carbon and (c) water. The mud is settled and the water-white supernatant juice separated and concentrated to give direct white sugar and edible molasses, the latter having a natural maple flavour and odour. The juice is produced from cane which is steam-cleaned to remove dirt and wax.

Cane harvester chopper mechanism. R. F. Spargo, of Bundaberg, Australia, *assr.* Massey-Ferguson Services N.V. **3,995,520.** May 23, 1975; December 7, 1976.

Increasing the sucrose content of cane. J. E. Franz, of Crestwood, MO, USA, *assr.* Monsanto Co. **3,996,040.** June 27, 1975; December 7, 1976. – The sucrose content of cane is increased by treatment [2 – 8 (3 – 7) weeks before harvest] with an effective amount (0.11 – 5.6 kg.ha^{-1}) of a N-phenylsulphonamido-N-phosphonomethyl glycine of formula $RCO\text{-}CH_2\text{-}N(SO_2\text{-}R_1)\text{-}CH_2\text{-}PO_3H_2$, where R_1 = 2-X_a, 4-Y_b – phenyl, R = OH, a = b = 1 and X = Y = NO_2; or R = OH, a = O and b = O or 1; or R = a lower alkoxy group (*n*-butoxy), a = O and b = 1; or R = NH_2, a = O or 1 and b = 1, and Y = NH_2.

Sucrose esterification. K. J. Parker, R. A. Khan and K. S. Mufti, *assrs.* Tate & Lyle Ltd., of London, England. **3,996,206.** March 6, 1974; December 7, 1976. – A surfactant is prepared by reacting solid sucrose (of particle size < 250 μm) with at least one triglyceride (of a C_{16} – C_{18} fatty acid) (tallow) (in substantially equimolecular amounts) in the presence of (5 – 12% w/w of) a basic transesterification catalyst (K_2CO_3) at a temperature of 110° – 140°C (120° – 130°C, 125°C) without distilling off any component and in the absence of any solvent [but in the presence of (5 – 10% of) an emulsifier comprising a diglyceride, monoglyceride or the surfactant reaction product].

Continuous process for recovery of sugar from molasses. K. W. R. Schoenrock, C. L. Hsieh and H. G. Rounds, of Ogden, Utah, USA, *assrs.* The Amalgamated Sugar Co. **3,997,357.** October 17, 1975; December 14, 1976. An aqueous beet molasses solution containing 5 – 20% of sugar w/w is treated with 15 – 50% of the active CaO required to react with this sugar in the form of burnt lime, hydrated lime or milk of lime. The mixture is cooled to below 20°C and injected as a first stream into a second stream which is a slurry of ground lime in an organic liquid carrier inert to both CaO and sugar [an alcohol, ketone, amine, glycol, aromatic or aliphatic hydrocarbon, chlorinated hydrocarbon or ether (*iso*-propanol)], the amount of slurried lime being enough to provide 40 – 70% of the active CaO needed to react with the sugar in the molasses. The combined streams are passed through a static mixer to give a homogeneous mixture while maintaining a temperature below 20°C. The cool mixture is then filtered and the cake (of precipitated Ca saccharate) washed. The slurry is obtained by grinding active burnt lime in the inert carrier in a weight ratio of 0.5 – 2.5 : 1 for ½ – 2 hr. The separated organic liquid plus wash water is heated to precipitate residual saccharate (which is combined with the filter-cake) and vaporized to recover the liquid for recycling.

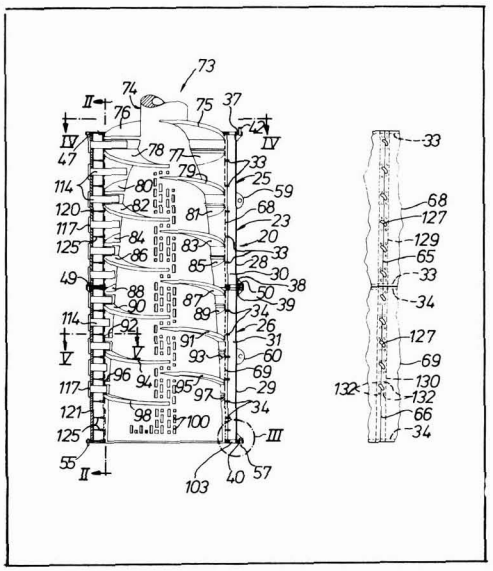
Beet pulp press. H. Mainka, H. Schmidt and G. Grosshennig, *assrs.* Salzgitter Maschinen AG, of Salzgitter, Germany. **3,998,148.** December 18, 1974; December 21, 1976.

