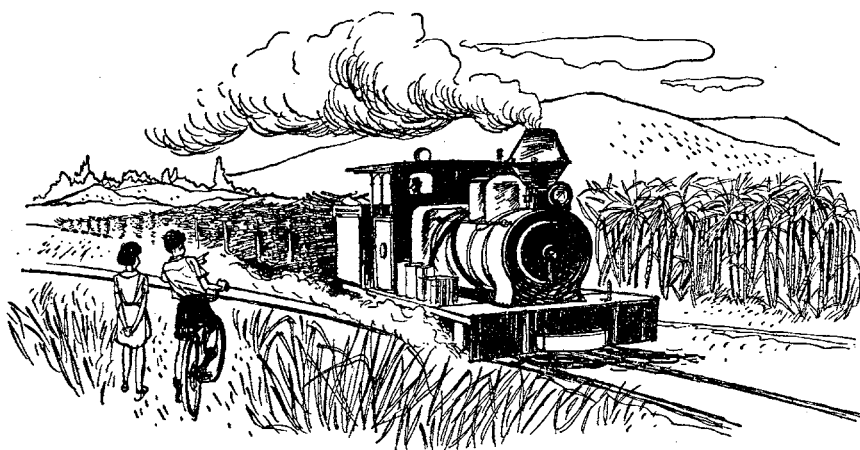




CHAPTER 6

Sugar Milling by C.S.R.

J. M. DIXON

Having given a general picture of the sugar industry in the South Pacific we now come to more detailed descriptions of C.S.R. activities in it. The milling operations of C.S.R. in Australia and Fiji constitute one of its major activities. The company has been in milling for over eighty years so that a description of its methods and organization in this sphere reveals a good deal about its policies and traditions.

As Fiji has been considered specially in Chapter 4, this chapter deals more with the company's Australian mills than with those in Fiji, especially in relation to the field side. A number of matters referred to in Chapter 5, dealing with the Australian sugar industry as a whole, are covered here in more detail.

September 1955

A raw sugar mill is a giant-sized and complex tool for breaking up sugar cane stalks, squeezing out their sweet juice, and recovering the sucrose as crystals of "raw sugar". In simplest terms, the task of the mill is to get rid of the bulky container, the fibrous and watery cane stalk, in which nature has produced sugar and to convert this sugar into an intermediate product which is reasonably stable and will keep well enough while it is stored and shipped to the refineries. That intermediate product is raw sugar, containing about 98 per cent sucrose.

The technology of the process is deeply involved with the chemical nature of sucrose, which is particularly subject to losses when diluted, as in cane juice and in many of the stages of milling and refining. Acid conditions, excess heat, enzymes, bacteria and similar "wogs" are its chief enemies. Even in the crystallized raws losses still result if dampness occurs in warm conditions. In tropical climates the deteriorating organisms, which are air-borne and omnipresent, can breed in sugar as quickly as bacilli in the human system. Such losses are less in the cooler, drier, temperate zones where the refineries are situated and the main body of consumers live.

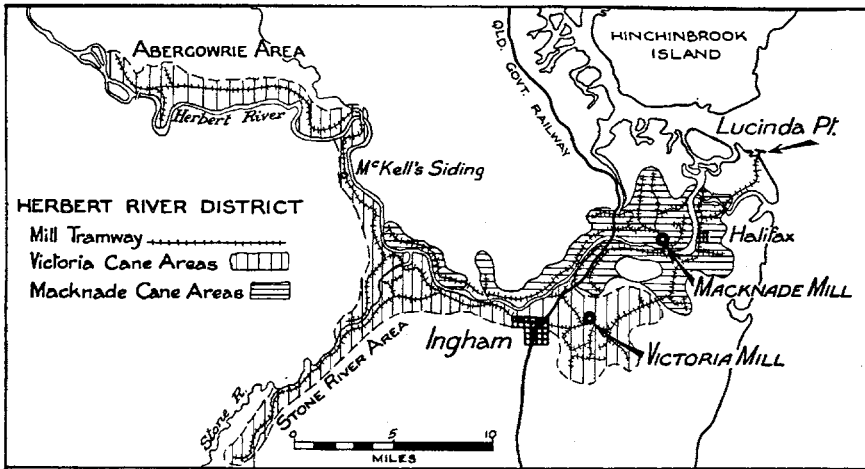
Marketing of the raw sugar is fully described elsewhere in this book; in the company, sugar marketing has its own organization separate from milling. The latter functions through two divisions: Australia, with seven mills, and Fiji, with five mills.

The regional location of sugar mills is determined by those geographical factors, soil, climate and terrain, which define the areas where cane can be grown successfully. Mills must have large continuous supplies of cane and cane growers must have a mill nearby. Cane is too bulky, heavy and perishable to transport over great distances, although moderate distances are practicable if the transport method is quick, cheap and sure.

The transport system is therefore the link between grower and miller, largely determining, within a given area, just where cane will be grown. Both growers and millers are vitally dependent on a good transport system and, in C.S.R. areas and many others in the South Pacific, it is the miller who supplies most of it. For a typical medium to big mill the permanent way, bridges, locomotives and trucks would cost today over £1 million. This feature of sugar milling is one which distinguishes it from other large-scale manufacturing enterprises. And sugar milling has other distinctive features.

Most factories, including sugar refineries, work to a planned level of weekly output conditioned by the sales budget, and this level is often less than full capacity. It is not so with a sugar mill: sales may determine

SUGAR MILLING BY C.S.R.



the mill's total production for a season, but, once started, the mill is "flat out" until the crop is finished, storing what sugar it cannot ship. This fundamental concept is accepted by everyone in and around the mills and farms, and imparts a very striking atmosphere to cane districts during the "crush". It is a basic characteristic of the cane plant which creates this situation. The sugar content of the cane is rising in June and July, reaches a peak in October and then begins to decline. The whole design and operation of the milling business must be geared to handle as much cane as possible during the shortest possible economic period. C.S.R. mills usually operate for about six months of the year, between mid-June and mid-December.

Sugar mills are classed as "heavy" industry, far too big, massive and expensive to be compared readily with other food factories like flour mills, butter factories, or fruit canneries. A medium-big mill, like Hambledon in Queensland or Rarawai in Fiji, with a capacity of, say, 45,000 tons of sugar per season, would today cost with its transport system almost £4 million. In relation to its supplying area this represents the surprisingly high investment, in the mill alone, of about £300 per acre of cane harvested annually. There is no counterpart of a sugar mill for size or for expense of capital equipment to be found in other food industries—and not many in any type of industry. And in sugar manufacture there is the additional process of refining, which is also heavy industry. The heavy investment factor is aggravated for business purposes by the short season of milling operations.

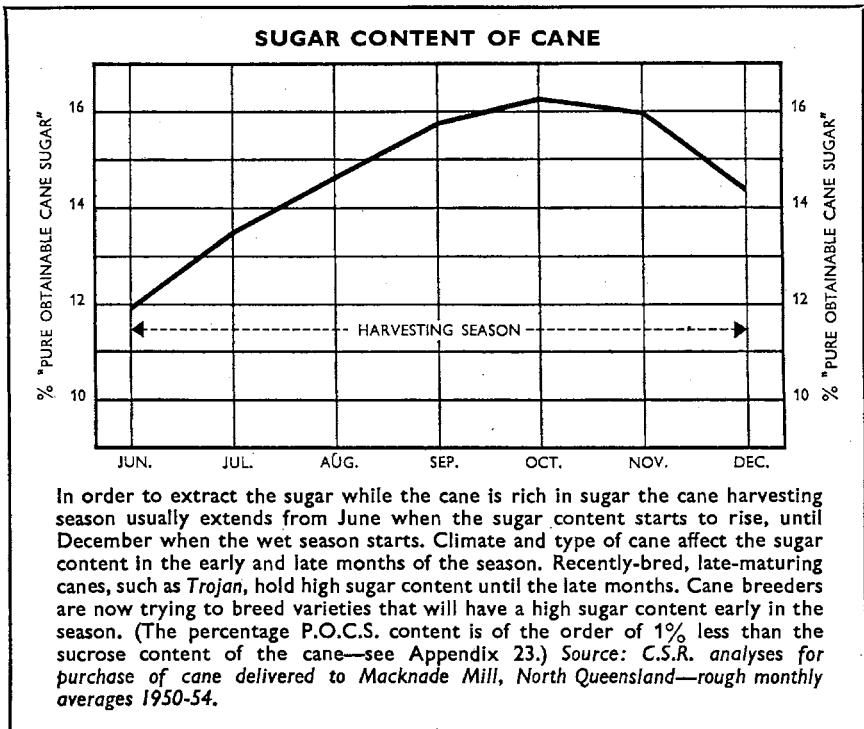
The overall result of these factors is unusually high overhead expenses per ton of output. Therefore for business and financial success

SOUTH PACIFIC ENTERPRISE

the highest possible output of sugar each season becomes a most important consideration, but this depends, first and foremost, on a full supply of cane. And it is important for the cane to be clean, fresh and sweet.

Almost all South Pacific sugar mills depend for their supplies of raw material on a large number of independent farmers; by contrast, for example, with a large copper smelter depending on its own single mine. It is in contrast, also, with overseas raw sugar industries where millers, to ensure full cane supplies for their mills (as well as to obtain the profits of growing), grow all or a large proportion of the cane on their own plantations. C.S.R. has to rely upon the farmers, almost all of them working farmers, producing their crops under the incentive of profit for themselves. A typical Australian grower harvests each year 750 to 1,000 tons of cane, and a grower in Fiji 110 to 140 tons.

As well as having points of difference, sugar milling has much in common with other manufacturing undertakings. Success requires adequate capital; a range and combination of specialized skills in buying, transport, engineering, processing; skilful organization and



management of men; and assured and not unremunerative markets for the final product. All this must be measured in monetary terms—the cost versus the market returns. But economics measure in material terms the results of the acts of men, and it is men, armed with tools bought by capital, who make sugar out of nature's resources. This chapter examines the functions of the capital tools and the teamwork of the various groups of men in making raw sugar from cane by the methods evolved by C.S.R. over eighty years.

Status as a Sugar Miller

C.S.R. is one of the world's largest raw sugar manufacturing companies, now ranking second or third in the world for tonnage of raw sugar produced. The other companies in the top half-dozen are American corporations operating in Cuba, San Domingo, Puerto Rico and Hawaii; and they also grow cane, which C.S.R. does not do to any significant extent. It makes about twice as much raw sugar as any other milling company in the British Commonwealth. In efficiency, its rating and reputation stand high in the sugar milling world.

The company owns twelve sugar mills of greatly varying sizes, some relatively small. Of the seven mills in Australia, three are in New South Wales and four in Queensland, and their current aggregate annual raw sugar production target is 261,000 tons; the target of the five mills in Fiji is 185,000 tons. The Australian mills process one-fifth of the total Australian cane crop, the balance passing through twenty-seven other mills owned by farmers' co-operatives and by other companies.

The company's two biggest mills are Victoria at Ingham, in northern Queensland, and Lautoka, in Fiji. While these are large by any standards there are much larger mills in the Caribbean. Victoria and Lautoka have each handled cane crops in excess of 650,000 tons in a season. Like many figures, it is difficult to grasp the physical import of this tonnage; put in another way, each of these two mills at the height of the season transports and crushes each week about 25,000 tons of sugar cane, which is equivalent to a continuous train of loaded cane trucks $17\frac{1}{2}$ miles long or to the full cargoes of three typical overseas tramp ships.

In the good season of 1953 these twelve mills hauled over their 800 miles of permanent and 360 miles of portable railway line, and in their 200 river punts, a total of 3,170,000 tons of cane. From it they manufactured 438,000 tons of raw sugar and 97,000 tons of molasses. During the crush they employed 4,600 people. About 6,000 cane

cutters harvested the cane grown by the 12,950 farmers who supplied their crops to the mills and who depend for their families' livelihood on the successful harvesting and milling of their cane.

The shareholders of the company see in the annual balance sheet that £15,300,000 is shown under "fixed assets" as the book value of the twelve sugar mills. They would also know that it would cost far more to replace them new at today's inflated costs. In fact, it would cost at least £35 million. In old factories, as these in part are, replacement is occurring all the time, and the company's chairman has pointed out repeatedly that this presents a major problem under out-moded taxation laws in these years of inflation. It often pays a business better to repair and maintain old plant at high cost, because this expenditure is allowable for taxation purposes, than to replace it with more modern and more efficient plant. This is a bad situation when national policy should be aimed at increasing efficiency and improving output per worker by giving him more efficient equipment. Unfair and unwise though present taxation laws may be, the company has spent some £8 million since the war on replacing old plant and adding new plant and capacity in its mills.

The large C.S.R. investment in milling is widely scattered: along the eastern coast of Australia from 400 to 1,500 miles away from the head office in Sydney and, in Fiji, 2,000 miles away.

Contribution to Cane-Growing

Before dealing with the actual operations of the mills, the contribution made towards the growing of sugar cane will be explained. The company grows no cane commercially in Australia, and only between 2 and 3 per cent of the crop in Fiji.

