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United Nations Industrial Development Organization

Distr.
LIMITED
ID/WG.247/20
16 May 1977
ENGLISH

Joint UNEP/UNIDO Seminar on the Implication of Technology Choice in the African Sugar Industry

Nairobi, Kenya, 18-22 April 1977

ECONOMY OF SCALE IN THE SUGAR INDUSTRY 1/

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id.77-3532

I. INTRODUCTION

Although the question of economy of scale has been considered by many economists, especially since 1940 - cf.(15), yet little has been published, so far, on the economy of scale in the cane sugar industry. However, since more and more developing countries, especially in Africa, are considering the setting up of local sugar production, it is of interest to investigate this problem from the theoretical point of view, but also by utilizing practical examples from territories having a reasonably developed sugar industry.

Historically there can be no hesitation in stating that the change over from a large number of small sugar factories to a small number of large sugar centrals has taken place almost everywhere.

This is clearly exemplified in Figure I which summarizes the historical evolution in LOUISIANA, MAURITIUS and SOUTH AFRICA. Other sugar producing territories have generally experienced the same trend which indicates that there is an economy of scale in the cane sugar industry.

It is proposed, in what follows, to consider the various factors that make up the total cost of production of a tonne of sugar, and to show how this cost of production decreases with an increase in production capacity.

It must be pointed out that the problem of effluents has been made more difficult since they are now concentrated at the few localities where the large sugar centrals have been erected. But modern techniques are presently available to reduce the environmental impact of these effluents, and hence the difficulty experienced for their disposal, as will be indicated later in the text.

The data which will be used, when considering the various items of cost, are derived mainly from the Mauritius Sugar Industry and although their relative importance may vary from one sugar country to another, it is felt, however, that the general trends and conclusions would apply to any cane sugar industry.

II. GROWING THE CANE

As a first approximation, it can be stated that the number of man hours per year required to grow one tonne of cane is not significantly related to the size of the acreage under cane, especially if we consider plantations of 500 hectares or more.

However large cane estates can use more mechanical implements for land preparation, fertilization, planting, herbicide treatment, cutting and loading which would not prove economical on very small fields of one or two hectares. Hence cultivation man hours per tonne of cane on these mechanized large estates can be decreased, although one should be aware that the mechanized cultivation costs are often not lower than that depending, in a large measure, on manual work, especially now that the cost of energy has increased spectacularly since 1973.

From the data obtained in Mauritius, where mechanization is not yet greatly utilized, it follows that cultivation cost per tonne of cane is approximately constant and relatively independent of size of acreage under cane. It should be stressed, however, that for very small fields, in Mauritius, the tonnage of cane produced per hectare (10 000m^2)

is much lower than that of large estates, in a large measure because of less thorough and competent agricultural husbandry. This is indicated in Table I.

It must be pointed out, that, in some cane sugar producing territory, especially in TAIWAN, the cane produced per hectare, in small fields, is higher than what obtains in Mauritius.

There is a tendency, in many countries, for small planters to form co-operatives and, using more adequate methods on the larger acreage thus formed, to obtain better yields almost equivalent to the larger estates.

It can be concluded, bearing in mind this progressive improvement, that, in general, there is little economy of scale for cane cultivation and harvesting.

III. TRANSPORTING THE CANES

Let us assume that the cane fields form a circular area and that the sugar factory is located at the centre. This is the most efficient set up to minimize cane transport costs.

As the capacity of the factory increases, so must the field area to supply the necessary tonnage of cane. But simultaneously does the average distance of transport for the canes. This is indicated in Table II with a circular field area.

Cane estates are generally not circular, but rectangular in shape, with, hopefully, the factory at the geometric centre of the area.

However this results in an increase in the average transport distance of canes to the mill and, for a given area, the more we depart from a square configuration towards an elongated rectangle, the more does the average transport distance increases. This is indicated in Figure II.

It must be pointed out that many cane sugar producing territories are narrow and long - cf. Queensland, the South African Natal belt, the Hawaiian coastal belt, etc, with the result that the average cane transport distances are longer there than would be the case for an equal area of square shape.

This factor should be borne in mind when developing a new region under cane and a square configuration should be favoured, as far as the geographical constraints would allow.

Cost of transport varies with distance, but there is a significant fixed cost, so that transporting cane over say 10 km cost about US $2.22 per ton, while transporting over 1 km cost about US $1.14. So that as you increase the distance by 10:1 you only increase the cost by about 2:1. Table III indicates cost of cane transport applying in Mauritius presently.

So that although the cost of transport of cane shows an inverse or diseconomy of scale with increasing capacity, yet in the total build up of cost of production of sugar, as will be indicated later in the text, it has not got a sufficient weight to neutralize the other factors which produce economy of scale, such as administrative charges, depreciation, insurance, etc.

IV. PROCESSING THE CANE FOR SUGAR PRODUCTION

For a given factory capacity, it is fairly evident that under utilisation of this capacity will lead to increased milling (or processing) costs per tonne of cane. Similarly over utilisation, with rapid wear and heavy maintenance, will also lead to increased milling cost.

This point has been well covered by G.J. RYLAND (16), who also indicated that with increasing theoretical capacity, and with each factory working at its designed optimal capacity, we would have a general trend showing lowering of cost of production with increasing capacity, i.e. economy of scale.

This is indicated in Figure III which is adapted from Ryland (16).

We must now consider, in more details, the main items which added together build up the cost of processing.

(i) The first thing which is noticeable in processing is that the number of personnel employed does not increase in direct proportion to the capacity of the factory. The same remark applies to the administrative personnel and the direct changes associated with them.

The cost of these employees increase fairly slowly with increasing capacity and, as a first approximation, we can say that they increase as the $^{2}/_{10}$ th power of the capacity.

Thus if P is the cost of employees and C the capacity of the factory we can write : $\frac{P_1}{P_2} = \frac{C_1^{0.2}}{C_2^{0.2}}$ and Table IV

indicates how these changes vary with increasing capacity.

(ii) The second point which should be stressed, and which has been recognized in many industries - cf. (3), (7), (10), is that the capital cost of a raw sugar factory varies, approximately, as the $7/10^{th}$ power of the capacity. This relation has been checked with some sugar factories in Mauritius and appears to be a fair approximation for the sugar industry. It is indicated in <u>Figure IV</u> and although conditions may vary from one sugar producing country to another, yet the curve of Figure IV should be representative of the general trend for raw cane sugar factories.

Hence, in the cost build up of sugar production, items like depreciation, repairs and maintenance, machinery and plant insurance, etc, which are directly proportional to the replacement cost of the equipment, will vary as the $7/10^{th}$ power of the capacity of such equipment.

For those interested in more detailed data, Appendix A gives a nomenclature of the main items of three typical raw sugar factories of 120, 175 and 250 tonne cane per hour with indicative prices which were representative of conditions obtaining in Mauritius in 1973. The costs are expressed in Mauritian Rupees which were worth about US $0.18 per rupee at that time.