The vertical press is in three portions, the top one including the drive means for the central shaft and also feed ports for the pulp and a pre-compression scroll to deliver pulp into the middle portion illustrated. The top portion is provided with a flanged bottom surface which is located on the upper flange 37 of the middle portion by means of centring pins and held tight by means of bolts 42. The housing of the middle portion is in the form of two tubes 25, 26, also flanged (38, 39) located by centring pins 49 and held together by bolts 50. The bolts 57 hold the bottom flange 40 of the middle portion to the upper flange of the bottom portion of the press housing, location being by means of centring pins 55. This bottom portion holds the supports for the shaft and the ducting for pressed pulp and expressed water.

The middle portion holds the shaft 74 which has a perforated surface (100) so that water can be expressed into the space inside. It carries the scroll elements 75 – 98 which convey the pulp from the top to the bottom of the press. Inside the tubular housing sections 25, 26 are a series of radial mounting members 30, 31 which carry rings 33, 34 which support the screens 68, 69 through which passes expressed water which drains in the channels between the screens and the outer walls.

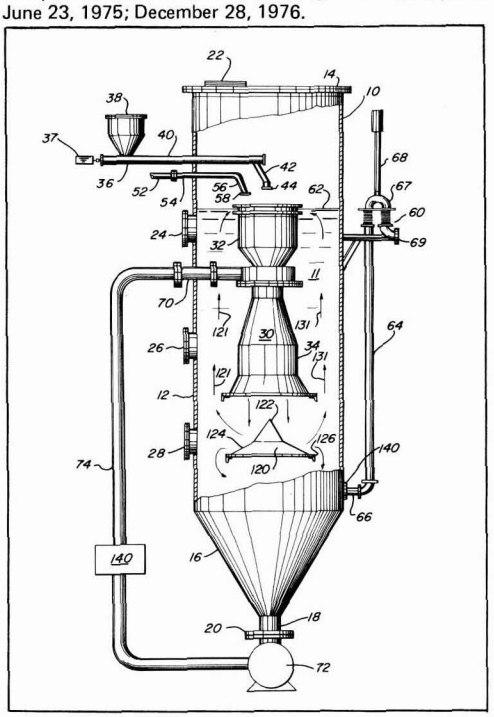
[1] *I.S.J.*, 1980, **82**, 129.

Copies of specifications of United Kingdom patents can be obtained on application to The Patent Office Sale Branch, Block C, Station Square House, St. Mary Cray, Orpington, Kent, England (price £1.25 each). United States patent specifications are obtainable from: The Commissioner of Patents, Washington, D.C., USA 20231 (price 50 cents each).



The edges of screen sections are held by screws 132 against edge members 129, 130 and these have apertures 127 through which protrude the stop arms 114. These are located between the limits of the scroll sections and prevent rotation of pulp with the shaft.

Saccharate precipitation vessel. L. Toth, of Denver, CO, USA, *assr.* The Great Western Sugar Co. **4,000,001.** June 23, 1975; December 28, 1976.



The vessel 10 includes a vertical wall 12 with an upper cover plate 14 and a bottom conical portion 16. Lime from hopper 38 is admitted to pipe 40 under the control of regulator 37 and passes through discharge pipe 42 to the exit which is co-axial with the vessel. Molasses solution is similarly admitted through pipe 52, 54, 56, pipes 40 and 54 passing through the wall 12 of the vessel. A conventional regulator 60 governs the liquid level in the vessel. Liquid withdrawn from the bottom of the conical portion 16 is directed by pump 72 through a cooler 140 and recirculated through pipe 70 into the agitator 30.