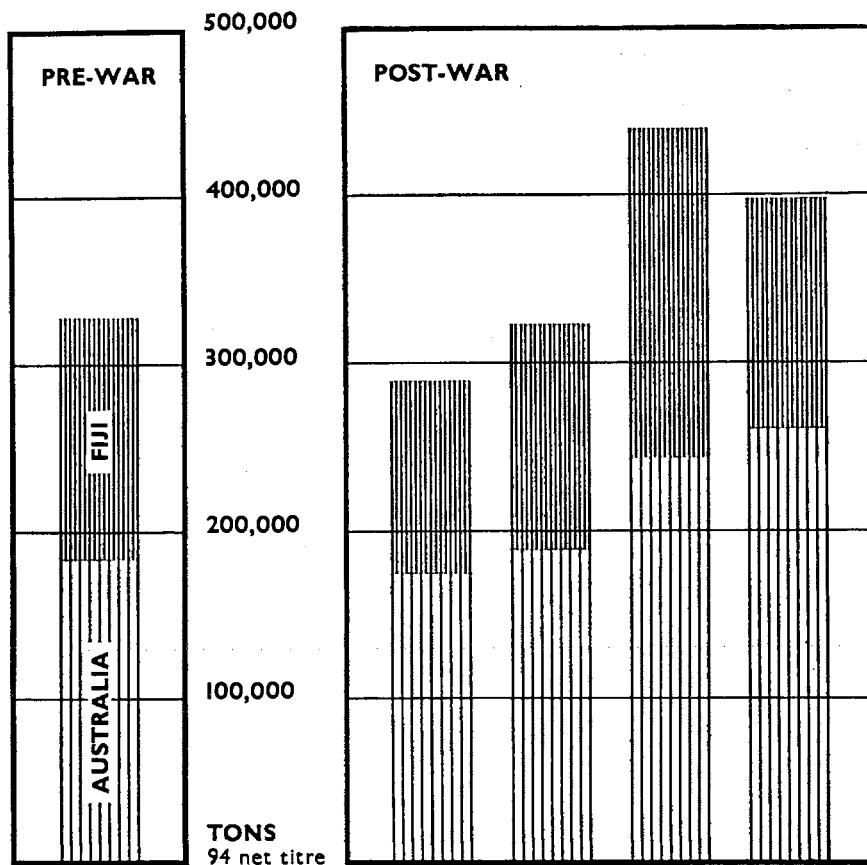
Over 85 years ago, even before the first C.S.R. mill was in operation in New South Wales, efforts were made to help the farmers grow good crops. In 1870 the company's first agricultural bulletin was issued, *Plain Hints to Plain Men for the Cultivation of the Sugar Cane* by Melmoth Hall, an officer of the company who was previously a planter in the West Indies. Over a period of ten to twelve years, Hall carried out a great many cultivation and varietal trials. His work probably constitutes the first major attempt at systematic investigational work in the raw sugar industry of Australia. It preceded chemical control in the factories.

Since then, attention to crop improvement has never slackened. All the company's mills have technical field officers whose job is to work with the farmers to improve their methods and to help in

SUGAR MILLING BY C.S.R.

PRODUCTION OF RAW SUGAR BY C.S.R. IN AUSTRALIA AND FIJI

C.S.R. manufactures raw sugar at 3 mills in northern New South Wales, 4 mills in Queensland and 5 mills in Fiji. Quantities apply to cane harvesting seasons which occur in the second half of the calendar year. Source: C.S.R. records.



PRE-WAR average 1936-37-38

43,435

140,282

183,717

144,268

327,985

N.S.W.

Q'LAND.

AUST.

FIJI

TOTAL

1951

1952

1953

1954

(Seasons)

41,049

14,263

33,992

26,290

133,503

174,982

209,656

234,499

174,552

189,245

243,648

260,789

115,744

133,645

194,994

136,800

290,296

322,890

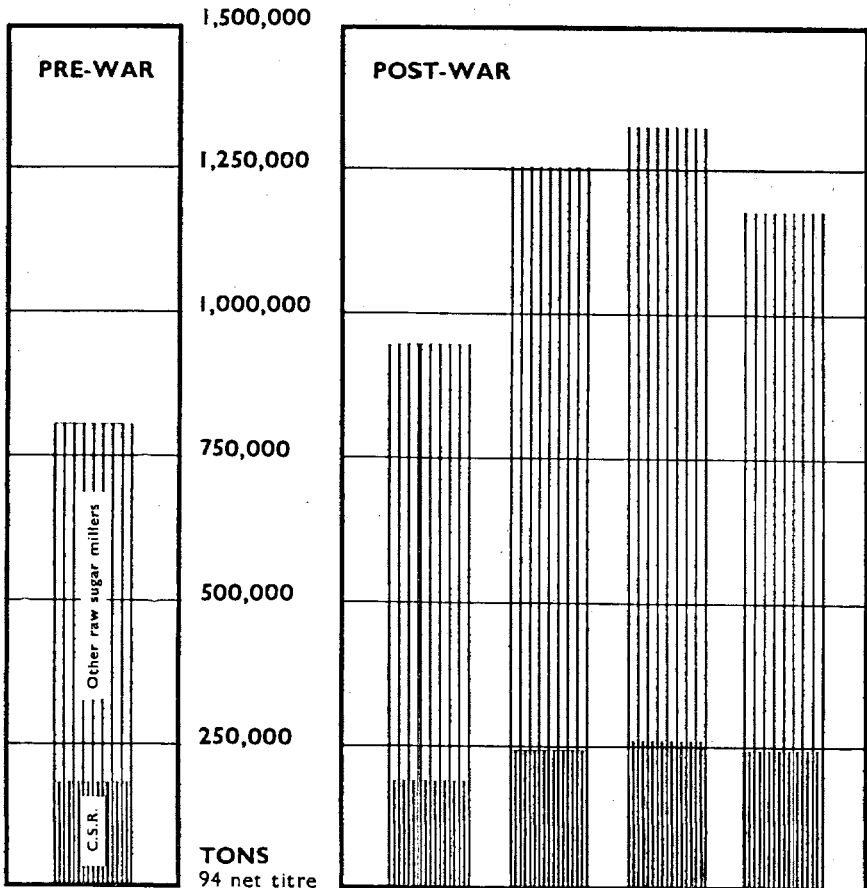
438,642

397,589

SOUTH PACIFIC ENTERPRISE

PRODUCTION OF RAW SUGAR BY AUSTRALIAN RAW SUGAR MILLS

There are 34 raw sugar mills in Australia: 14 of these are owned co-operatively by cane-farmers, 7 by C.S.R. and 13 by various other companies. C.S.R. produces about one-fifth of Australia's raw sugar. *Source: C.S.R. records.*



PRE-WAR
average
1936-37-38

183,717
621,006

804,723

C.S.R. MILLS
OTHERS
TOTAL

1952

1953

1954

1955

(Seasons)

189,245
759,244

948,489

243,648
1,010,216

1,253,864

260,789
1,065,620

1,326,409

236,860
934,106

1,170,966



Hambledon Mill, near Cairns, North Queensland. The company owns four mills in North Queensland and three in northern New South Wales.

Nausori Mill, Fiji, with staff golf course in foreground. The company owns five mills in Fiji, four on the main island of Viti Levu and one on Vanua Levu.

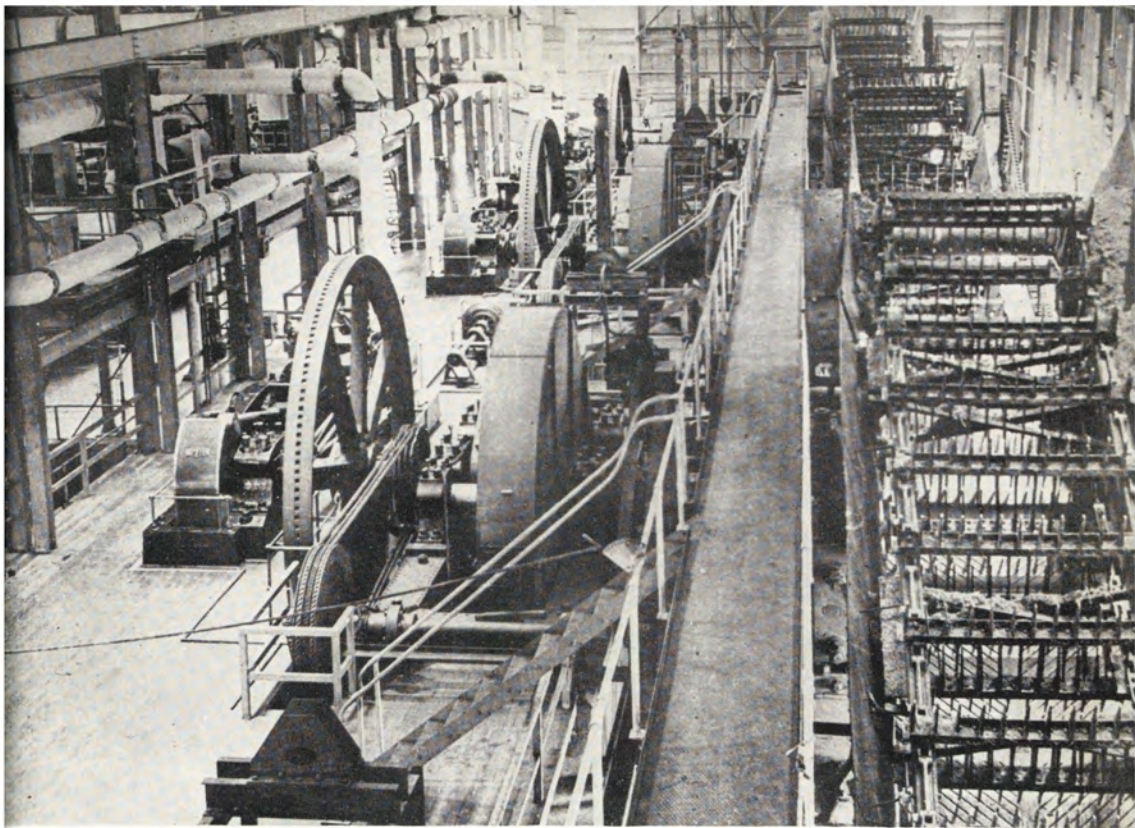




Power house and boiler station at the company's Victoria Mill, Queensland.

Lautoka Mill, Fiji. Employees' houses in foreground, wharf and ship loading sugar in background.





Mill engines at Hambledon Mill. The crushing rollers are hidden from sight underneath the megass carriers on the right.

Mill engine and fly-wheel. These steam engines drive the rollers which crush the juice from the cane.





Laying portable line in cane field.

Farmer hauling empties from main line to field.

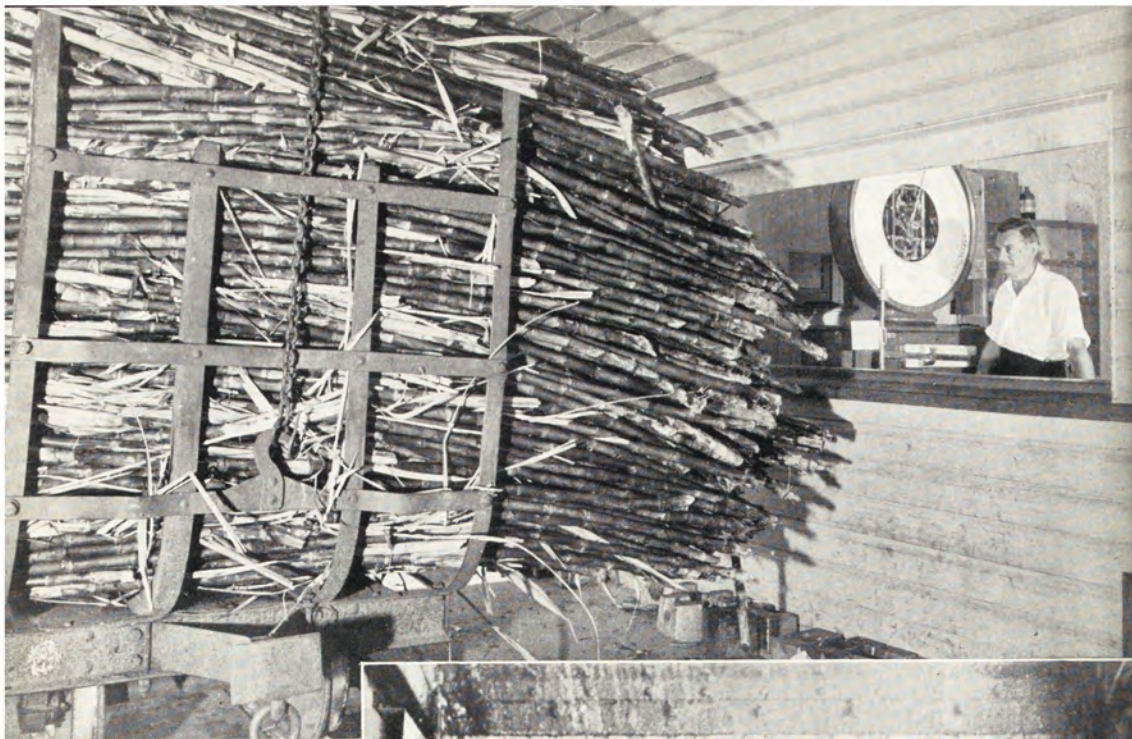




Loading cut cane on trucks standing on portable line in field. As the truck fills, cutters use a short ladder to load the heavy stalks of cane.