It has been a frequent and unfortunate feature, in the sugar industry, to duplicate small size equipments when planning an enlargement of capacity of factories. References (5) and (11) give a more rational approach to this problem. The conclusion to be drawn is that with proper planning a modern factory can show significant economy of scale and substantial reduction in the number of personnel employed for its proper operation and maintenance.

(iii) The other items of the cost of production of sugar can be considered, as a first approximation, to vary directly with the capacity of the factory.

To recapitulate there are three categories of items in the cost structure of sugar production :

(a) Factory and Administrative Personnel expenses which will vary as the $2/10$ th power of the capacity of the factory.

(b) Depreciation, repairs and maintenance, and plant insurance which will vary as the $7/10$ th power of the capacity of the factory.

(c) All other items, which have been assumed to vary in direct proportion to the capacity of the factory.

V. THE END RESULTS

It is now possible, bearing in mind the data and assumption made in Sections II, III and IV, to construct a table, with about 15 individual items of cost, which will indicate how the final cost of production of a tonne of cane (or of a tonne of sugar) varies with the capacity of the sugar estate. This data is contained in Table V. It has been established on the basis of the tonne of cane, as the sugar content of the cane varies appreciably from one region to another and, indeed, from one season to another. Once the cost per tonne of cane has been established, it is easy to translate this cost into its equivalent per tonne of sugar, utilising the average sugar extraction prevailing in the particular factory area concerned.

The figures in Table V, which are based on conditions generally obtaining in Mauritius, assume that the tonnage of cane produced per hectare is 76 tonnes and that the duration of the crushing campaign is about 130 working days. This data will have to be corrected when applied to specific areas where the productivity of cane fields and duration of crop are different. But it is believed that the general conclusion will still apply, demonstrating economy of scale, although in varying degrees.

The average cost of raw sugar production per tonne of cane was approximately US $30 in 1975 in Mauritius. Instead of using this figure which varies and inflates from year to year, Table 5 utilises the index cost figure of 100 for a sugar estate having a capacity of 100 TCH. And cost figures for larger capacities are expressed in relation to this 100 index cost figure.

In order not to make Table V too complicated the transport cost of cane has been envisaged for only two specific configurations of cane areas, namely the optimal circular configuration and the rectangular configuration with a 5:1 side ratio.

The cost of transport of labour and of sugar has been assumed to vary directly with capacity. This applied, approximately, to the Mauritian factories considered, but would have to be reviewed for other conditions.

For the cultivation and harvesting section, it has not been possible to obtain a separate figure for depreciation, as some items, like transport and other charges, already incorporated an element of depreciation in their cost.

No account has been taken of milling tax and sugar export tax; also the insurance premium paid against cyclones and droughts has not been considered. So that the cost index indicated in Table V is representative of ex factory cost (plus transport to the central sugar warehouse) but without any taxes or levies.

Notwithstanding the above mentioned limitations, the general conclusion to be derived from Table 5 is that as the capacity increases from 1 to 5, the total cost of production increases from 1 to about 4, that is the unit cost of production per tonne of cane decreases from 1 to about 0.82, as indicated in Figure V.

VI. THE ENVIRONMENTAL IMPACT

This subject has been well covered in the recent literature, cf (1), (2), (4), (6) and (8), but it is proposed to say a few words on the concentration of effluents which derive from the larger sugar centrals.

These effluents can be divided into three main items :

(i) Acid condensate surplus water,

(ii) Cane wash water,

(iii) Fly ash and smut.

(i) It should be noted that as the capacity of the factory increases, and also, as steam economy improves with more advanced technology, the volume of surplus acid condensates will increase significantly as indicated in Figure VI.

Thus for a 100 TCH factory, with limited technology, the surplus may be around 5.3 tons of acid condensate per hour, while for a 500 TCH factory, with improved technology, the surplus could well amount to 114.5 tons of acid condensate per hour. The modern central can thus be regarded as a source of water which, with limited but adequate treatment, can be used for irrigation and domestic purposes.

The acid condensate surplus is relatively hot (about 90°C) and its dissolved oxygen content is thus very low. Its BOD content may be as high as 400 ppm, but with proper check of sugar entrainment or carry over, it should be lower than the 50 ppm acceptable limit. Proper cooling and aeration are generally sufficient to render usable the acid condensate.

Condenser cooling waters should pose no real effluent problem if they are used in closed circuit, through a suitable cooling pond. This is the standard modern procedure and the old "once through" system, (with its very high consumption of 700 to 1 250 tons of cooling water per hour for a 100 TCH factory) should not be encouraged.

(ii) With the advent of mechanical harvesting, some factories require cane washing operations which consumes very large volume of water e.g. 500 tons per hour for a 100 TCH factory. This effluent carries in suspension large amount of soil and dissolved soluble organic and inorganic substances. A figure of 3 000 ppm total solids in cane wash water is average and its BOD content can vary between 300 and 1 000 ppm.

This water constitutes the most serious pollutional load in raw cane sugar manufacture, and generally calls for fairly sophisticated treatment which includes screening, settling and extended aeration - cf (1) and (2).

(iii) Steam boiler stack emission of fly ash and smut generally reach the level of 5 000 mg per normal m^3 of flue gases - cf (4) and (12). It represents, roughly, about 500 kg of ash per hour for a 100 TCH factory, which can prove a real nuisance for those living in the vicinity of the factory on the lee side.

Fortunately there are now centrifugal dry collectors and impingement type wet scrubbers which are fairly efficient and can reduce the average boiler stack emission of 5 000 mg per m^3 to 200 mg per m^3, or less. This is considered, quite rightly, to be highly acceptable by most sanitary authorities.

VII. SOCIAL AND ECONOMIC IMPACT

The influence, in the social and economic field, of a large sugar central, can prove beneficial, given an efficient organisation.

Sugar production is an agro-industrial activity that can prove a useful transition channel for the change over of purely agricultural workers to industrial operatives. It has a number of useful linkages like sugar equipment manufacture and repairs, transportation equipment repairs, agricultural equipment manufacture and repairs, fertilizer and pesticide production - or at least mixing plants, that will mean job creation and economic growth.

The by-products of the sugar industry can be substantial adjuncts to improve the economy of the community. Thus the utilization of bagasse for the production of particle board and of molasses for the production of alcohol, is a natural development of the sugar industry. In most cases a large sugar central has a significant surplus of electricity which it can supply to the local grid at a competitive price per kWhr.

The specialists employed by the sugar estate - agronomists, engineers, chemists, accountants, etc can be a useful nucleus that will act as a catalyst to activate the social and economic development of the community.

J.M. PATURAU.

