## Life Member

## Colin CLARKE

**TRAINING AND QUALIFICATIONS**

**Trade & Government Certificates:**
Completed Apprenticeship Probationary Period at Harris Implement Works formerly at Four Ways at Mackay in 1946;
Indentures transferred to Proserpine Mill later in the same year (Note: The Mill Manager during my apprenticeship at Proserpine was M. Gibson and I served under Engineers C. Mc Walters and J. Perry who were Society members and regular contributors to Proceedings)

Following transfer to A. Sargeant & Co in Brisbane a Trade Certificate was awarded in February 1952.

Granted a Certificate of Competency under the Inspection of Machinery Acts to take charge of machinery in June 1959. Completed studies with Technical and Further Education Queensland to obtain Certificates for Waste Water Plant Operator and Water Treatment Plant Operator.

**Professional Qualifications:**
Completed studies with Queensland University leading to the granting of a Diploma in Mechanical and Electrical Engineering in October 1951;
Completed studies and satisfied examiners for acceptance into the Institution of Engineers Australia, and was elected to the grade of Associate Member in November 1963.

**Mill Engineering Staff Positions:**
Engineering Draftsman with A. Sargeant & Co, Brisbane from August 1951 to January 1954:
Design Draftsman at Proserpine Mill from January 1954 to February 1956;
Appointed Project Engineer at Farleigh Mill in February 1956 and subsequently Assistant to the Chief Engineer (B.L. Wright who was president of the Society in 1964), being promoted to Chief Engineer on his retirement in 1968. I held this position until taking early retirement in 1987.

**Engineering Activities subsequent to retirement from Farleigh**

GOLD MINING AND EXTRACTION (1987-1989):-
During this period I was associated with a consultancy firm associated with this industry and was involved in project management and process plant maintenance as well as the procurement and refurbishment of second hand ball mills and crushers. I was involved with the operation of mines at Home Island (Torres Strait), Ban1boo Creek (W.A.), and Sunnybank (Atherton Tableland)

ASSISTANT ENGINEER AT CATTLE CREEK MILL (1989):-
I was engaged in this capacity for the last season of the mill's operation and subsequently as fabrication supervisor

for the conversion of the mill's steel trams to Mackay Sugar specification.

PROJECT SUPERVISION AT RACECOURSE SUGAR REFINERY (1994):-
Projects included conversion of a boiler for coal firing including receivals hopper,conveyors and bunkers; installation of the refinery cooling tower, pumps and piping systems; modification of steam mains and installation of the refined sugar loading station.

PROJECT SUPERVISION AT MARIAN MILL (1993-1994):-
Projects included juice heater, pumping and piping systems and extensions to pan-stage condensate system.

PROJECT SUPERVISION AT INVICTA MILL (1995):-
Installation of a Rotary Mud Filter with associated support steelwork, pumps and piping systems, access galleries and covering building and conveyors.

PROJECT SUPERVISION AT PLANE CREEK MILL (1995):-
Installation of Syrup Flotation Plant.

OVERSEAS CONSULTANCY CONTRACTS:-
2002 and 2006: Visits to Indian sugar industry with Dr P Wright, working as S.R.I. Associates, to prepare audits for several factories to assess factory efficiencies and submit recommendations for increasing plant capacity.
1992: Investigate operating and design problems with a new milling train installation at a sugar factory in Pakistan.

LOCAL CONSULTANCY CONTRACTS:-
2002:- Investigation into operating problems with the Farleigh milling train.
2009:- Developing a Blending Plant for Molasses Based Animal Feed Supplements at Marian Mill.

MAJOR PLANT OVERHAUL PROGRAMME AT RARAWAI FACTORY (FIJI):-
This factory was in a seriously run-down condition and required an extensive program of refurbishment for the 1996 crushing season. I was subsequently retained as Maintenance Advisor for the following two seasons. In 1997, I was also involved in damage assessment following the floods of cyclone Manu Manu.

CONCEPT, LAYOUT, DESIGN AND EQUIPMENT SELECTION FOR COMPLETE SUGAR FACTORIES:-
I was a member of a design team working for a fabricator of sugar factory equipment. Proposals for major international projects were developed and submitted as follows: 7000 T.C.D Cane Sugar Factories for Iran (1995); 3000 T.C.D Beet Sugar Factory for Azerbaijan Republic (1998).