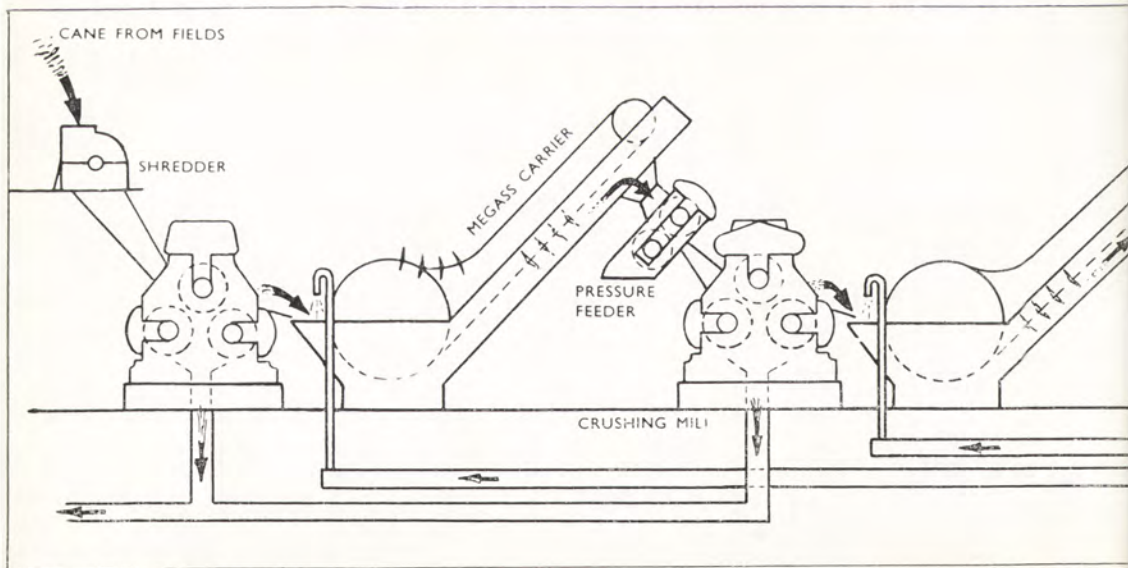
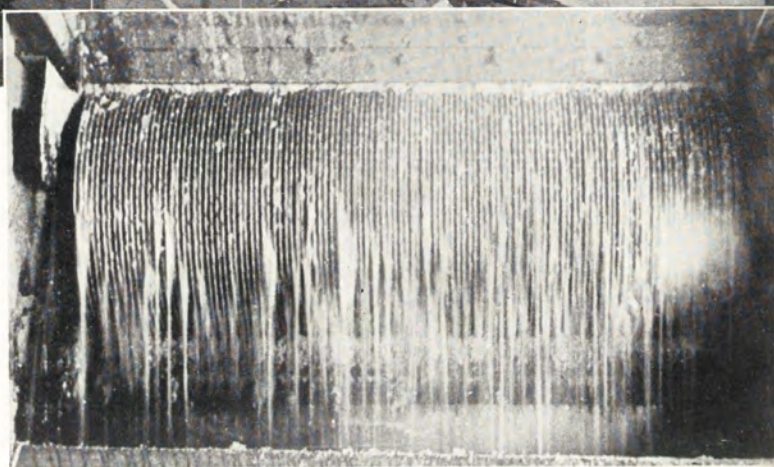
Loading cane on punt, Clarence River, N.S.W. A derrick is used to lift cane from farmer's tractor-drawn cart.

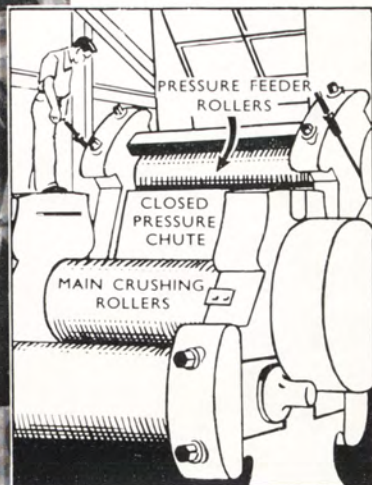
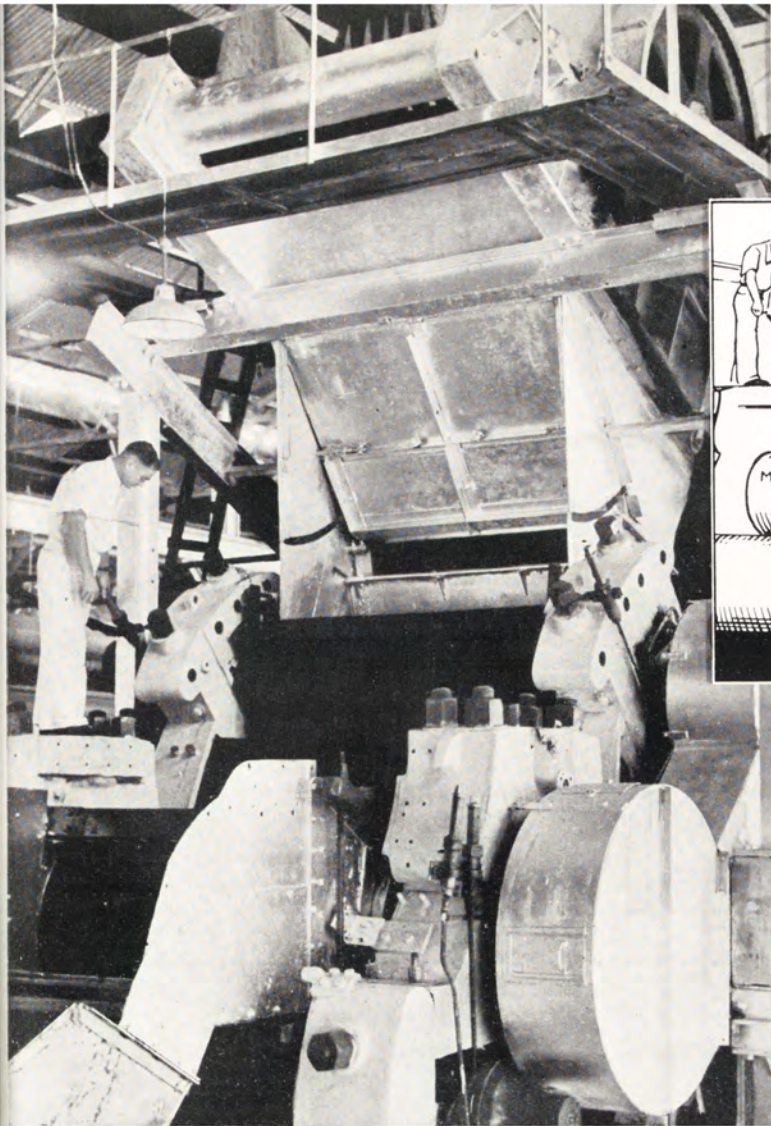




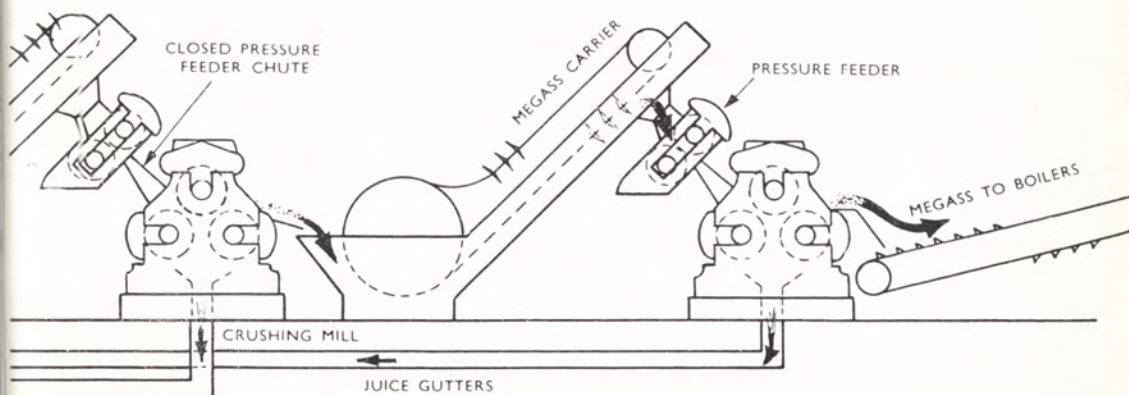
Weighing farmers' cane at mill.

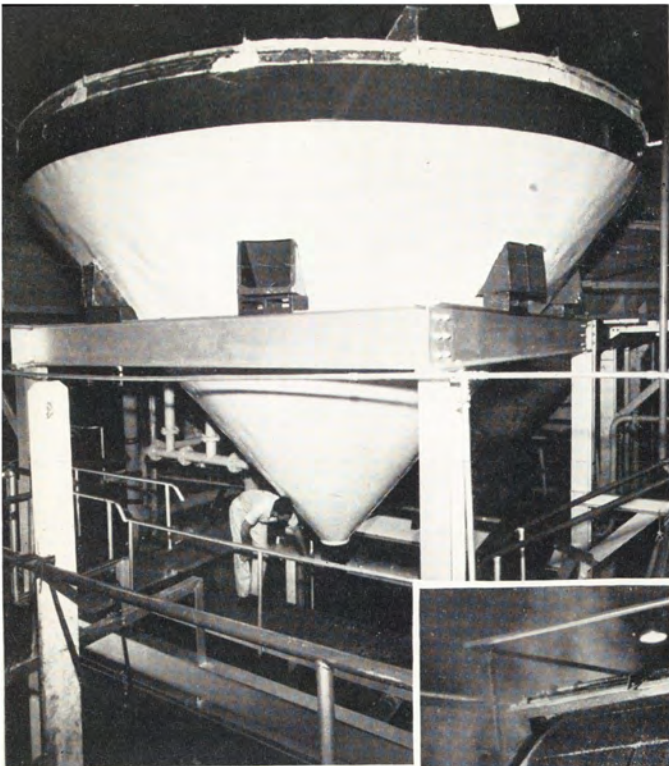
Juice is crushed from the cane fibre by large rollers arranged in sets of three. Rollers are of iron, grooved on the surface, and weigh up to 19 tons each.





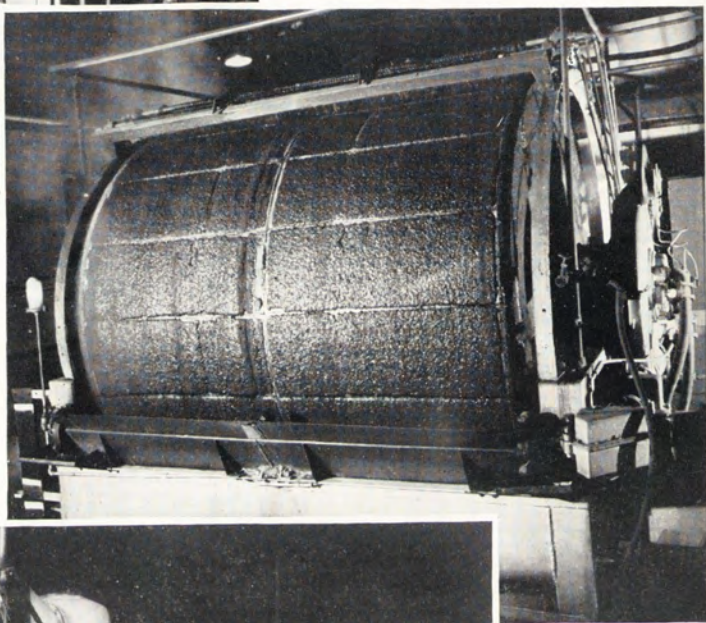
The C.S.R. Company has developed pressure feeders which consist of two subsidiary rollers which push cane fibre under pressure through a closed chute to the main crushing rollers. See diagram of milling train below.