Liquid in the tank flows continuously through apertures in its upper periphery into the upper part 32 of the agitator. It is directed by the vortex action induced by the flow of liquid through pipe 70 and so passes downwards through the lower part 34 against the deflector plate 120 mounted inside the vessel. This induces recirculation of part of the liquid upwards while part is recirculated by pump 72. The high velocity and turbulence inside the agitator encourage rapid reaction of the incoming lime and molasses and permits use of molasses solutions of higher sucrose content. Part of the calcium saccharate suspension formed is withdrawn from the cooling unit 140.

Isomerizing dextrose with an enzyme immobilized within a microbial cell. N. Tsumura and T. Kasumi, of Tokyo, Japan, *assrs.* Director of National Food Research Institute. **4,001,082.** February 26, 1976; January 4, 1977. – (Intact) Microbial (bacterial) cells [from one of the genus of the group *Aerobacter, Lactobacillus, Brevibacterium, Bacillus, Microellobospora, Streptosporangium, Leuconostoc, Pasteurella* and *Actinoplanes* (a *Streptomyces* sp. or *Lactobacillus* sp.)] containing a dextrose-isomerizing enzyme, are heat-treated (treated with a flocculant) and dipped (at least twice) in an aqueous solution of $\geq$ 1% of citric acid or a metal salt (Li, Na, K, Mg, Co or Ca citrate or a mixture) (at pH 5 – 8) (at 0° – 80°C), [treated with a supplemental means to improve enzyme retentivity (ionizing radiation or an aqueous solution of Na_2SO_3, cysteine or glutaraldehyde)] and dried (at $<$ 50°C). The treated cells, containing the immobilized enzyme, are then brought into contact with an aqueous dextrose solution under conditions suitable for isomerization (in the presence of Mg, Mn or Co ions).

Medium for growth of micro-organisms. A. B. Rizzuto, R. D. Skole, H. H. Newman, J. N. B. Hogu and V. A. Toscano, *assrs.* Amstar Corp., of New York, NY, USA. **4,003,791.** September 29, 1975; January 18, 1977. Penicillin may be produced by growing a mould (*Penicillium chrysogenum*) in a culture medium in the presence of 4 – 8% (4%) w/v of a high-ash containing sugar syrup (e.g. affination syrup, refinery molasses) having an analysis of 40 – 85% (53 – 66%) (41 – 59%) (73 – 84%) sucrose, 8 – 30% (8 – 22%) (13 – 30%) invert sugar and 3 – 25% (8 –13%) (8 – 20%) ash, all by weight, the remainder (10 – 24%) (14 – 25%) being other organic components. The ash comprises 8 – 45% Ca, 2 – 7% Mg, 0.5 – 3% Na, 10 – 35% K, 0.1 – 0.5% Fe, 0.01 – 0.1% Cu, 0.1 – 0.7% other heavy metals, 4 – 55% sulphate and 1 – 15% phosphate. The medium also contains 1 – 5% (3%) w/v of corn steep liquor (solids), 0.5% (0.05%) w/v phenyl acetic acid or a derivative [N-(2-aminoethyl) phenyl acetamide] (and 0.2% $NaNO_3$, 0.5% $CaCO_3$).

Holland sugar imports and exports[1]

	1979	1978
	—— *tonnes, tel quel* ——	
Imports		
Austria	279	1,000
Belgium	44,607	39,278
Czechoslovakia	17	750
France	12,587	303
Germany, West	3,062	68
Poland	1,000	0
Surinam	2,171	3,124
Other countries	211	424
	63,934	44,947
Exports		
Algeria	5	3,000
Belgium/Luxembourg	4,104	9,515
Cameroun	0	500
China	0	22,300
Cyprus	0	1,000
Djibouti	15	500
Egypt	2,500	500
Germany, West	4,741	10,764
Ghana	60	500
Iran	59,253	23,012
Iraq	3,000	1
Israel	9,588	7,568
Ivory Coast	0	4,200
Jordan	21,345	0
Korea, North	0	9,163
Kuwait	1,950	900
Mali	800	0
Malta	6	1,213
Morocco	6,100	0
Nigeria	35,487	19,632
Oman	0	600
Sri Lanka	0	11,866
Sudan	3,800	9,950
Tunisia	10,350	36,550
UK	45,623	37,722
United Arab Emirates	2	1,502
USSR	35,500	0
Venezuela	0	15,000
Yemen, North	3,000	0
Yemen, South	0	3,000
Other countries	1,124	1,576
	248,353	232,034