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TABLE I

CANE CULTIVATION DATA (IN MAURITIUS)

FIELD AREA (Hectares)	AVERAGE LABOUR REQUIREMENT (Man per hectare)	CANE PRODUCED (Tonne Cane per hectare)	PRODUCTIVITY (Tonne Cane per worker)	INDEX OF LABOUR COST PER TONNE OF CANE
1	0.70	39	56	100
5	0.65	43	66	85
50	0.60	56	93	60
500	0.66	73	111	50
1 000	0.67	75	112	50
2 500	0.68	76	112	50
5 000	0.68	76	112	50

TABLE II

HOW TRANSPORT DISTANCE FOR CANES INCREASES WITH FACTORY CAPACITY

CAPACITY OF FACTORY (Tonne Cane per hour)	CANE TONNAGE FOR A 130 DAYS CROP (tonnes)	ACREAGE REQUIRED AT 76 T.C. per hectare (hectares)	GROSS ACREAGE 120% (hectares)	RADIUS OF FIELD (km)	AVERAGE TRANSPORT DISTANCE (km)
100	286 000	3 763	4 516	3.79	1.90
200	572 000	7 526	9 032	5.36	2.68
300	858 000	11 289	13 548	6.57	3.29
400	1 144 000	15 052	18 064	7.59	3.80
500	1 430 000	18 815	22 580	8.48	4.24

TABLE III

COST OF CANE TRANSPORT (PER TONNE OF CANE)

DISTANCE (in km)	COST (in US $ per tonne)
1	1.14
2	1.26
3	1.38
4	1.50
5	1.62
6	1.74
7	1.86
8	1.98
9	2.10
10	2.22

TABLE IV

WAGES AND ADMINISTRATIVE CHARGES VARIATIONS WITH CAPACITY

CAPACITY OF FACTORY (Tonne Cane per Hour)	INDEX OF WAGES AND ADMINISTRATIVE CHARGES: TOTAL	INDEX OF WAGES AND ADMINISTRATIVE CHARGES: PER TONNE OF CANE
100	100	100
200	115	57.5
300	125	41.7
400	132	33.0
500	138	27.6

TABLE V

COST OF PRODUCTION OF RAW SUGAR VS. CAPACITY OF SUGAR FACTORY

	ITEMS	COST INDEX PER TONNE OF CANE				
	For Typical Capacity in Tonne Cane/Hr	100 TCH	200 TCH	300 TCH	400 TCH	500 TCH
	A. CULTIVATION & HARVESTING					
1.	Wages and Salaries (Varies as Capacity)	35.92	35.92	35.92	35.92	35.92
2.	Supplies and Other Charges (Varies as Capacity)	19.00	19.00	19.00	19.00	19.00
3.	Transport of Canes (Optimal Configuration of Land)	5.53	5.94	6.27	6.54	6.77
3bis	(5:1 Rectangular Configuration of Land)	(6.03)	(6.48)	(6.48)	(7.13)	(7.38)
4.	Other Transport (mainly labour) (Varies as Capacity)	5.00	5.00	5.00	5.00	5.00
5.	Administration and Overhead (Varies as Capacity $^{0.2}$)	7.35	4.22	3.05	2.43	2.03
6.	Repairs and Maintenance (Varies as Capacity $^{0.7}$)	1.22	0.99	0.88	0.31	0.75
7.	Depreciation (not already charged) (Varies as Capacity $^{0.7}$)	1.19	0.97	0.86	0.79	0.73
8.	Insurance (mainly building & transport) (Varies as Capacity $^{0.7}$)	0.43	0.35	0.31	0.28	0.26
	B. PROCESSING					
9.	Wages and Salaries (Varies as Capacity $^{0.2}$)	5.82	3.34	2.42	1.92	1.61
10.	Administration and Overheads (Varies as Capacity $^{0.2}$)	5.69	3.27	2.36	1.88	1.57
11.	Supplies and Other Charges (Varies as Capacity)	1.09	1.09	1.09	1.09	1.09
12.	Transport of Sugar and Labour (Varies as Capacity)	1.26	1.26	1.26	1.26	1.26
13.	Repairs and Maintenance (Varies as Capacity $^{0.7}$)	3.64	2.96	2.62	2.40	2.25

(contd.)

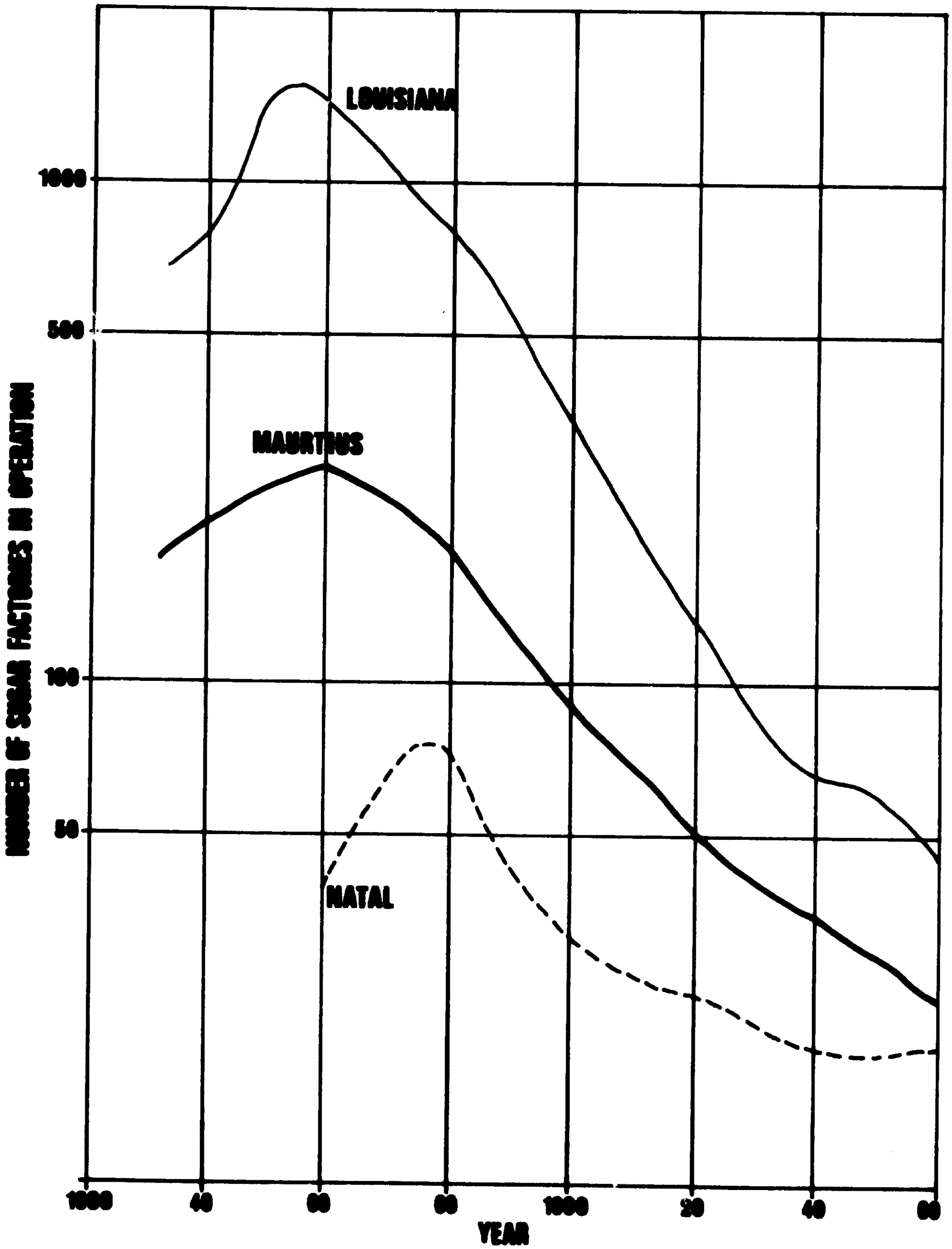
TABLE V (contd.)