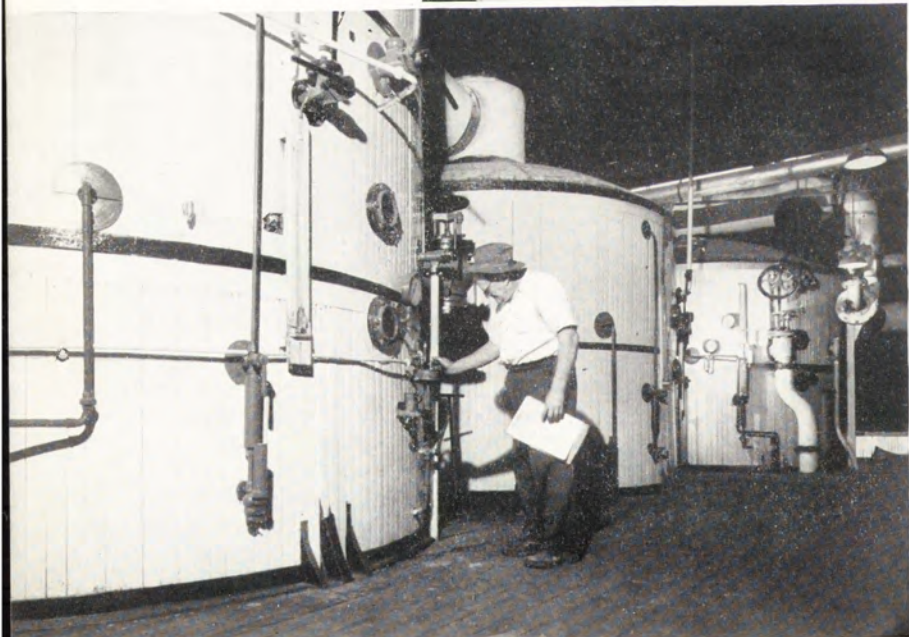


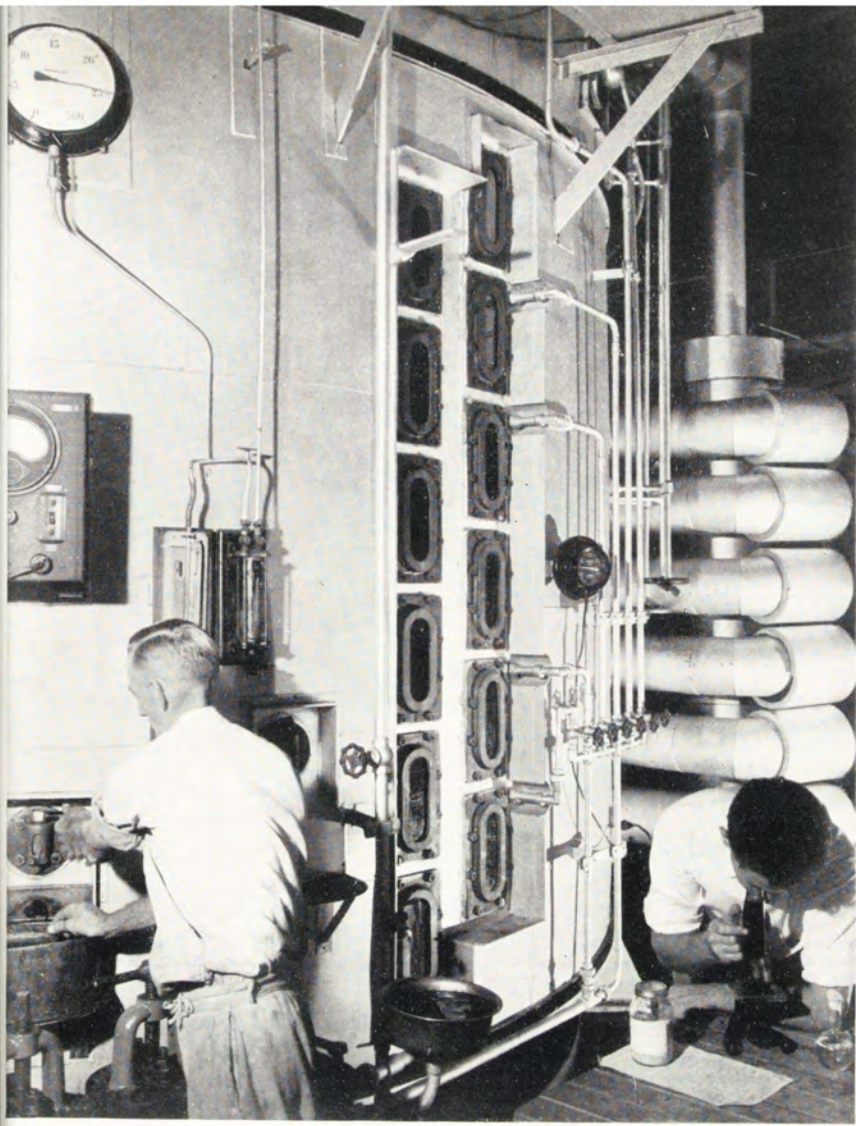
A vessel in which the impurities in limed cane juice settle out. This is an old-fashioned C.S.R. type subsider in the company's Broadwater Mill, still giving good service.

A rotary vacuum filter sucks out the sugar-containing juice from the subsided residues. The "mud" which is left is used as fertilizer.



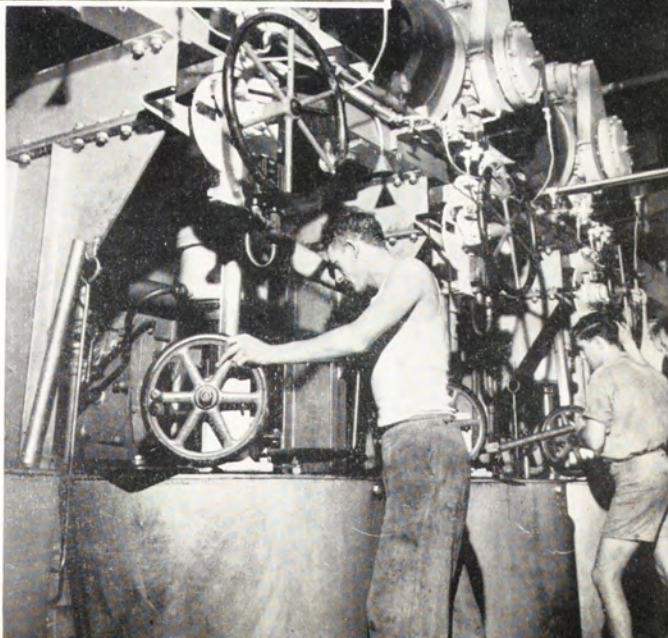
A series of old servants: timber sheathed efferts or vacuum pots at Broadwater Mill, used to concentrate clear juice by boiling under vacuum.





A new 12,000 gallon vacuum pan at Victoria Mill. The sugar boiler is taking a test sample to check the process of crystallization, while a chemist examines crystals under a microscope.

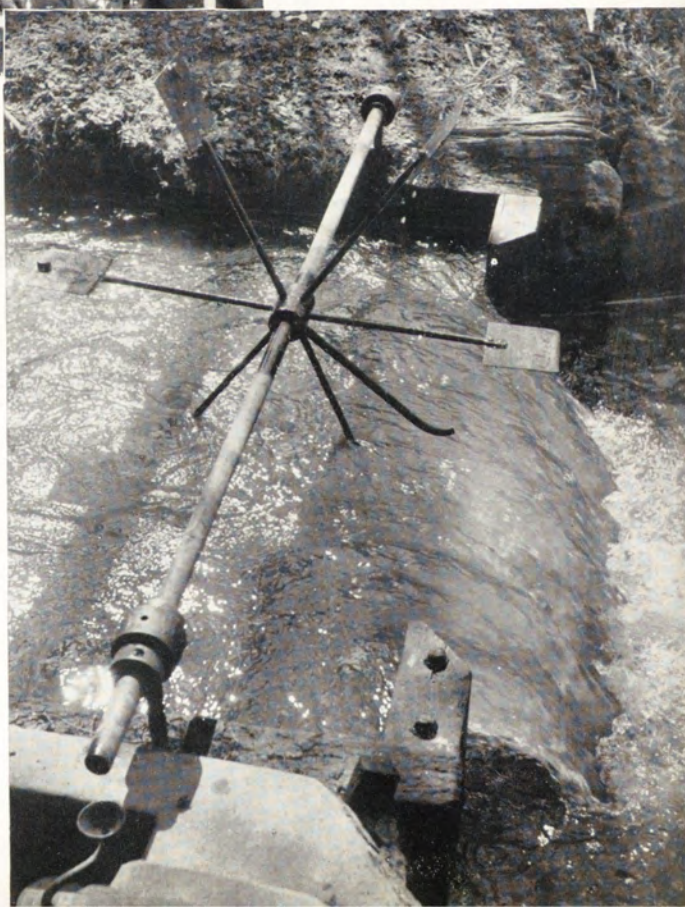
A battery of automatic centrifugal machines at Victoria Mill. The centrifugal "baskets" spin at 2,200 revolutions per minute, throwing off the syrups and leaving nearly dry crystals of raw sugar.





Laboratory, Victoria Mill. Chemists analyse the cane juice and syrups at various stages in the process, the megass, the molasses, the water in the mill mains, etc.

A paddle wheel device for collecting samples of water from a main mill drain. Samples are analysed regularly to determine if any sugar is being lost through leaking pipes.





Mr H. Freeman, general inspector of C.S.R.'s Australian mills, (now retired) discusses plans for the duplication of Victoria Mill with Mr R. N. Selman *left* and Mr W. M. Livie *right*.

Mr G. J. Holden, cane inspector, Harwood Mill, talking to Mr John Skinner, secretary of local cane growers' association.





Harwood Mill, on the Clarence River, N.S.W. C.S.R. built its first mills on the Clarence in 1869, and established there the system of large central mills supplied by independent farmers. This system was eventually followed by the Australian sugar industry. Harwood is the oldest mill in Australia. It started crushing in 1870.

producing better cane crops. In addition, the Queensland mills have to meet their share of the expenses of the Bureau of Sugar Experiment Stations, an organization which was started by the Queensland Government in 1901 and now has a quite outstanding record of service to Queensland growers.

It may be asked why C.S.R. spends money on the agricultural side, in which it is not engaged. It is quite a rational policy and has been tested over a long time. Healthy cane, rich in sugar, is better for the miller as well as the grower. If yields per acre can be improved the crop will tend to be produced on land closer to the mill and transport costs to the mill will be lower. Mills become unprofitable unless the cane supply is full in quantity and good in quality. Cane-growing and milling are essentially a joint enterprise: what helps the grower helps the miller and vice versa; prosperous growers and millers are good for one another—and ultimately, too, for the consumer.

The company's technical field officers collectively possess a wide range of skills. There are the plant pathologists specializing in cane diseases, plant geneticists breeding their thousands of seedlings in the search for improved varieties, erosion and soil experts, and also plain "all-round" technical field men working with and for the growers on methods of cultivation, fertilizer trials, pest control, and the many questions which affect the health and productivity of this fascinating crop.

In the fight against insect pests, the company has been responsible for introducing birds, fish, parasitic insects and even a giant toad, *bufo marinus*, into Fiji. There is some doubt whether *bufo* worried the beetles very much, but the gruesome-looking creature certainly gives many shocks to the visitor when, for instance, he pops up unexpectedly in the bathroom.

Sugar cane will not grow well in sour, badly drained ground. This was appreciated at least 83 years ago, for a report by E. W. Knox, then manager on the Clarence River, said that "one or two farmers have already commenced to drain their land with tiles and to these we have lent money without interest to cover the expense of the tiles". Drainage continues to be important on all flat, heavy soils, particularly on the Tweed and Richmond Rivers in New South Wales and on the Rewa in Fiji. In addition, at Lambasa Mill in Fiji the company has built 23 miles of sea wall with 35 flood gates, in order to reclaim mangrove swamps and bring them under cane, grazing pasture and rice.

One of the most important methods of increasing the productivity of farms and reducing costs is the breeding of improved varieties of sugar cane, which are released to growers free of any charge. This

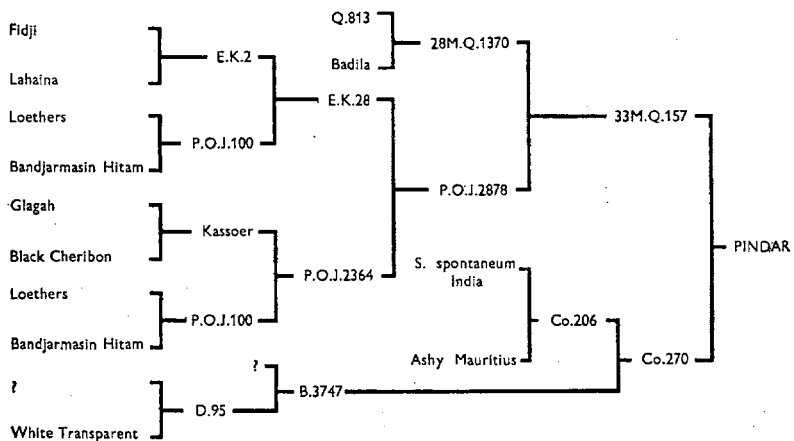
work calls for great patience, enthusiasm of the well-controlled kind and, for best results, that extra insight which is talent of a high order. Successful new varieties, in addition to possessing the inherent ability to increase the yield of sugar to the acre, must be resistant to drought and disease, and possess good ratooning and harvesting characteristics; and they should not present serious problems when they reach the milling operations.

The plant breeders know a great deal about how plant characteristics are transmitted from parent to progeny—for instance, whether some of the features desired in the children, the seedling canes, are more likely to come from the male parent or the female parent—and they make their crossings accordingly. Some blood lines, like a few “noble” and very sweet New Guinea native canes, transmit high sugar content, although nature is a little perverse in this and has ordained that sweetness should be a partially recessive quality. Others, including thin, wiry, “wild” canes from India, Java and other tropical countries, transmit vigour and strong root systems and, therefore, drought resistance and heavy yields to the acre.