US sugar consumption and production[2]. — The US Secretary of Agriculture has said that US sugar production in the 1980/81 season is expected to rise while consumption will most likely decline as the use of high fructose corn syrup increases and the world deficit in sugar supplies pushes domestic sugar prices up from present levels. Based on growers' planting intentions, sugar production from beet in the US is projected at about 3,000,000 short tons, raw value, up 4.3% from the 1979/80 level. Mr. Bergland said that higher sugar prices have resulted in increased investment in corn wet-milling facilities and consumption of high fructose corn syrup may exceed 2 million short tons (dry basis) in 1980 compared with 1.75 million short tons in 1979. Syrup shipments are expected to increase for the next 5-10 years, resulting in a continuing decline in US sugar deliveries and consumption. US sugar consumption could decline by perhaps 100-150,000 short tons annually. Domestic sugar deliveries totalled 10,760,000 short tons in 1979.

New Bangladesh sugar factories[3]. — Two new sugar factories to be built at Kushtia and Natore, together with extensions of the factories at Rajshahi and Mobarakganj, should permit self-sufficiency in sugar for Bangladesh.

Taiwan sugar export[4]

	1979	1978	1977
		tonnes, raw value	
Japan	121,849	165,635	296,746
Korea, South	216,976	136,534	160,478
Saudi Arabia	17,936	10,870	65,981
USA	25,733	51,476	78,227
Other countries	4,394	13,446	59,419
	386,888	377,961	660,851

Sudan sugar imports, 1979[5]. — In 1979, Sudan imported 201,108 tonnes, raw value, of sugar, against 220,193 tonnes in 1978 and 177,827 tonnes in 1977. The 1979 suppliers were Brazil (55,015 tonnes), the EEC (123,593 tonnes), India (12,000 tonnes) and Poland (10,500 tonnes).

Egypt sugar production, 1979[6]. — Sugar production in Egypt was 623,000 tonnes, tel quel, in 1979. Demand is expected to reach 2,000,000 tonnes a year by the year 2000 and, to cope with such an increase, a new sugar factory capable of producing 100,000 tonnes of refined sugar a year would need to be established every 18 months, according to the National Council of Production and Economic Affairs.

Sweden campaign results, 1979/80[7]. — In the 1979/80 campaign, the seven Swedish sugar factories sliced a total of 2,181,563 tonnes of beets, to produce 258,538 tonnes of white sugar, 66,749 tonnes of raw sugar, 88,063 tonnes of molasses, 94,842 tonnes of molassed dry pulp and 44,551 tonnes of molassed dry pulp pellets.

China sugar production[8] — Official figures issued by the State Statistical Bureau in Beijing (formerly Peking) have confirmed an earlier report from the US Embassy there that sugar production in calendar year 1979 reached 2,680,000 tonnes white value (made up of 2,400,000 tonnes of cane sugar and 280,000 tonnes of beet sugar), against 2,267,000 tonnes in 1978 (made up of 1,997,000 and 270,000 tonnes, respectively) and 1,816,000 tonnes in 1977 (made up of 1,570,000 and 246,000 tonnes). Based on other figures available, F. O. Licht estimate sugar production in the 1979/80 crop year to be about 2.5 million tonnes raw value, or about the same level as in 1978/79 so that import demands will be unchanged unless there are significant changes in consumption.

Norway sugar imports, 1979[9]. — In 1979 white sugar imports by Norway reached 171,475 tonnes against 163,257 tonnes in the previous year. The principal supplier was Denmark with 51,582 tonnes while the UK supplied 32,784 tonnes, Austria 23,833 tonnes, West Germany 22,288 tonnes, Finland 16,348 tonnes and Sweden 10,381 tonnes.

Argentina sugar production, 1979[10]. — Argentina's sugar cane harvest rose to 14.1 million tonnes in 1979 from 13.6 million tonnes the previous year, according to the final estimate of the Agriculture Department. The area harvested fell to 305,600 hectares from 343,000 hectares, but yields per hectare rose to 46.2 tonnes against 39.65 tonnes in 1978. Production of sugar from cane was 1,411,000 tonnes, raw value, against a production quota set by the Government of 1.32 million tonnes.