COST OF PRODUCTION OF RAW SUGAR VS. CAPACITY OF SUGAR FACTORY

	I T E M S	COST INDEX PER TONNE OF CANE				
	For Typical Capacity in Tonne Cane/Hr	100 TCH	200 TCH	300 TCH	400 TCH	500 TCH
14.	Depreciation (Varies as Capacity $^{0.7}$)	6.36	5.17	4.57	4.20	3.92
15.	Insurance (mainly factory equipment, building and transport) (Varies as Capacity $^{0.7}$)	0.50	0.41	0.36	0.33	0.31
16.	INDEX OF TOTAL COST OF PRODUCTION (Per tonne of cane) (Optimal Land Configuration)	100.00	89.89	85.97	83.85	82.47
	(5:1 Rectangular Land Configuration)	(100.50)	(90.43)	(86.54)	(84.44)	(83.08)

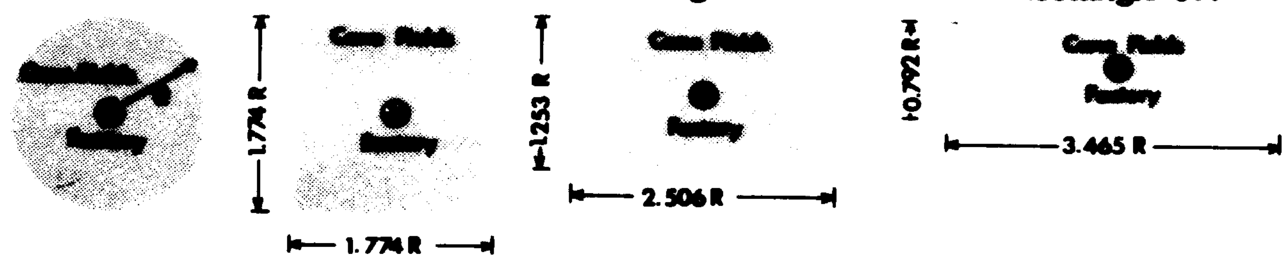
HISTORICAL REDUCTION IN NUMBER OF MILLS

FIGURE 1



INFLUENCE OF CONFIGURATION — FIGURE 2

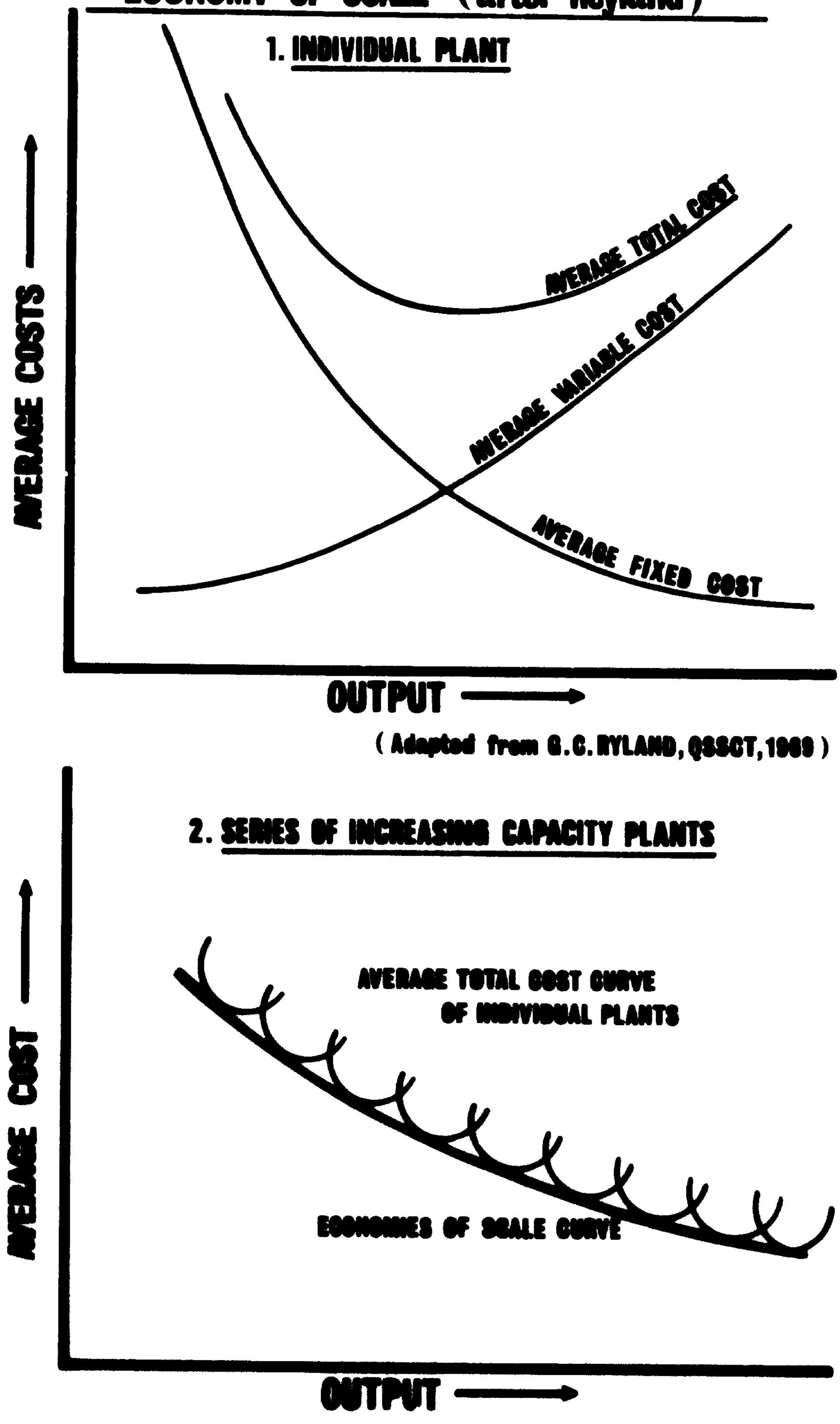
	Circle	Square	Rectangle 2:1	Rectangle 5:1



	Circle	Square	Rectangle 2:1	Rectangle 5:1
AREA	πR^2	$(1.774 R)^2 = \pi R^2$	$(2.506 \times 1.253 R^2) = \pi R^2$	$(3.465 \times 0.792 R^2) = \pi R^2$
AVERAGE DISTANCE OF TRANSPORT	0.5 R	0.533 R	0.586 R	0.800 R
INDEX OF TRANSPORT DISTANCE	100	107	117	160
INDEX OF TRANSPORT COST PER TONNE OF CANE	100	101	103	109