Once a promising new variety has been produced in the nurseries, it has to be tested in the field and then it has to be multiplied for

PEDIGREE OF PINDAR CANE

Pindar (37 M.Q. 22) is a sweet, early maturing cane raised in 1937 by the C.S.R. Co. at the Macknade Field Experiment Station, Herbert River, North Queensland.



commercial planting. All this takes, probably, ten years, and out of every 10,000 or 20,000 seedlings maybe one or two, or none, will prove a successful commercial variety. Patience and a long view are required, but it is interesting and creative work.

The ability of cane to produce fertile seed was discovered in Java in 1885, although the discovery was not announced until 1888. In that year the discovery was also made independently in Barbados. The company immediately saw the possibilities of improving yields by growing new seedling varieties. In 1890 publications referred to the Barbados work and in April of that year arrangements were made to carry out trials at all C.S.R. mills. The first seedlings were raised in 1891 at Harwood and in 1892 at Broadwater and Lambasa, although some years were to pass before successful new commercial varieties were developed.

The company now has one breeding station in Queensland, one in New South Wales and two in Fiji. There have been striking successes which, perhaps, justify the heroic names the company gives to its new cane varieties. *Jason*, *Atlas*, *Comus* and *Ajax* have given good results in the past. *Vesta* has proved a most valuable two-year cane for New South Wales. *Trojan*, *Eros* and *Pindar* have the notable achievement of having increased the yield of sugar per acre in some of the large cane districts of northern Queensland by 20 per cent. Such an increase from the same area, farmed with practically no added expense except for harvesting the heavier tonnage, is a tremendous economic advance; other things remaining constant, it would increase the growers' profits alone by considerably more than 50 per cent. No wonder *Trojan* was affectionately christened the "mortgage lifter" by the growers in one northern Queensland area.

Disease has for long been the dreaded enemy of cane industries and has left a long history of economic and social ruin. In the early days of the cane industries in the South Pacific almost every known cane disease was unwittingly imported, in the zeal of those concerned to get the best varieties from all countries of the world. Through the efforts of the Bureau in Queensland and of the company in New South Wales and Fiji, and in part in Queensland, cane diseases have been eliminated or brought under control. One of the important successes of our plant pathologists was in controlling gumming disease which constituted a drastic threat, at different times, to the industry in New South Wales and parts of Queensland. Serious diseases controlled, and in some cases eliminated, include Fiji disease, downy mildew, gumming, leaf scald, and mosaic; but the position is maintained only by constant vigilance. Indeed, Fiji disease and downy

mildew remain endemic in Fiji and are limiting the growing of susceptible varieties which, if they could be grown with safety, would raise production considerably.

Today, the entire crop in New South Wales is produced from C.S.R. varieties, while in the Queensland crop milled by C.S.R. the proportion is 89 per cent and in Fiji 60 per cent.

Purchasing the Cane

The agreement covering price, terms and conditions of cane purchase is where grower and miller meet and where their interests both clash and combine. Naturally, it has been the subject over the years of a great deal of discussion and negotiation.

Four important elements in the situation are: the transporting of the cane, the quantity (weight) of cane, the quality of the cane, and the price of raw sugar.

The mills transport the cane over their tramline and punt systems at their own expense, which is a great advantage to the more distant growers. In many cases they would not grow cane if they had to bear the cost of transporting it.

The weight of cane determined at the mill weighbridge is an obviously basic factor and has always been used when paying for cane.

The sugar content is taken into account in three ways in the sugar world: on the basis of the sugar actually made; on the polarization (or percentage sugar content) of the juice; and on a wider analysis which incorporates the polarization and allows for other factors, including the impurities and fibre, affecting the amount of sugar which mills can recover. The company's unique P.O.C.S. (Pure Obtainable Cane Sugar) formula is an example of the latter type and is given in Appendix 23. Dr Kottmann evolved this formula in the 1880s to measure the amount of sugar which mills should recover from the cane received. It was logical for the company, which had tried to find a way to pay for cane according to its sugar content when it was starting milling in the late sixties, to apply a proven formula to cane purchase. This was done in 1899 and this early application of a method which was at once equitable and incentive-producing has stood the test of time for over half a century. Subsequently, the P.O.C.S. formula came to be applied generally throughout the Australian sugar industry under the name of the Commercial Cane Sugar formula (C.C.S.).

This system puts the onus on the grower to grow cane rich in sucrose and rewards or penalizes him accordingly. The miller pays for the

analysed amount of recoverable sugar in the cane, which is a powerful incentive towards high standards of efficiency on his side.

The P.O.C.S. formula is not used outside the South Pacific sugar industries. Only in comparatively recent times have similar systems been used in a few other countries. A number of others use the out-right sugar-in-cane basis, and others again relate cane price to actual *average* yields of sugar obtained by the mill from all growers. A return to this last system occurred in Fiji in 1940 for local reasons and at the wish of the growers, but it is fundamentally not as good a system because it does not produce the same force of individual responsibility, rewards and penalties.

The application of the obtainable cane sugar formula to cane purchase in 1899 was the first of its kind in world cane sugar industries. It may well have been the first system fully organized over a range of mills which took sugar-in-cane into account. Research indicates, however, that, although not general, some mills in Louisiana in the nineties were apparently making adjustments to cane prices by reference to the polarization; and one report suggests that one mill in Demerara had a similar practice in respect of "villagers' canes" in the early 1880s.

It is customary, and correct, to give to the P.O.C.S. cane payment system a great deal of the credit for the South Pacific industries obtaining the highest ratio in the world of sugar to cane, because of its impact on the grower and on milling efficiency. Without favourable climatic conditions in the form of cooler and drier months to ripen the cane as harvesting starts, however, such ratios would not have been possible. Respect should also be paid to that famous sweet cane, *Badila*, which was brought from New Guinea by Henry Tryon's 1896 expedition. It set the standards and dominated the cane varietal position for thirty to forty years.

The value received by millers for raw sugar is the fourth main element determining the price of cane. It has always been a strong general factor influencing cane price over any lengthy period, but it has not always been directly linked (mathematically for each season) with the price of cane, in a way that intimately associates growers' fortunes with the ups and downs of the sugar market. This stage has not been reached until the ups and downs have been evened out by some scheme of stabilization of the market returns; failing that, the growers have been glad to allow the impact of market fluctuations to fall on the millers. In Australia this part of the system of cane purchase did not come into operation generally until World War I, when government controls had stabilized the raw sugar price. Some mills had been

operating such a system before then and its origin cannot be accurately stated. C.S.R., from at least 1906, had given its growers the option each year of applying this system but few took up the option, preferring the specific price which was the alternative.

In Fiji the company protected the growers from market changes, so that they could have stability and confidence, until 1940 when a new agreement was made which related the price of cane to the price received for sugar season by season. The wartime sugar sale arrangements with the United Kingdom Government had given stability to the sugar price for the first time.

Without exception the company has come to mutual agreement with its growers in New South Wales and Fiji on cane price and conditions. Looking back over the long period during which it has been buying cane, it is a fair summing up to say that only on rare occasions have serious difficulties arisen between the company and its growers. In Queensland, too, C.S.R. has almost invariably come to mutual agreement with the growers, although there has been an arbitral authority operating there since 1916, and, over the years, there has naturally come to be no great difference between the agreements at the company's mills and the decisions of the tribunal as applicable to the rest of the Queensland industry. On occasions, wide differences of opinion have existed early in the negotiations and have eventually been reconciled by patient consideration of each other's viewpoint.

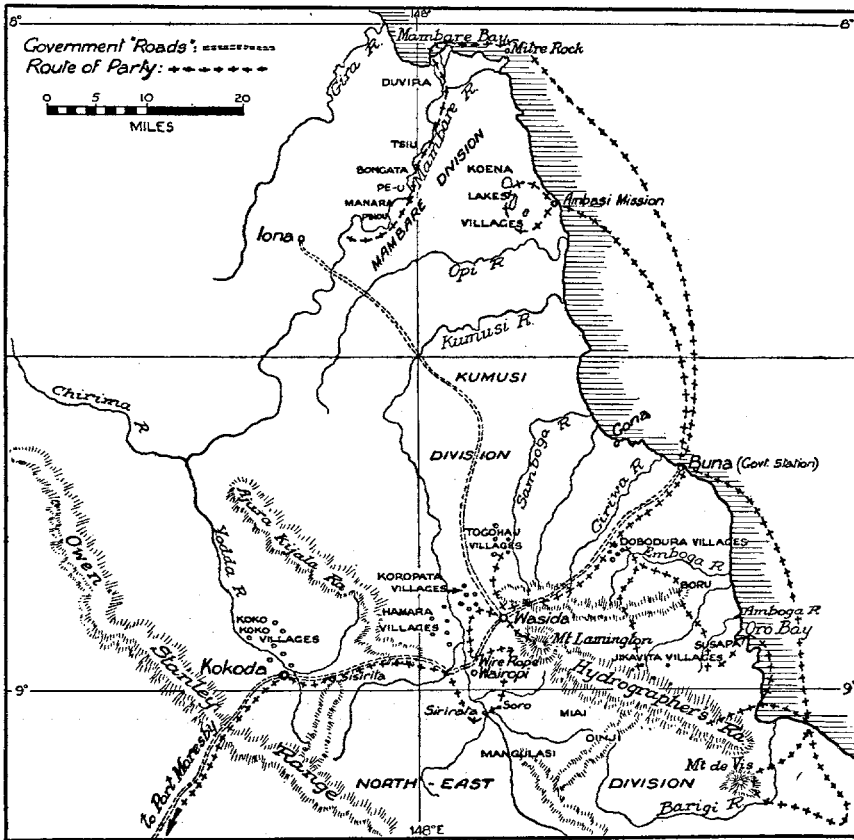
Harvesting and Transporting the Cane

The handling of milk and cream in a dairying district has special features because of their highly perishable character, but the bulk and weight of dairy products are insignificant compared with cane, and sugar cane, too, is highly perishable and should be milled, if possible, within twenty-four or thirty-six hours of cutting; moreover, the butter factories or milk depots work throughout the year, whereas the cane crops must be handled in five to six months. With wheat or wool there is not the same urgency in handling because they do not deteriorate rapidly, and their processing is widely spread and not closely related to the producing areas; yet the tonnage of the wool clip for the whole of Australia is only about one-sixth of the tonnage of cane handled in a season through the company's twelve mills.

"The crush" is a period of intense effort—from the farm, through the harvesting and transport system, and right through the mill. There is, once experienced, a not easily forgotten fever of activity and an infectious atmosphere of purpose and drive to get on and finish the job.

SUGAR MILLING BY C.S.R.

ROUTE OF C.S.R. CANE COLLECTING EXPEDITION TO PAPUA 1914

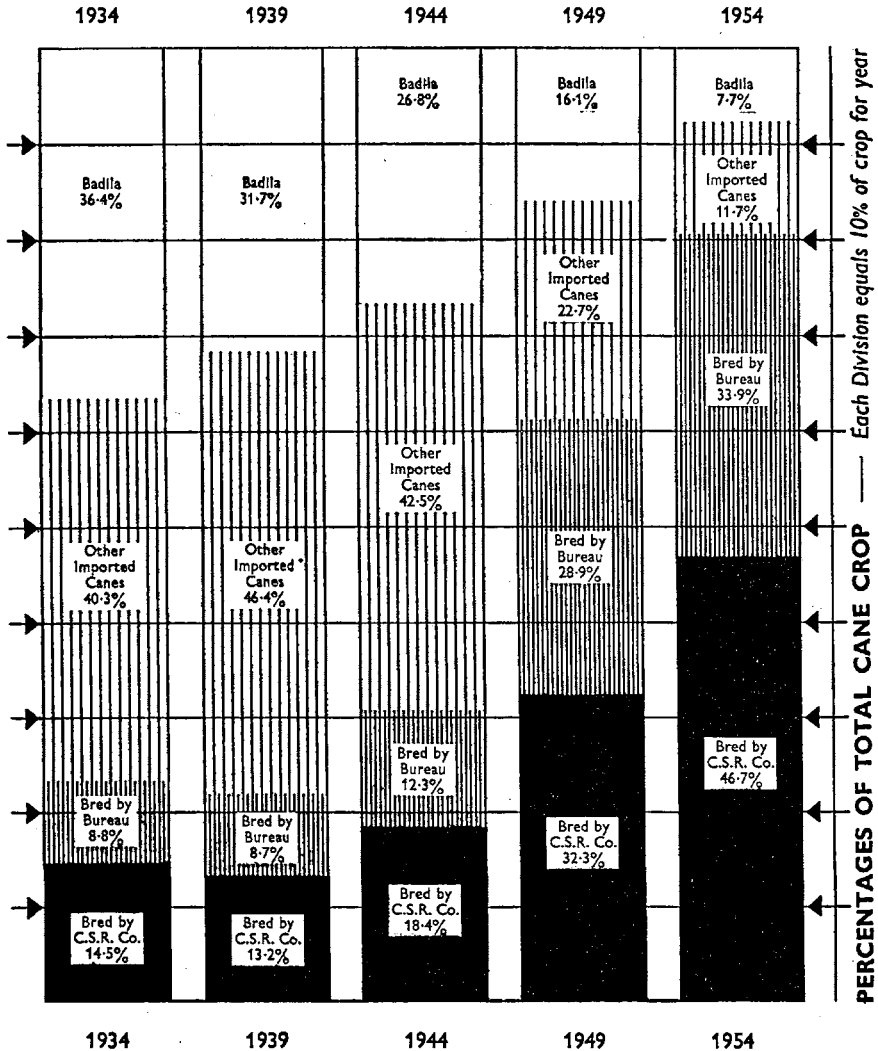


The expedition, under the leadership of Messrs A. M. Carne and C. Baker of C.S.R., set out from Buna on 31 May 1914; collected 29 varieties in the Mt Lamington district; returned to Buna; sailed south to the Barigi River district, and north to the Mambare River district. 77 varieties were collected. The expedition finally set out from Buna to Port Moresby over the Kokoda Trail

but collected no canes because the area between Kokoda and Moresby was drought-stricken, and the natives had eaten all their cane. The varieties collected were tested at the company's field experiment stations in Queensland and Fiji. Several became of commercial importance and are among the ancestors of highly successful modern canes such as *Trojan*, *Eros* and *Vesta*.