FACTORY EXPANSION PROJECTS (1994-2004):-
Further work contracts with the above team involved site assessment to determine T.P.s together with equipment selection, design and modification to enable installation into an existing factory as follows: Evaporator vessel at Invicta Mill; Evaporator Station at Marian Mill; Pan Stage at Plane Creek Mill; Heater/Evaporator Stations at Plane Creek Mill; Wet Scrubber for Boiler at Pleystowe Mill; Surplus bagasse loading, storage and reclaim systems as part of a Mackay Sugar Investigation into optimum usage of bagasse fuel; Site investigation into spatial feasibility of providing an economizer and air heater on No 4 Boiler at Farleigh Mill; Project evaluation to convert drives on milling train and shredder prime movers from steam turbine to electric drives at Racecourse Mill.

COOLING TOWER AND ACID DOSAGE STATION FOR FURFURAL PLANT
(2009):- In 2009 work was commenced on the design, manufacture and installation of a Furfural Plant at Proserpine Mill. Much of this work was undertaken by the previously mentioned supplier and I was asked to assist with the selection of a cooling tower for plant cooling water, the sizing of basin and pump wells as well as the selection of

pumps and piping systems. The work also included storage and dosing systems for acid used in the process.

CONSULTANCY WORK ON SUGAR FACTORY PROCESS STATIONS (PERIOD 1989-1991)
At the request of the above equipment supplier I was asked to select and size plant and equipment and suggest layouts for process stations appropriate to Raw Cane Sugar Factories of 8000 and 10000 T.C.D. capacity. (1995):- Further to the above, preliminary designs were prepared for Cane and Bagasse Diffusers of 10000 T.C.D. capacity.

**Notes from experiences at Farleigh.**

In 1956 Farleigh Mill was the center of a small town-ship. In this township, the mill owned some twenty dwellings for staff and permanent employees, quarters for single staff, barracks for mill workers, a kitchen and dining hall and the main office and laboratory building. The township itself had a general store and Post Office, hotel, school of arts hall, police station, Catholic Church and convent school, a state school, a small Protestant Church, a picture theatre, and a bakery. There was also a small cafe to which was attached a billiard room and barbers shop. The mill provided a reticulated water supply to the township as well as a sanitary service (a dray fitted with a housing for pans and drawn by draft horse). The mill also maintained tennis courts and a cricket field for local use. That thirty year period spent at Farleigh Mill was one of considerable expansion in the Australian Industry. At Farleigh, factory throughput was raised from 140tch to 500tch as a result of three major Capital Work Programs involving new plant and machinery and up-grading of existing plant. The mill processed 1000 000 tonnes of cane for the first time in 1984. This period also saw the application of developments in Sugar Technology flowing from work by Sugar Research and other industry research agencies. Australian sugar machinery manufacturers were also offering improved equipment designs, and a number of innovations were coming from industry personnel.

STUDY TOUR:- In 1971, I was sent on a study tour of overseas sugar industries in Hawaii, the U.S and South Africa and visited the engineering works of manufacturers of sugar factory machinery in the U.K. Germany and France. This tour also included attendance at the International Sugar Conference held in Louisiana.

INTERNATIONAL SUGAR TECHNOLOGY SOCIETY:- I was granted leave of absence to attend conferences of this society held in Brazil (1977), the Philippines (1980), and Indonesia (1986), and subsequently in Brisbane in 2002. A.S.S.C.T.:- I was sent by Farleigh Mill as a delegate to the 1957 conference of the Society (then known as The Queensland Society of Sugar Cane Technologists) and attended all subsequent conferences until 2010. Two papers were presented to engineering sessions. I served on the executive committee as Secretary of the Manufacturing Section in 1981 and subsequently as its Chairman.

THE MACKAY SUGAR MILL ENGINEERS INSTITUTE:- I joined this association in 1956 and subsequently served as secretary and chairman. I was involved in committee activities associated with the preparation of papers on local mill plant and performance for A.S.S.C.T. conference. I was also involved with the presentation of lectures to prepare factory plant operators for certification examinations.

INSTITUTION OF ENGINEERS, AUSTRALIA:- I was a member of the Mackay local group, joining as a student member in 1958 and was subsequently elected to full membership. I attended a number of regional conferences of this Institution.