FIGURE 3

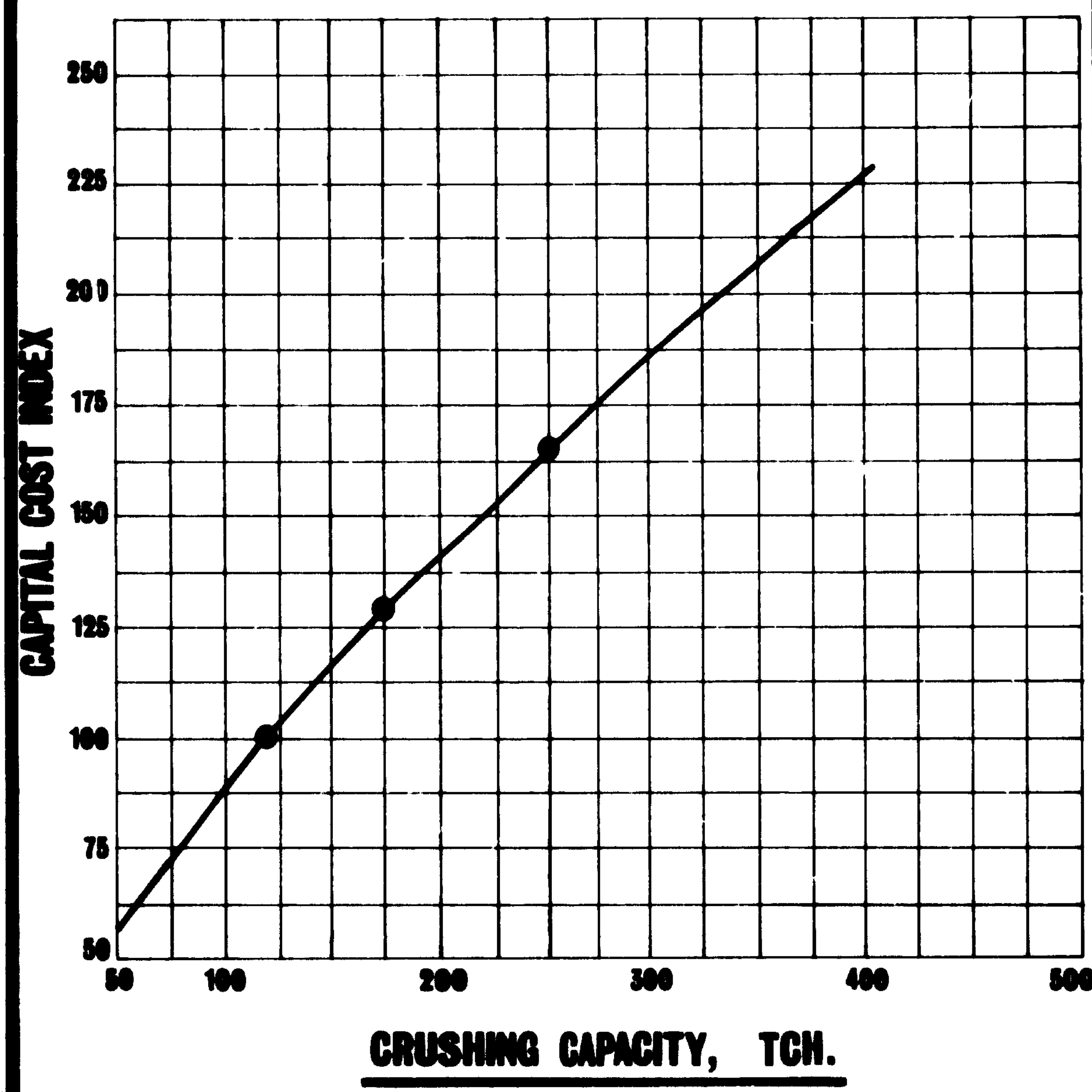
ECONOMY OF SCALE (after Reyland)

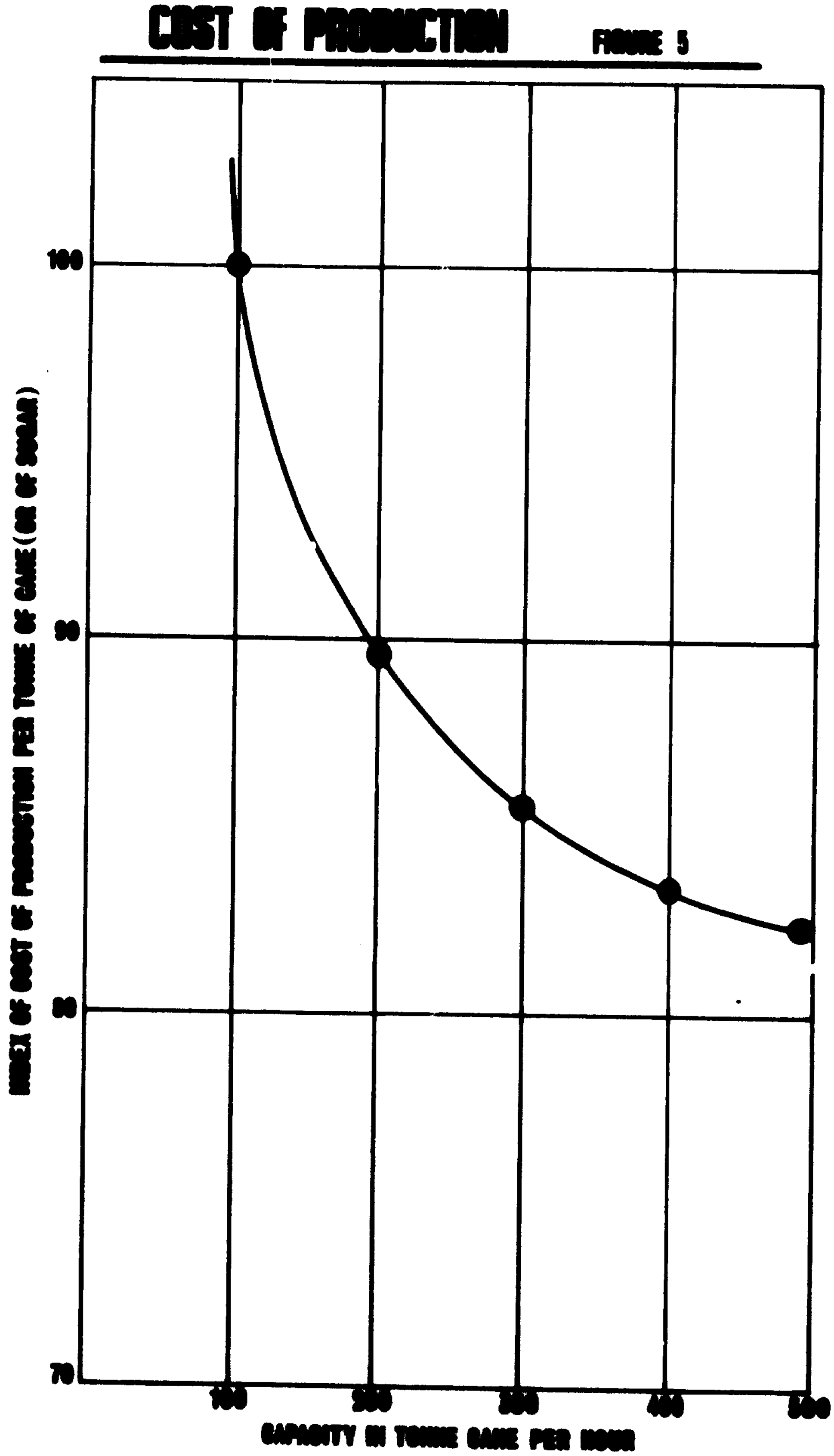


(Adapted from G.C.RYLAND, QSSCT,1969)