VARIETIES OF CANE GROWN IN AUSTRALIA

Percentages of Australian-bred and imported canes, grown throughout the industry in Queensland and N.S.W.



The heading "Bureau" refers to the Queensland Bureau of Sugar Experiment Stations. Included under this heading are canes produced last century by the Queensland Acclimatisation Society. Under the heading "C.S.R. Co." are included canes bred by C.S.R. in Fiji and imported into Australia. Source: Bureau reports for Queensland, C.S.R. records for N.S.W.



Gumming disease in cane: the effects on leaf and stalk.

Gumming disease provided a grave threat to New South Wales farmers in the 1890s and to farmers in parts of Northern Queensland until recent times. Control of the disease has been effected mainly through breeding and use of resistant varieties of cane.

In the crush, everything in the mill district is geared to the capacity of the mill, and this affects everyone in the industry. For instance, the rate of crushing practically fixes the number of cane cutters. Goondi Mill, in Queensland, crushes at 105 tons an hour; this requires 22,520 tons of cane a day and, as Australian cane cutters cut and load, on an average, almost 7 tons per man per day, 388 cutters were signed on at the beginning of the 1955 season. The cane cutters work in gangs of six or seven men, at contract rates of pay (paid by the growers), and are directed from farm to farm by the cane inspectors in accordance with the harvesting programme.

The grower has the responsibility for the cutting of the cane, for loading it on the cane trucks on the portable line laid into his fields, and for hauling these loaded trucks by tractor (or often by animal power in Fiji) to the main tramline. A small proportion of the cane crushed at the company's mills is loaded onto lorries in the field and carried to main lines; and, where river transport is the method, it is hauled to derricks on river banks for transfer to cane punts. In C.S.R. mill areas in Australia, to cut the average farmer's cane requires four or five weeks' work from the cutting gang. This would be divided into two, or perhaps three, periods of work on each farm, in accordance with a carefully worked-out harvesting programme and the cane inspector's decisions. The smooth co-ordination of cutting and loading on individual farms in every corner of the mill's supplying area and speed in getting such large quantities to the mill in an even flow are justly regarded as exacting tests of men and organization. Moreover, they call for excellent co-operation between grower and miller.

The cane inspectors in Australia and the field superintendents and the traffic officers in Fiji are responsible for the supply of cane to the mills. For them the mill is a great hungry beast into whose graping maw they must pour, night and day, an endless meal of cane—as much as 5,000 tons in a night and a day at the biggest mills. The full trucks of cane have to be pulled away from the fields, assembled on the main line and at shunt lines, and hauled to the mill; and a constant supply of empties has to be returned in the right numbers at the right time to the scattered gangs of cutters. The loco drivers, train crews and traffic men work in shifts, twenty-four hours of the day, to keep the trucks flowing and the marshalling yards at the mill stocked with a few hours' supply of cane.

The mill tramline system, a light railway of 2 ft. gauge, is the great artery of the cane-producing area. It is located according to practicable grades, the distribution of the good cane lands, and the geographical and historical facts which originally determined the location of the

mill. Once established, it largely determines the location of new farms and even townships, and it ties together and serves the whole cane-growing area. The maps of the mill areas show the relation between the cane transport system and the strung-out fertile cane lands.

This method of cane transport, with portable line laid to take the trucks right to the cutting gangs at the cane face, is a distinctive feature of most of the South Pacific sugar industries, especially in C.S.R. areas. It is used abroad, for instance in Jamaica, but, as far as is known, it is not found to the same predominating extent in other cane industries. In general summary, it saves double-handling of the cut cane (which the lorry or cart systems, from cane face direct to mill, also do); it helps longer hauls to be made more economically and evens out the value of cane farming land; it affects soils that are inclined to compact less than other methods and minimizes damage to cane stools and subsequent ratoon crops; it allows harvesting to continue when fields are wet and boggy; and it reduces the growers' expenses. A disadvantage is the high capital cost to the millowner, and it may prove less adaptable to mechanical harvesting than to present methods. Over the years the tramline method has had a strong beneficial influence by stretching out to and keeping cane-growing to flatter, moister and less erodable land; in the long run such land gives higher average yields.

Lautoka tramline extends in one direction for 82 miles from the mill. Victoria Mill's longest haul is 35 miles. The longest and costliest average hauls are Lautoka 27 miles, Victoria 16, and Hambleton 9. Goondi, on the other hand, is favourably situated near the centre of a compact cane area, with 3.7 miles for its average haul.

When the cane inspectors and field and transport officers have seen the harvesting and delivery of cane completed to time, their performance will be judged by such things as the cost per ton-mile of cane hauled, the speed of turn-round of trucks, and the absence of lost time in the mills through shortage of cane. In helping to organize the harvesting work efficiently, they have to exercise the right combination of co-operation and firmness towards growers and cutters. Differences of opinion naturally occur and disputes require just, prompt and calm settlement. In Australia, cane inspectors serve as officers of the Arbitration Court to give prompt, on-the-spot decisions about fair rates of pay for cutting tangled and difficult cane.

Technology for Economic Ends

At the "tip" of a big mill in the crush there is the throbbing of the mill engines, the roar of the disintegrators smashing up the cane stalks,

the punctuating crash as cane trucks, uncoupled from the long rake stretching back down the yard, are tipped, dumping their two and a half tons of cane, holus-bolus, onto the slats of the huge conveyor; there is a vista along the "crushing train" of the successive sets of giant rollers, with conveyors climbing to the top of each set, and of the remorselessly-revolving 18 ft. diameter flywheels of the mill engines; there may be dust in the air and in the eyes from the cane and the marshalling yards; the grassy-sweet scent of cane blends with the characteristic pungent, sour-sweet smell of raw sugar and molasses. All this combines to create an atmosphere of its own, never forgotten by mill men.

At the mills on the three northern coastal rivers of New South Wales and at Nausori on the Rewa River near Suva most of the cane arrives by river punt and is unloaded by grab. This is even more picturesque, with the string of punts stretching out behind a towing launch along the beautiful waterways.

The function of the factory is to make a capture, in commercial conditions, of the sucrose produced by nature and farmers. Fundamentally, the miller is concerned with two interrelated tasks: the physical task of recovering the highest possible proportion of the sugar in the cane and the financial task of recovering it at the lowest possible cost. Each task conditions the other; neither is an absolute goal in itself.

A general picture of what happens in the milling process, until raw sugar and molasses are produced as the final products, has been given in earlier chapters. A sugar mill is designed and developed to a capacity which is a reasoned compromise to meet two main considerations: first, the necessity to handle the cane while it is rich in sugar; secondly, the heavy capital expenditure—and hence the cost for maintenance, depreciation and profit—required to provide increased milling capacity. It is out of the question to provide enough plant to handle the crop in the two or three months of maximum sweetness and, in any case, the harvesting and mill labour would not be available in sufficient numbers for such a short season of work.

Sugar cane, the material on which the mill works, is a variable material and its qualities are, to a degree, unpredictable. It is a product of nature and varies with soil, climate, variety and fertilizers used. It differs from year to year according to seasonal conditions—droughts, floods, disease, pest damage—and from human factors, such as when bad harvesting sends in rubbish, tops, and soil with the cane. Much is known of its chemistry and physiology but there are still gaps in knowledge and unforeseen factors arise. The chemists and engineers

SOUTH PACIFIC ENTERPRISE

must be forever on the alert, constantly sampling and testing and observing their instruments, ready to adjust the process at a moment's notice.

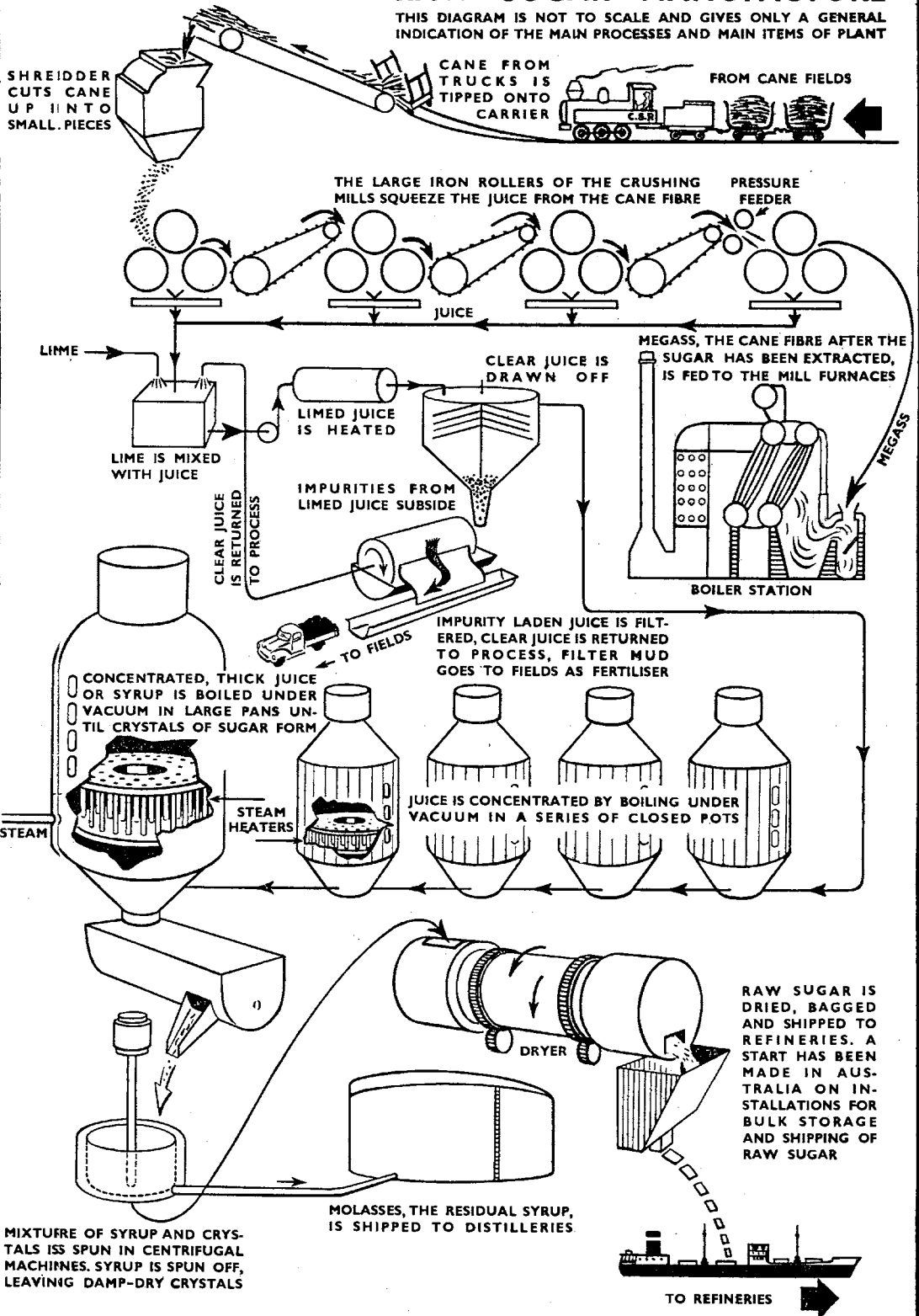
As the cane is received, it is weighed and sampled. By means of the polariscope the sugar content is measured. The percentages of fibre and of other non-sucrose components, called impurities, are also determined. From every 100 tons of sugar introduced to the mill in the cane and measured in this way, the amount captured in raw sugar in modern mills throughout the world falls within a range of 82 to 89 tons, exceptional cases excluded. The Director of the Queensland Bureau of Sugar Experiment Stations, speaking in general terms, recently said, "of the cane sugar taken into the mill in cane, about 86 per cent is recovered. The remaining 14 per cent is lost." For the C.S.R. mills in the 1954 season the proportions of the various losses and of the sugar recovered are as follows:

	<i>On basis of overall loss</i>	
	<i>Best 6 mills per cent</i>	<i>Worst 6 mills per cent</i>
<i>Lost:</i>		
<i>In fibre (megass)</i>	3.92	3.95
<i>In mud from filters</i>	.36	.37
<i>In molasses</i>	6.76	7.77
<i>In various ways: leaks, drains, destroyed by acids, excess heat and bacteria, and lost in transport to refineries</i>	0.95	2.52
<i>Total lost</i>	11.99	14.61
<i>Recovered:</i>		
<i>Made into raw sugar and delivered to buyer</i>	88.01	85.39
<i>Introduced in the cane</i>	100.00	100.00

These figures are a summarized form of what is locally called in the mills the "chemical balance"; more accurately described, it is the sugar balance or polarization balance. The above figures, particularly for "lost in molasses" in the case of the "worst 6 mills", were adversely affected by rubbish (up to 6 per cent) received with the cane, by interrupted crushing because of shortage of cane cutters, and by difficult flood-damaged cane. In New South Wales, partly for these reasons and partly because of a small crop, the mills operated at an overall financial loss in 1954. At a number of C.S.R. mills in 1954 fibre was high and the "purity" of the cane was low, which unavoidably

RAW SUGAR MANUFACTURE

THIS DIAGRAM IS NOT TO SCALE AND GIVES ONLY A GENERAL INDICATION OF THE MAIN PROCESSES AND MAIN ITEMS OF PLANT



increased losses to an unusual extent in the megass and even more in the molasses. Seasonal conditions affect the sugar balance in ways which are in some degree beyond the control of the technologists.