Malaysia sugar factory closure[11]. — The integrated sugar project, Syarikat Gula NS, formed by cooperation between the Negri Sembilan State Government and Phaltan Sugar Works, of Bombay, India, is closing down after six years in which it has incurred losses of around $14 million. The main reason for the closure is insufficient availability of cane; this is also the reason for heavy losses suffered by another venture, Gula Perak, which is now in the hands of receivers.

1 C. Czarnikow Ltd., *Sugar Review*, 1980, (1483), 51.
2 F.O. Licht, *International Sugar Rpt.*, 1980, **112**, 275-276.
3 *Zuckerind.*, 1980, **105**, 289.
4 F.O. Licht, *International Sugar Rpt.*, 1980, **112**, S56.
5 C. Czarnikow Ltd., *Sugar Review*, 1980, (1486), 68.
6 F.O. Licht, *International Sugar Rpt.*, 1980, **112**, 211.
7 *Zuckerind.*, 1980, **105**, 404.
8 F.O. Licht, *International Sugar Rpt.*, 1980, **112**, 175-180.
9 C. Czarnikow Ltd., *Sugar Review*, 1980, (1485), 63.
10 F.O. Licht, *International Sugar Rpt.*, 1980, **112**, 190.
11 *World Sugar J.*, 1980, **2**, (11), 39.

Guatemala sugar statistics[1]

	1979	1978
	tonnes, raw value	
Initial stocks	86,527	8,809
Production	414,802	445,931
	501,329	454,740
Exports		
Mexico	7,800	0
El Salvador	2,000	0
USA	185,686	140,539
USSR	0	12,003
	195,486	152,542
Consumption	223,049	368,213
Final stocks	82,794	86,527

Dominican Republic sugar exports[8]

	1979	1978	1977
		tonnes, tel quel	
Dutch Antilles	0	0	9,450
Finland	0	0	23,630
Morocco	0	4,040	52,840
Portugal	0	0	13,050
Puerto Rico	0	418	430
Senegal	6,500	6,200	25,900
Tunisia	0	0	12,600
USA	793,896	583,676	894,250
USSR	0	45,399	0
Venezuela	196,682	262,535	43,540
West Indies	7,738	7,129	8,410
	1,004,816	909,397	1,084,100

Sugar scheme for Ethiopia[2]. — The Ethiopian Sugar Corporation (ESC) has appointed Shawnigan Engineering Company of Canada as main consultant for a US $200 million sugar scheme to be built at Fincha, in Welega province. Shawnigan is to design a sugar factory with an eventual capacity of 129,000 tonnes a year, a 6000-hectare cane farm with an irrigation system, and a town, including services, for 4000 workers. Construction is expected to start in 1981 and production of 75,000 tonnes of refined sugar a year is planned for 1984/85. Redpath International and Agrodev Canada, both of Montreal, have been appointed as consultants for sugar refining and land development, respectively.

Syria sugar imports 1979[3]. — Imports of sugar by Syria rose from 182,916 tonnes, raw value, in 1978 to 285,433 tonnes in 1979. As in the previous year, the major suppliers were Cuba and the EEC.

Portugal sugar factory plans[4]. — The Administraçao-Geral do Açúcar e do Alcool is planning to build the first of four beet sugar factories, each of 50,000 tonnes annual sugar production capacity, at Ribatejo in the region of Muge.

Czechoslovakian bulk sugar silo design. — One of the most interesting exhibits at the International Food Industries Fair held in Brno, in March 1980, was a model of a metal silo for storage of up to 10,000 tonnes of sugar, constructed by ZVU Engineering Works in Hradec Králové, Czechoslovakia. It is claimed that this new silo has a number of advantages, including the possibility of direct linking with a packing line and lower maintenance, energy consumption and labour input than bagged sugar storage.

Sri Lanka sugar factory plans[5]. — In order to reduce the country's dependence on imports (expected to be 150,000 tonnes of 1979/80 consumption of 180,000 tonnes), Sri Lanka is establishing a third sugar factory. The Severagala Sugar Development Project is estimated to cost $52.2 million, with $39.9 million in foreign exchange and the balance in local currency. It will be financed by the Asian Development Bank. The project includes a sugar factory with a daily cane crushing capacity of 2000 tonnes and a 300 $hl.day^{-1}$ distillery. The government of Sri Lanka is at the same time negotiating with the World Bank for financial assistance for the establishment of another project, to cultivate about 20,000 acres for several mini-sugar factories in the Uva province.