FIGURE 4

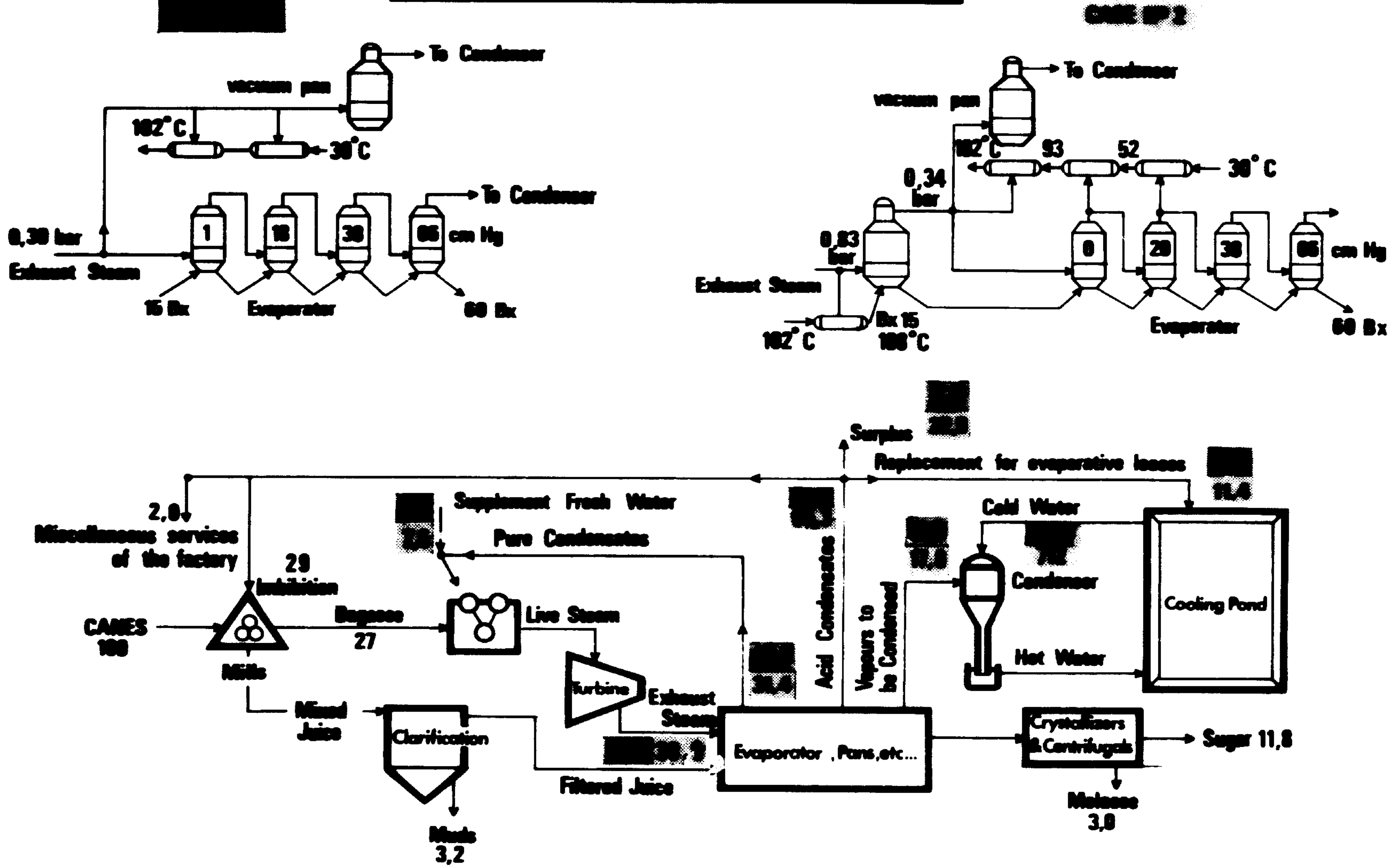
COST OF FACTORY V/S CAPACITY




COST OF PRODUCTION
FIGURE 5
INDEX OF COST OF PRODUCTION PER TONNE OF CANE (OR OF SUGAR)
100
90
80
70
100
200
300
400
500
CAPACITY IN TONNE CANE PER HOUR

WATER UTILIZATION

FIGURE 6



APPENDIX A

VALUATION OF EQUIPMENT OF RAW SUGAR FACTORIES (1973)

ITEMS	CRUSHING CAPACITY					
	120 TCH		175 TCH		250 TCH	
1. CANE UNLOADING & CONVEYING EQUIPMENT	Rs 1 886 000		Rs 2 587 000		Rs 3 607 000	
(a) Overhead Travelling Cranes	2 Bridges 10 Tons capacity	750 000	3 x 10 Tons	1 125 000	4 x 10 Tons	1 500 000
(i) Height of Lift	45 ft					
Speed of Lift	125 ft/min					
Speed of Travel	250 ft/min					
Speed of Traverse	120 ft/min					
(ii) Gantry	250 ft long x 70 ft	415 000	250' x 70'	415 000	2 x 250' x 70'	830 000
(iii) Foundation & Erection		165 000		190 000		330 000
(b) Feed Table						
(i) Feed Table	Drag Type 25' wide x 34' overall, 12 strands	122 000	2 x 25' x 34'	244 000	2 x 25' x 34'	244 000
(ii) Drive	Slip coupling, 15 HP	36 000	2 x 15 HP	72 000	2 x 15 HP	72 000
(iii) Foundation & Erection		18 000		35 000		35 000
(c) Cane Kicker						
(i) Cane Leveller	10 HP	28 000	2 x 10 HP	56 000	2 x 10 HP	56 000
(ii) Foundation & Erection		3 000		5 000		5 000
(d) Cane Carrier						
(i) Length	130 ft		160'		190'	
(ii) Width	72 ins.	236 000	78"	300 000	84"	350 000
(iii) No. of slats	600		740		890	
(iv) No. of strands	3		3		4	
(v) Drive	35 HP, slip coupling	60 000	50 HP	75 000	75 HP	95 000
(vi) Foundation & Erection		55 000		70 000		90 000