What is the importance of such technical figures and the mass of technical data and jargon that lies behind them? "Technology," says Webster, "is not an independent science . . . but consists of applications of the principles established in the various physical sciences—chemistry, mechanics, etc.—to manufacturing processes." This definition, however, does not sufficiently stress the relation of technology to business necessity. Growers are not paid for cane, but for the recoverable sugar in the cane. The purchase price constitutes rather more than 70 per cent of the mills' total costs. If, therefore, the chemists and engineers lose more than the absolute minimum of this costly yet unstable and perishable material, the manager of the mill, the inspectors in the head office and the general management of the company are likely to become exceedingly terse.

A variation of 1 per cent in the sugar recovered as crystals represents about £20,000 in a biggish mill over the season—if gained that is fine, but if lost there would be some hard thinking and action. A variation of 3 per cent for the season, which could happen if rubbish came in with the cane, if control were bad or equipment inadequate, would amount to as much as £90,000 in the largest mills. The importance of fresh, clean cane and of efficiency in extraction and recovery of sugar from the juice is very clear.

There is one principal aim behind technical advances—to cheapen the final cost of the product to be sold. That way lies greater profit as the first result but, subsequently, there follow cheaper sugar for consumers, increased cane prices for the growers, increased wages and salaries, or a combination of all those things.

One very desirable kind of technical advance is the one which makes more effective use of existing capital, by getting more tons per hour through existing plant or by simplifying and cheapening plant by improvements in design. In the present period of grave inflation and very high costs of additional equipment, these possibilities assume major importance. More investigation, closer supervision, more attention to "know-why" as well as to "know-how", and more scientific measurement and "instrumentation" give accretive, yet cumulatively significant, gains—in lower costs, more profit, or less capital expenditure. While further improvement is difficult because the milling process is an old one and many able men in many parts of the world have worked on it, technical advances must be sought if reasonable profits are to be made.

New ideas and improvements have many origins. Overseas visits by company officers are one source. Another is from chemists and engineers on the job, who not only keep the plant running by standard methods but are expected to suggest improved methods. Constant attention to improvement is given also by senior technical inspectors in the head office and by the central technical services, including the comprehensive technical library and the large technical research department. Some officers are relatively free of day-to-day administration, so that they can concentrate on improvements and developments.

One fairly recent successful example of progress by inventiveness within the company is the "pressure feeder", developed by the chief mill engineer. It delivers the shredded cane to the main crushing rollers under continuous forced feed and increases the capacity and efficiency of the crushing plant. The use of this device is now spreading into Australian mills other than those of the company and overseas millers are becoming interested in it.

Success does not attend all efforts to solve problems—at least not quickly and easily. An instance is the attempt, as yet unsuccessful, to eliminate the troublesome and costly deterioration which still occurs in raw sugar despite every care by known methods. A loss of $\frac{1}{2}$ per cent of the sucrose between manufacture and final delivery of the raws to a refinery would cost perhaps £10,000 on one mill's annual output. The C.S.R. research department, after several years' investigation, identified the main organism, *aspergillus glaucus*, that was causing this; in theory there are remedies, and some improvement has been obtained, but as yet no method that is economic in practice has been developed to prevent the airborne spores from making contact with the sugar or from multiplying in tropical atmospheric conditions of warmth and moisture and doing some damage.

The science of "sugar crystallography", the study of the formation of the crystals at the final stage of boiling, is being applied to improve the design of the vacuum pans and the "instrumentation" of them, so helping to economize in the use of steam and to give more evenness in the raw sugar crystals. Improvements in the "steam balance" and the installation of new and costly furnaces and boiler stations have reduced the cost of coal and wood needed to supplement the mills' megass fuel; working conditions are also better at these new stations.

All products of the mill process are utilized: the cane fibre to feed the furnaces and a little for the manufacture of "Cane-ite" insulating board, the molasses by distilleries, and the filter mud by the growers as fertilizer. An interesting point is that even the water in the cane

stalk, which represents 70 per cent of its total weight, is put to good use. C.S.R. practice is to give the crushed cane fibres a longer and more intense soaking, called "maceration", than in most overseas countries, as one of the methods of extracting maximum sugar. Some mills do not have abundant natural water supplies for steam and maceration and are concerned with their "water balance". These mills can get 100 per cent of their total water requirements, except when starting up, from the water in the cane juice, which is recovered as steam from the evaporators and pans, condensed back to water, and re-circulated.

Management and Men

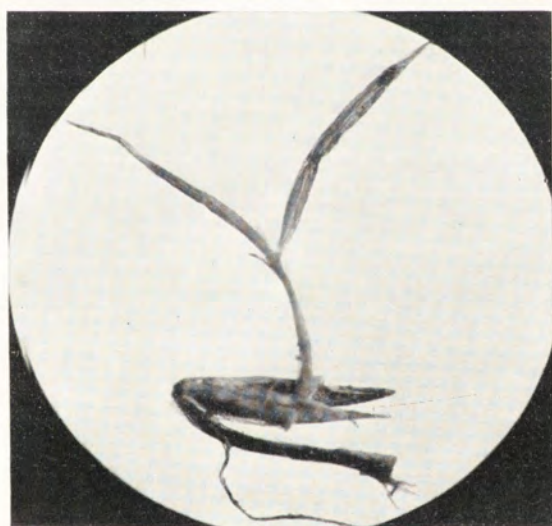
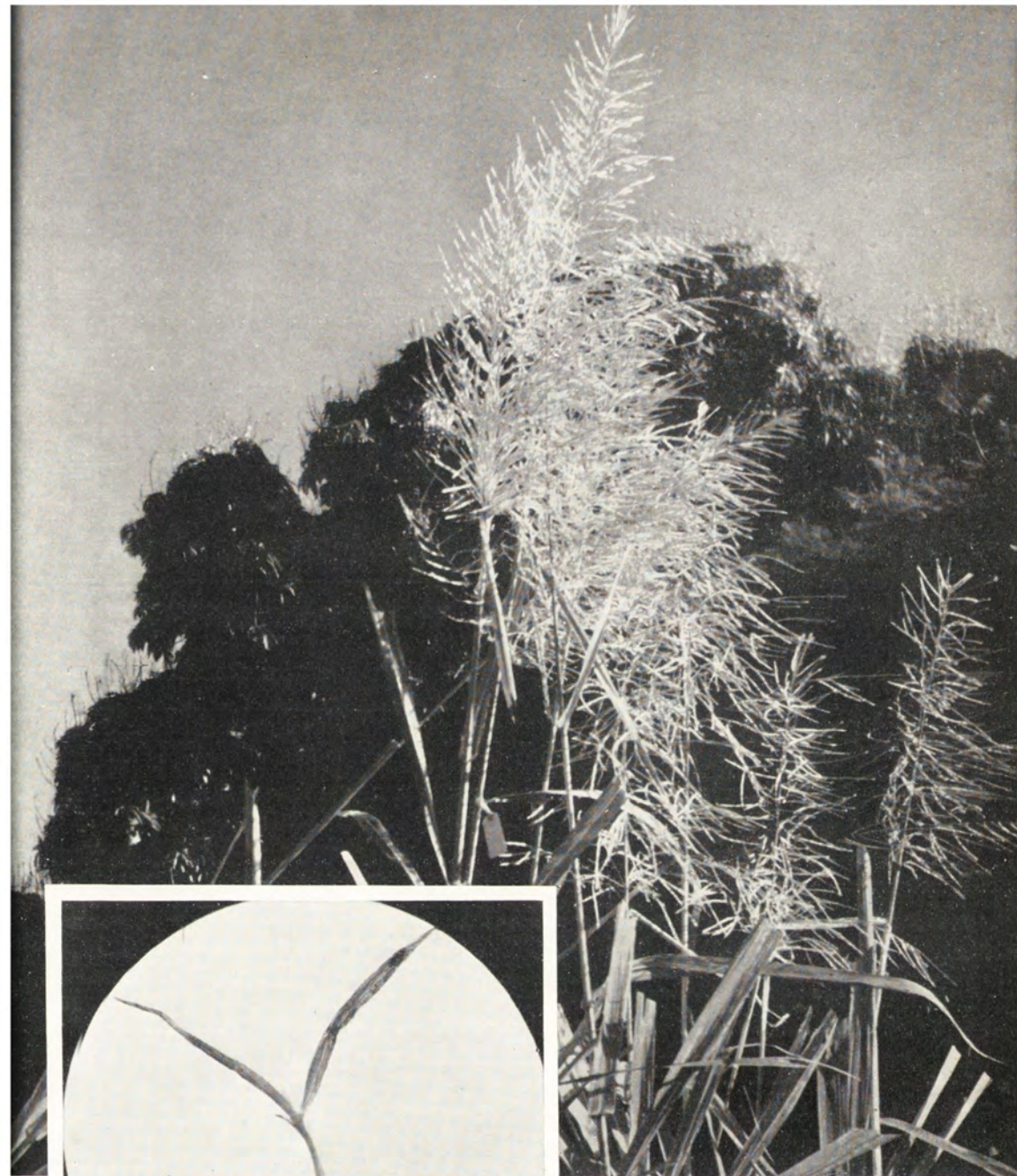
As with any human endeavour involving men and equipment, the quality of the leaders, the organization of the chain of command, and the *esprit de corps* of the "officers and men" have a vital bearing on success or failure.

The managers of the mills are mainly men who have worked for most of their lives in the mill organization. They are responsible not only for the internal running of the mill and its transport system and for the management of 300 to 900 employees but also for the relations with growers, the welfare and training of staff, and the despatch of sugar. The manager has to be a man of clear, analytical mind, firmness and tact. Many of them would have been leaders in any walk of life.

Under the manager, the usual heads of departments in a mill are the field superintendent or senior cane inspector, the chief engineer, the "mill manager", the accountant, the technical field officer, and, in Fiji, the traffic officer. The departmental work of several of these officers has already been described. At a few mills there are additional departmental heads with specialist functions.

The name "mill manager" is at first confusing to the stranger but the history of the name is indicative of one aspect of past growth and change. When chemists were first introduced into the mills, seventy years ago, they were regarded with some degree of suspicion by the managers and engineers of the day, who had been accustomed to judging the efficiency of extraction by tasting the megass for sweetness. The then general manager, Mr E. W. Knox, emphasized their importance by giving them the title "mill managers". The name persists, although in modern phraseology their function is nearer to that of process managers or manufacture superintendents.

Obviously there must be the closest co-operation between the engineers and the "mill manager" and his staff of chemists. Broadly,



Cane flowers, usually called "arrows". The arrow is actually a group of flowers which, under favourable conditions, produce minute fertile seeds. The cane breeder germinates such seeds in his nursery.