Rumania sugar crop, 1979[6]. — Sugar production in Rumania reached 525,000 tonnes, white value, in 1979, which compares with 555,000 tonnes in 1978 and 516,000 tonnes in 1975. Total beet production in 1979 was 6,080,000 tonnes, 164,000 tonnes more than in 1978 and 1,250,000 tonnes more than the average during the period 1971/75. The beet yield per hectare in 1979 was 23.203 tonnes.

Thailand sugar production, 1979/80[7]. — A total of 12.12 million tonnes of cane was crushed during the 1979/80 season, producing 507,150 tonnes of white sugar for domestic consumption and 491,259 tonnes of raw sugar for export. Thailand will thus have available a total of about 700,000 tonnes of raw sugar for export, including 200,000 tonnes carried over from the preceding season. Originally, a minimum of 550,000 tonnes of white sugar had been required of the sugar producers before they could make raw sugar for export.

New Chinese sugar factories. — The New China News Agency reported that three newly-built sugar factories producing about 20,000 tonnes of sugar annually, with a daily handling capacity of 900 tonnes of beet, have begun operating in the Inner Mongolia Autonomous region in China. They added that this brings to 17 the number of sugar factories in that region having an annual capacity of 130,000 tonnes of sugar.

Zimbabwe fuel alcohol plant[9]. — Zimbabwe's first alcohol plant has been built in the "sugar cane" lowveld and a national blend of 15% alcohol, 1% benzol and 84% petrol is to be produced. The plant has cost almost $4 million but the net saving to the country in foreign exchange will be $3 — $4 million yearly.

South African cane crop damage by drought[10]. — The prolonged drought which is ravaging Zululand is likely to cut the new season's South African crop by 10% to 1,800,000 tonnes, tel quel, which would be the lowest since 1975/76. This is doubly unfortunate because South Africa will not be able to increase production to take advantage of the lifting of crop quota restrictions. South African Sugar Association extension officers say that they have never seen the cane in such poor condition as it is in Zululand from Gingindhlovu to Empangeni. There are practically no patches of green, only vast areas of brown dying cane. The Umfuli River, a tributary of the Umhlatuzi River, is bone dry. Farmers in the Entumeni area report that perennial streams that have not failed in 40 years are running dry. Adding to the problem, particularly in Zululand, is the Eldana borer outbreak which is threatening sugar cane, especially in the Amatikulu area. The General Manager of the Association has even said that production could be cut by about 20% which could halve South Africa's export capability.

Erratum — In line 3 of column 2 on page 137 of our May issue, the phrase "a very thick layer of scale" should read "a very thin layer of scale".

French food industry exhibitions. — During the period November 17 — 22, 1980, two important food industry exhibitions will be held in Paris. The 9th International Food Products Exhibition is in several parts but will include the Food Industry Engineering Exhibition, while there will also be an International Trade Show on Packaging and Presentation, both being at the Parc des Expositions. Information on the former is available from SIAL, 43 rue de Naples, 75008, Paris, and on the latter from SEPIC/Emballage, 40 rue du Colisée, 75381 Paris Cedex 08, France.

PERSONAL NOTES

Mr. A. M. Bartolo, formerly Vice-President — Refinery Operations of Imperial Sugar Company, has been promoted to Executive Vice-President of the Company. **Leon A. Anhaiser** has been promoted to Plant Manager of the Sugarland refinery.

1 C. Czarnikow Ltd., *Sugar Review*, 1980, (1485), 65.
2 F.O. Licht, *International Sugar Rpt.*, 1980, **112**, 192.
3 C. Czarnikow Ltd., *Sugar Review*, 1980, (1485), 62.
4 F.O. Licht, *International Sugar Rpt.*, 1980, **112**, 246.
5 *World Sugar J.*, 1980, **2**, (11), 39.
6 F.O. Licht, *International Sugar Rpt.*, 1980, **112**, 209.
7 *Standard Chartered Rev.*, April, 1980, 35.
8 F.O. Licht, *International Sugar Rpt.*, 1980, **112**, S111; C. Czarnikow Ltd., *Sugar Review*, 1980, (1492), 96.
9 *Standard Chartered Rev.*, April 1980, 12.
10 F.O. Licht, *International Sugar Rpt.*, 1980, **112**, 229.