2. <u>CANE KNIVES</u>	Rs 571 000		Rs 610 000		Rs 670 000	
(a) First set	90 knives, 500 RPM, 250 HP	252 000	102 knives, 600 RPM, 900 HP	275 000	110 knives, 600 RPM 700 HP	300 000
(b) Second set	90 knives, 500 RPM, 500 HP	267 000	102 knives, 600 RPM, 900 HP	275 000	110 knives, 600 RPM, 700 HP	300 000
(c) Foundation & Erection		52 000		60 000		70 000
3. <u>CRUSHING PLANT</u>	Rs 8 912 000		Rs 10 413 000		Rs 11 705 000	
(a) <u>Milling Plant comprising</u>						
(i) Mills	15 rollers 36" x 72"	3 750 000	15 rollers 38"x78"	4 150 000	15 rollers 42"x84"	4 500 000
(ii) Intermediate carriers	4	500 000	4	530 000	4	560 000
(iii) Platforms	1 set	75 000	1	30 000	1	85 000
(iv) Steam Turbines	5 x 500 HP	1 100 000	5 x 700 HP	1 225 000	5 x 900 HP	1 375 000
(v) Control Panel	1	25 000	1	25 000	1	25 000
(vi) Reduction Gear, double helical	5	375 000	5	500 000	5	625 000
(vii) Compound reduction Gear	5	2 250 000	5	2 750 000	5	3 250 000
(viii) Vibrating screens	2, Total filtering area 46 sq. ft	35 000	2 x 3' x 24'	53 000	2 x 4' x 24'	70 000
(ix) Maceration chokeless pumps	3 }	70 000	3 }	75 000	4 }	90 000
(x) M. Juice centrifugal pumps	2 }		2 }		2 }	
(xi) Overhead travelling crane	1 of 15 Tons, span 55 ft gantry 130 ft, hand operated	137 000	1 x 30 Tons; 70' x 150'	280 000	1 x 30 Tons; 70' x 150'	200 000
(xii) 2nd O.T. Crane	1 of 5 Tons, as above, electrically operated	45 000	1 x 5 Tons	45 000	1 x 5 Tons	45 000
(xiii) Foundation & Erection		550 000		700 000		800 000

4. JUICE TREATMENT PLANT	/Rs 2 227 000/		/Rs 3 100 000/		/Rs 3 879 000/	
(a) One automatic scale (juice)	150 tons/hr	285 000	225 T/hr	366 000	300 T/hr	439 000
(b) Milk of lime tanks	2	39 000	2	50 000	2	60 000
(c) One automatic scale (inhibition)	40 tons/hr	128 000	60 T/hr	164 000	100 T/hr	225 000
(d) Liming tanks	3	40 000	3	50 000	3	60 000
(e) Enzymatic Treatment Plant	1	55 000	1	70 000	1	85 000
(f) Limed juice pumps	2 x 475 g.p.m. against 175 ft head	60 000	2 x 800 g.p.m.x175'	70 000	2 x 1100 gpmx175'	80 000
(g) Juice Heaters	3 x 2000 sq. ft	240 000	4 x 2000 sq. ft	320 000	6 x 2000 sq. ft	480 000
(h) Clarifier	1 of 30 ftx5 trays	600 000	1x34'x5 trays	770 000	1x40'x5 trays	1 000 000
(i) Rotary Vacuum filter	1 of 16' x 8'	550 000	2 x 14' x 8'	950 000	2 x 16' x 8'	1 100 000
(j) Foundation & Erection		230 000		290 000		350 000
5. EVAPORATOR	/Rs 1 260 000/		/Rs 1 720 000/		/Rs 2 270 000/	
(a) Evaporator	1x35,000 sq. ft, quadruple	1 090 000	1x39,000 sq.ft+ 1x8,500 sq.ft	1 500 000	1x55,000 sq.ft + 1x12,000 sq.ft	2 000 000
(b) Set of pumps :						
(i) Clarified juice	15 HPx500 gpmx45'	60 000	20HPx800gpmx45'	70 000	30HPx1100gpmx45'	80 000
(ii) Transfer Condensate from first effect	10HPx200gpmx75'		15HPx300gpmx75'		20HPx400gpmx75'	
(iii) Condensate Extraction from fourth effect	10HPx350gpmx45'		15HPx500gpmx45'		20HPx750gpmx45'	
(iv) Juice extraction from fourth effect	15HPx175gpmx95'		20HPx250gpmx95'		30HPx350gpmx95'	
(c) Foundation & Erection		110 000		150 000		190 000

6. VACUUM PANS	Rs 1 906 000		Rs 2 085 000		Rs 2 815 000	
(a) Calandria pans, without stirrier	4 of 60 tons unit capacity	720 000	4 x 80 Tons	900 000	5 x 80 Tons	1 125 000
(b) Calandria pans, with stirrier	1 of 60 tons unit capacity	250 000	1 x 30 Tons	300 000	2 x 80 Tons	600 000
(c) Seeding pan	1 of 30 tons unit capacity	120 000	-	-	-	-
(d) Steel staging for pans	1	120 000	1	140 000	1	195 000
(e) Syrup Tanks	5 of 600 cu.ft unit capacity	45 000	5 x 800 cu.ft	50 000	5 x 1000 cu.ft	55 000
(f) 'A' Molasses Tanks	4 of 600 cu.ft unit capacity	36 000	4 x 800 cu.ft	40 000	4 x 1000 cu.ft	44 000
(g) 'B' Molasses Tanks	3 of 600 cu.ft unit capacity	27 000	3 x 300 cu.ft	30 000	3 x 1000 cu.ft	33 000
(h) Magna storage Tanks	1 of 800 cu.ft unit capacity	38 000	1 x 1000 cu.ft	40 000	1 x 1000 cu.ft	40 000
(i) Steel staging for tanks	1	60 000	1	70 000	1	80 000
(j) Massecuite receiving tanks	3 of 1500cu.ft unit capacity	112 000	3 x 2000 cu.ft	121 000	4 x 2000 cu.ft	161 000
(k) Rotary massecuite pumps	3 of 850cu.ft/hr unit capacity	114 000	3 x 1000 cu.ft/hr	114 000	4 x 1000 cu.ft/hr	152 000
(l) Foundation & Erection		264 000		280 000		330 000
7. CONDENSING PLANT & COOLING POND	Rs 903 000		Rs 1 116 000		Rs 1 625 000	
(a) Barometric condensers	2 of 8 ft diameter	122 000	2 x 9'	136 000	2 x 10'	150 000
(b) Water-jet condensers	1 to operate with 1 vacuum pan	50 000	1	60 000	2	120 000
(c) Injection water centrifugal pumps	2 of 3500 gallons/minute, unit capacity	108 000	3 x 4000 gpm	115 000	3 x 5000 gpm	125 000
(d) Liquid ring vacuum pumps	2 of 2000 cu.ft/minute, unit volume displacement	168 000	2 x 2500cu.ft/min	130 000	3 x 2500cu.ft/min	270 000
(e) Cooling pond	1 of 20,000 sq.ft cooling surface	300 000	1 x 30,000 sq.ft	450 000	Equivalent 1x50,000 sq.ft	750 000
(f) Cooling pond centrifugal pump	1 of 7000 gallons/minute	70 000	1 x 8000 gpm	80 000	1 x 10,000 gpm	100 000
(g) Foundation & Erection		85 000		95 000		110 000