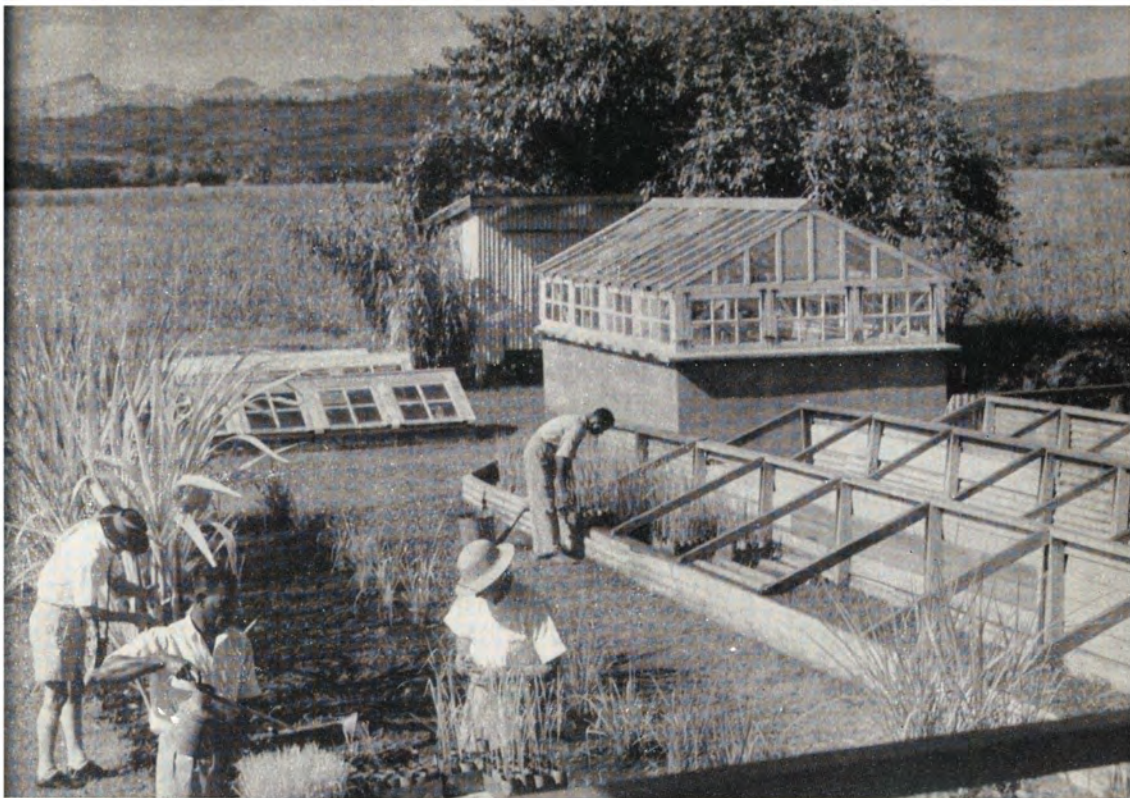
A cane seedling two weeks old magnified about five times. Only cane breeders propagate cane from seeds. The commercial grower plants lengths of cut-up cane.

Right: The officer in charge, Mr K. R. Gard, supervises the potting of seedlings at the C.S.R. field experiment station at Macknade, Herbert River, North Queensland. A number of successful commercial canes, including the well known *Trojan* and *Pindar* varieties, have been bred here.



Below: At the C.S.R. cane nursery at Broadwater, N.S.W., where more than 10,000 seedlings a year are raised.





At the C.S.R. cane nursery at Rarawai, Fiji. Both Indian and Fijian assistants are trained in experimental work.

Young seedlings are raised in hothouses and then transferred to glass-frame beds to acclimatize.





Cane seedlings from nurseries are planted in experimental plots. This one is on the Tweed River, northern N.S.W.



The development of every individual seedling in experimental plots is watched and recorded.





Taking sample of juice
from an experimental cane.



A drop of cane juice is poured on to the plate
of a refractometer and the instrument is read.
The refractometer measures the percentage of
soluble solids in the cane juice, which gives a
good indication of its sugar content.





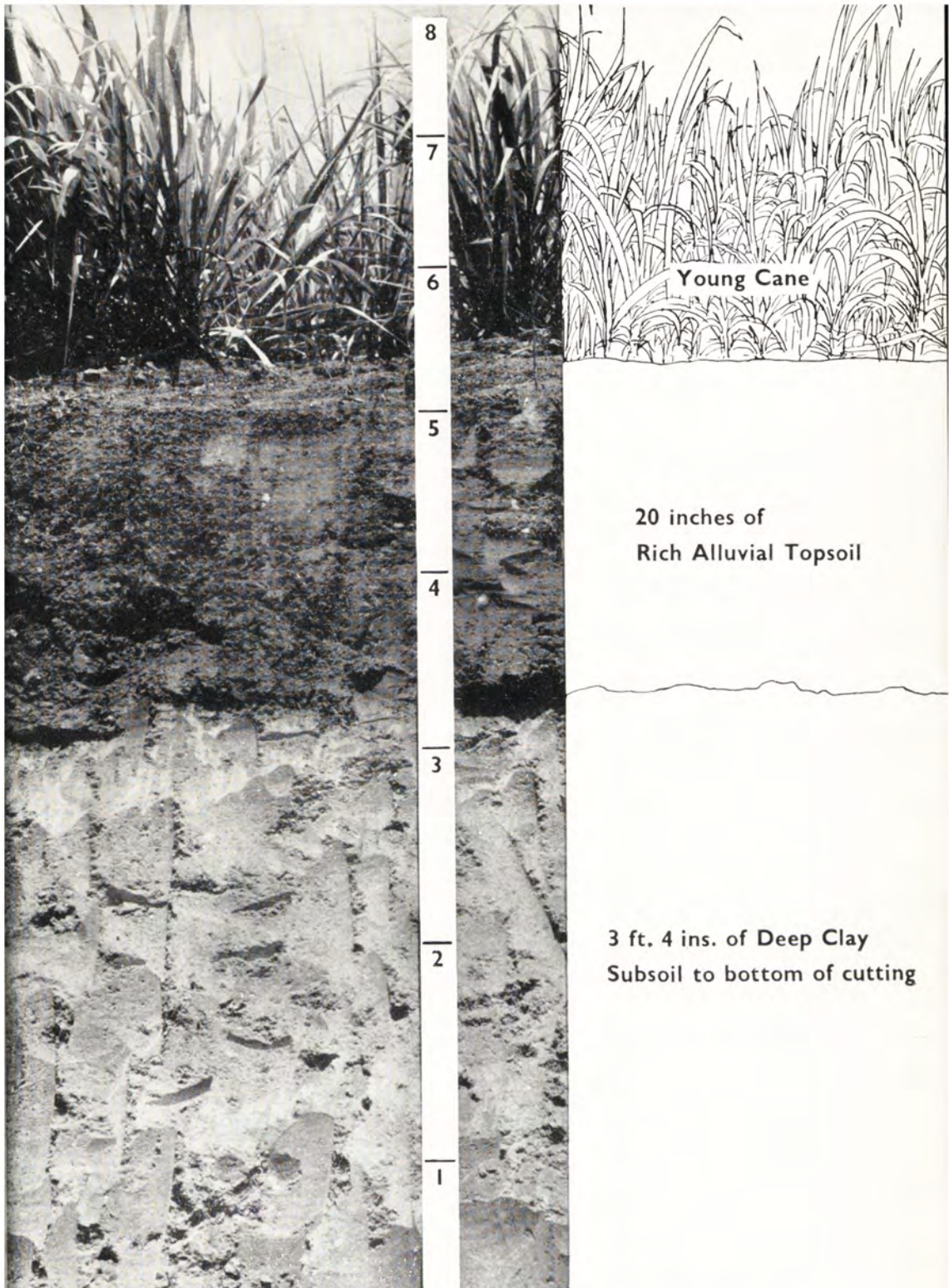
Above: On the left, grub damaged cane. On right, undamaged cane previously treated with benzene hexachloride.

Below: Grubs which eat the roots of cane.



Right: Healthy and diseased cane. The cane on the right has been stunted by Fiji disease. The main method of combating cane diseases is by breeding and growing disease-resistant varieties.





Second ratoon cane growing on top of cutting. This profile is fairly typical of alluvial soils in North Queensland. The soils of Australian and Fiji cane land vary from rich valley alluvials such as illustrated above to poorer soils on foothills. The soil above, shown up by a cutting for Hambleton Mill's light railway, yielded 40 tons per acre in 1952 from plant cane, 37 tons per acre in 1953 from first ratoon cane, and 35 tons per acre in 1954 from second ratoon cane.



C.S.R. technical field officer and grower on a cane farm near Innisfail, North Queensland.



Left: A Cairns cane farmer and C.S.R. technical field officer.



Indian cane farmer, Fiji, and company's field officer.



Left: The whole family gather while a company field officer talks to a Fijian farmer.

in respect of the actual process of production, the chief engineer and his staff control the train of milling rollers and the furnaces fed by the megass. The chemical staff is in direct control of the manufacture of sugar from the juice pumped away from the crushing train, and is responsible for all analytical chemical work, on the cane, in the crushing train and throughout the factory. The chemists must sample, measure, analyse and adjust the process to meet ever-changing conditions. A most important part of the chemists' functions is the supervision of the men on processing stations in their part of the factory and of those handling the manufactured sugar.

The chief engineer and his staff have most varied responsibilities. In addition to the milling train, the boiler stations and the power station, there are all the mechanical jobs in the mill, on the conveyors for cane and megass, and the overall maintenance and good order of all the motors, pumps, electrical services and machines. During the slack season, the whole equipment of the mill must be overhauled, new equipment installed and everything made ready for the "crush". When there is a major new installation it must be done before next season; it may be new boilers and furnaces, involving £300,000 to £500,000 in construction work, in addition to the usual overhaul of the whole mill. The "chief" and his staff often aver that the traditional term "slack season" has little meaning.

The engineers have responsibilities, too, in the maintenance of bridges, locomotives and rolling stock, and of the telephone and radiotelephone systems which are used in co-ordinating the transport system. Able, conscientious engineers mean smooth-running mills. The characteristic question of the chief as he enters the mill is "How's the rate?" meaning the tons of cane crushed per hour. Also characteristic is the way even the placid ones explode into action when a mechanical stoppage occurs, as when a piece of "tramp iron" entering with the cane stalks stops the crushing rollers.

The accountants, some located at the mills and some in Sydney, are, as ever, the watchdogs of the money, in the sense that they are expected to seek all avenues by which expense can be reduced and income increased. The chemists and engineers may have failed to recover a little of the sugar but to gain it might have cost more than it was worth because of extra expense on overtime, the employment of more men, or some other factor. The money figures of the accountant are the overall test. The accountants and their staffs make possible the business integration—as distinct from a technical integration—of the work of the different departments, and of the buying, manufacturing and selling. Sound decisions must be based on financial

data. Accurate and speedy, yet quietly efficient, office work, especially in handling payments for cane and wages, helps to encourage harmonious relations between the mill and the growers and employees. At Lautoka, for instance, there are nearly 5,000 growers and 1,000 employees, and keeping their accounts and making payments is in itself a formidable job for the clerical staff. The records and analyses required by governments and modern business are legion. Finally, the profit and loss figures, compiled by the accountants, set the seal on all the efforts of the organization.

"Head office" controls broad policy, manages the sale and sea transport of the raw sugar, and provides finance. In the head office are the two senior officers who control their respective milling divisions, specialist industrial officers, senior factory and field technologists, senior designing and operating engineers, and accountants. These and others play their part in the direction of affairs, by correspondence and by personal visits.

★ ★ ★

Since the war, production capacity at C.S.R. mills has been considerably expanded. Annual milling capacity has increased by about 900,000 tons of cane or 125,000 tons of raw sugar—a rise of some 35 per cent. The present rated capacity is 465,000 tons of raw sugar per season, slightly more than the immediate production target. Actual production has reached 438,000 tons, in 1953, although it was less in 1954 owing to seasonal conditions.

The most striking single instance of expansion is the duplication of Victoria Mill in northern Queensland and the building of 25 miles of tramline to reach and service an entirely new stretch of virgin country known as the Abergowrie area. Where there was before virtually nothing but trees, grass and a few cattle, there are now 10,000 acres of close settlement, a school has been built and a township is growing. The cost to C.S.R., for the expansion of the factory and of the transport system, was almost £3 million. Design and construction were carried out by the company's own engineering staff. From the conception of the plan, which followed immediately the agreement in London on the expansion principles of the British Commonwealth Sugar Agreement, to the start of crushing of the crops grown on the new area, was a period of slightly more than three years. Important developments, impressive in aggregate but not as individually spectacular as Victoria-Abergowrie, have occurred at other C.S.R. mills in Queensland and in Fiji.

In 1954 the gross revenue of all the company's mills from sugar made and sold was £17.4 million. Most of this was disbursed in the cane

districts, thus promoting industry, trade and development there. £11.7 million was paid to the growers for their cane and £2.6 million to the mills' employees. There are many other expenses, not all incurred locally, but local stores and businesses supplied mills with various materials, besides sharing in the trade generated by the expending of the farmers' and employees' incomes.

All this development rests upon the foundation stone of expanded markets—from Australia's increasing population and under the British Commonwealth Sugar Agreement and Empire tariff preference—to feed people in Australia, the United Kingdom, Canada and New Zealand.

This chapter could only deal with the broad outlines of the economic and social edifice: the capital resources supplied by thousands of shareholders, the profit motive, the partnership with nature, the victories of expertise and the places where victory is yet elusive, and the contributions of the captains, as representatives of their teams. There are others, too, with contributions of brain and hand and eye; many have been with C.S.R. most of their working lives, and some had fathers and grandfathers there before them. The intangible ingredients, so important for the best results, are also there—experience and tradition in the organization, with enthusiasm and teamwork from individuals.