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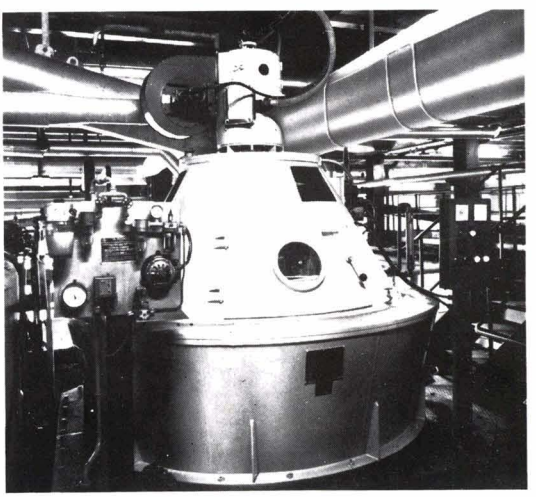

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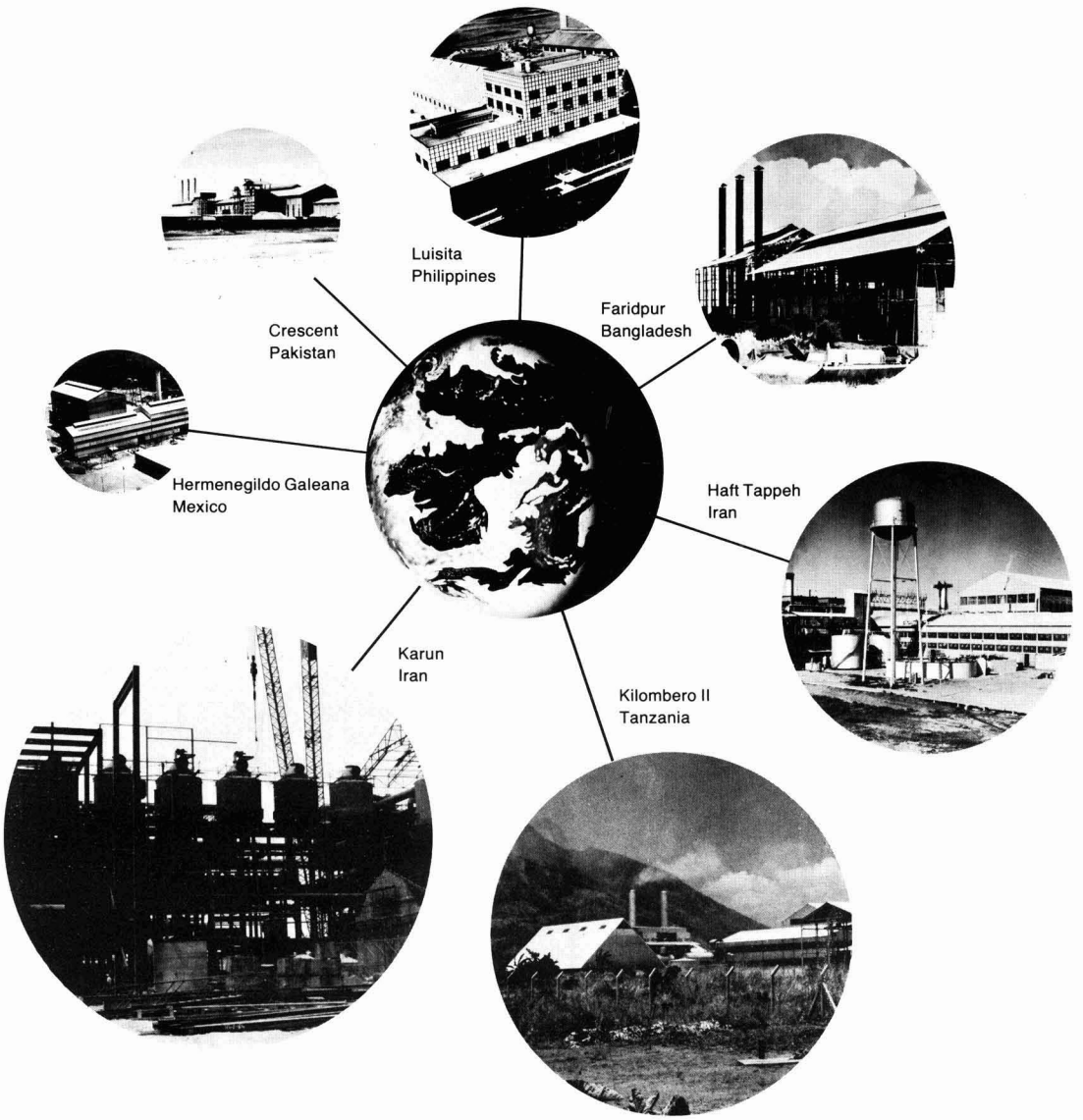