8. CRYSTALLISERS	/Rs 1 072 000/		/Rs 1 490 000/		/Rs 2 240 000/	
(a) A Crystallisers	1 Workspoor for 600 cu.ft/hr of A massecuite	250 000	2 x 450 cu.ft/hr A	500 000	3 x 450 cu.ft/hr A	750 000
(b) B Crystallisers	1 Workspoor for 300 cu.ft/hr of B massecuite	225 000	1 x 450 cu.ft/hr B	250 000	2 x 450 cu.ft/hr B	500 000
(c) C Crystallisers	9 Blanchard of unit capacity of 750 cu.ft	405 000	10x1000 cu.ft C	500 000	14 x 1000 cu.ft C	700 000
(d) Staging for crystallisers to allow gravity feed	1	30 000	1	115 000	1	140 000
(e) Foundation & Erection		102 000		125 000		150 000
9. CENTRIFUGALS	/Rs 1 827 000/		/Rs 2 224 000/		/Rs 3 182 000/	
(a) For A & B Massecuite	Five 48"x30" at 1500 RPM	320 000	3 x 52" x 40"	1 140 000	5 x 52" x 40"	1 900 000
(b) For C Massecuite	Four continuous type centrifugals	548 000	Five	686 000	Six	822 000
(c) Molasses pumps	three rotary displacement pumps	37 000	3	42 000	3	48 000
(d) Sugar drier	One rotary horizontal drier	160 000	1	180 000	1	220 000
(e) Sugar elevator	One bucket type, 40 ft high, 7½HP	60 000	1 x 45' x10 HP	70 000	1 x 55' x 15 HP	80 000
(f) Foundation & Erection		102 000		107 000		112 000
10. STORAGE AND BAGGING STATION	/Rs 277 000/		/Rs 390 000/		/Rs 547 000/	
(a) Sugar Bins	TWO of 150 tons unit capacity, metallic bins	130 000	2 x 250 Tons	200 000	3 x 250 Tons	300 000
(b) Sugar Weighers	Two, semi-automatic	20 000	2	20 000	3	30 000
(c) Bag sewing machine	One electric sewing machine	38 000	2	76 000	2	76 000
(d) Bag conveyors	Two, unit length 35 ft, 5 HP	50 000	2	50 000	3	75 000
(e) Foundation & Erection		39 000		44 000		66 000
11. WEIGHING & DISPOSAL OF MOLASSES	/Rs 465 000/		/Rs 581 000/		/Rs 606 000/	
(a) Molasses scale	One of 8 Tons/hr capacity	96 000	1 x 12 Tons/hr	98 000	1 x 20 Tons/hr	105 000
(b) Molasses pump	One of 8 Tons/hr capacity	11 000	1 x 12 Tons/hr	13 000	1 x 20 Tons/hr	16 000
(c) Molasses storage tanks	One of 6000	260 000	1 x 9000 Tons	340 000	1 x 12,000 Tons	405 000
(d) Foundation & Erection		95 000		130 000		160 000

12. **BOILER PLANT**	Rs 6 006 000		Rs 8 020 000		Rs 11 800 000	
(a) Bagasse carrier	One of 250 ft long with provision for storage and reclamation	350 000	1 x 300'	400 000	1 x 300'	400 000
(b) Boilers, complete	Two 35 Tons of steam per hr MCR, water tube boilers	5 200 000	2 x [illegible] Tons/hr	7 000 000	3 x 50 Tons/hr	10 500 000
(c) Foundation & Erection		456 000		620 000		900 000
13. **POWER STATION**	Rs 2 104 000		Rs 3 385 000		Rs 4 195 000	
(a) Turbo-Alternator	One of 2000 Kw	950 000	2 x 2000 Kw	1 900 000	2 x 3000 Kw	2 500 000
(b) Switchboard	One	300 000	1	350 000	1	400 000
(c) Connection to grid		96 000		105 000		120 000
(d) Stand-by diesel generator	One of 225 KVA	150 000	1 x 250 KVA	175 000	1 x 300 KVA	200 000
(e) Electric cabling, sub-distribution switchboard		328 000		405 000		475 000
(f) Power room Crane	One of 10 ton, hand-operated, 45 ft span by 50 ft long runway	70 000	1x10 Tonsx50'x80'	90 000	1x15 Tonsx50'x100'	100 000
(g) Foundation & Erection		210 000		360 000		400 000
14. **PIPING & CONTROL INSTRUMENTS**	Rs 1 755 000		Rs 2 090 000		Rs 2 640 000	
(a) Live steam piping	(a)	325 000	(a)	380 000	(a)	480 000
(b) Exhaust steam piping	(b)	170 000	(b)	200 000	(b)	250 000
(c) Vapour piping	(c)	300 000	(c)	350 000	(c)	450 000
(d) Water, juice, syrup, molasses and massecuite pipings	(d)	500 000	(d)	600 000	(d)	800 000
(e) Steam pressure regulators, reducing valves, PH control cuitometers, level and brix controller, one automatic vacuum pan control, all indicating & recording meters for boiler plant and one air compressor	(e)	280 000	(e)	330 000	(e)	380 000
(f) Erection	(f)	180 000	(f)	230 000	(f)	280 000

15. **LABORATORY**	Rs 90 000		Rs 120 000		Rs 145 000	
Equipment and Furniture		90 000		120 000		145 000
16. **WORKSHOP & TOOLS**	Rs 600 000		Rs 675 000		Rs 800 000	
Complete equipment with machine tools, overhead crane, sundry tools and equipment		600 000		675 000		800 000
17. **INDUSTRIAL BUILDINGS**	Rs 3 070 000		Rs 4 120 000		Rs 4 660 000	
(a) Factory						
(i) Mill House	One, span 55 ft, length 150 ft, steel columns, corrugated iron sheeting, concrete floor. Outside wall filled with concrete blocks.	450 000	1 x 65' x 200'	880 000	1 x 85' x 200'	880 000
(ii) Boiler Plant & Power Station	One, span 100 ft, length 200 ft, as above	1 000 000	1 x 100' x 250'	1 250 000	1 x 100' x 300'	1 500 000
(iii) Clarification, boiling etc.	One, span 100 ft, length 250 ft, as above	1 300 000	1 x 100' x 300'	1 580 000	1 x 100' x 350'	1 770 000
(b) Laboratory	One, span 35 ft, length 60 ft, concrete building, with metallic framed roof covered with corrugated asbestos cement, and concrete floor.	95 000	1 x 40' x 60'	110 000	1 x 40' x 60'	110 000
(c) Workshop	One, span 50 ft, length 100 ft, generally as in (b)	225 000	1 x 70' x 100'	300 000	1 x 70' x 130'	400 000
GRAND TOTAL	Rs 34 933 000		Rs 44 726 000		Rs 57 466 000	

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