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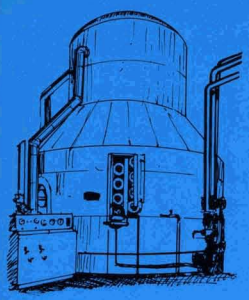

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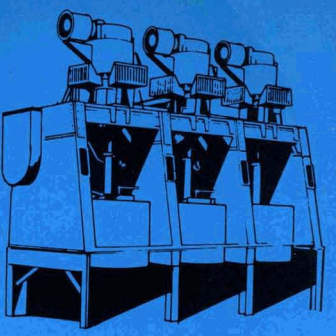

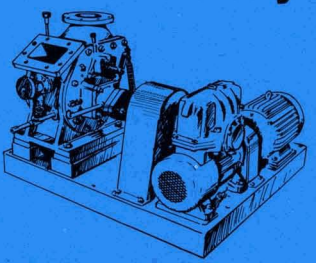

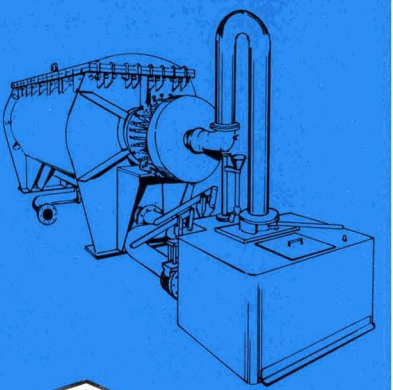

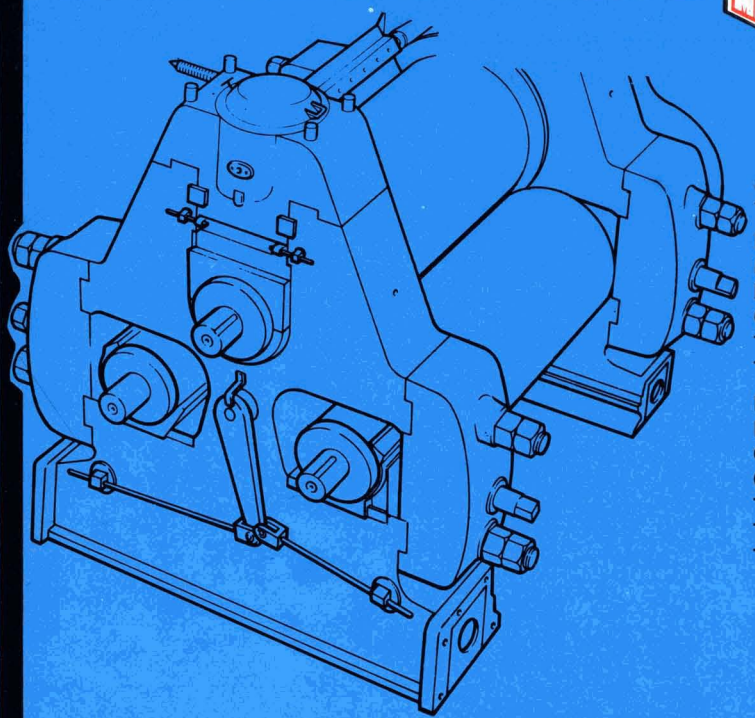

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