*INNOVATIONS*
Bulk Sugar Handling:- Against the doubts of many in the industry Farleigh chose to use a 400t silo to hold factory sugar for loading into Road Transport;
Early attempts to improve mill feeding:- In an attempt to increase the capacity of milling units a sloped apron conveyor surmounted by a weighted Aguirre feeding roller was provided at the feed opening of No 1 Mill and the approach speed of pushers at No's 2 & 3 mills was reduced;

The Light Duty Pressure Feeder:- Following on the limited improvements achieved by these alterations some of the first of the so-called "Light Duty Pressure Feeder" units were installed on these three mills in the Farleigh train. Their operation was based on the results of experimental work on mill feeding by The Sugar Research Institute. The units were fabricated in-house to designs prepared by mill engineering staff;
Continuous Centrifugal:- One of the first BMA Units in the Industry was installed and commissioned at the low grade station;
Continuous Launching of Steel Tramway Bridges:- In-house design and launch procedure was probably the first used in cane tramway bridge erection in Queensland;
Use of Pneumatic Control Equipment:- Before the advent of micro- processors, attempts were made to use pneumatic controllers for remote manual and semi-automatic controls for milling train and effet operation; Boil-through Chemical Treatment of effet heating surfaces to remove Scaling; Hot caustic circulation in juice heaters to remove scaling;
Partial Automation of Bagasse Storage/Reclamation in a 400t Bagasse Shed:- This was considered necessary for the satisfactory operation of the fuel system associated with a 200t/h boiler unit ; Solids Lubricants for Slow Speed Gearing and Mill Pinions using spray application from a central lubrication system; Lubrication of plain bearings throughout the milling train from centralized lubrication systems;
Milling Train Hygiene:- Extensive use was made of stainless steel sheeting for juice gutters and epoxy coatings applied to mill floors which were relayed with positive drainage falls;
Waste Water Treatment Plant:- With no suitable pondage site within reasonable distance, a Water Treatment Plant using aeration with activated sludge return and fed from surge ponds was installed. Final treatment was in large shallow "Polishing" ponds;
Water Conservation Measures:- A limited supply of fresh water, and the need to reduce the hydraulic load on the water treatment plant required the recovery, storage and reuse of all water from evaporation, surplus to boiler and process needs, small cooling towers were provided for closed circuit machine cooling water and crystallizer cooling watersystems, while, in addition, pan dilution feed and pan washout systems were connected to use ESJ; Precision Long Pitch Outboard Roller Chain for use at the cane carrier; An automated Milk of Lime Mixing Plant with silos to store bulk pelletised Lime; Submerged arc welding for restoration of worn flanges on tram wheels; Continuous Wire welding for roughing mill rollers.

*CHANGES TO PLANT AND MILL ENGINEERING*

To convey some idea of the changes to plant, operating technology and maintenance procedures over that period, it may be of interest to review the plant and its maintenance and operation as they were in 1956, as compared with 1987.

*Cane Haulage*

1956:- Cane supply was in whole stick form. With 40% of cane supply loaded into wooden Queensland Railway wagons delivered to siding at Farleigh Station. The balance was hauled in wooden tram trucks of nominal 2.5 tonne capacity over the mill tramway system. The bundles of cane on trams were held down by chain slings tightened on small winch drums using a long spanner and the drum locked with a pawl. Some 400 trams were in use served by a diesel locomotive (l6t) and four steam locomotives (l5t and 12t), the latter being used on short hauls and yard shunting. There was limited control of harvesting and with delays in delivery of railway wagons delivery of cane supplies could be up to five days from burn to processing, which could result in significant losses in recovery. The trams were built in mill workshops and during crushing small rakes were diverted to a makeshift workshop every day during crushing operations after unloading, for checking and overhaul. Limited facilities for locomotive servicing originally intended for steam locomotives were not suited to the new diesel locomotive.
1987:- Cane supply was now in billet form carried in mesh bins on steel trams of 4tonne capacity. Over 2800 trams were in service in a tramway system which had been extended to the northern growing area. Haulage was now by twelve diesel locomotives varying from 32t to l6t. Ballasted braking wagons were required to stabilize the long trains now being hauled. Main haulage lines in the tramline system had been up-graded using heavier rails on concrete sleepers bedded on crushed blue-metal ballast. To increase haulage speeds, alignments, curves and gradients had

been modified and the track was regularly maintained using ballasting machines. To minimize deterioration with chopper harvested cane, harvesting and cane haulage were scheduled to ensure minimum delay from field to factory (<24hrs).

*Cane Receivals and Unloading*

1956:- Railway wagons were shunted from the cane yard (or railway station siding) and weighed over by a steam locomotive to fill the supply lines leading to the two unloading stations at the Cane Carrier. Unloaded wagons were run forward by incoming wagons onto holding lines from where they were shunted back to the railway siding. Wagons were drawn from the supply lines by steam winch. To winch up, the long hauling wire was drawn out by a draft horse. Unloading of wagons was by lowering overhead open conveyor chain rakes, the wagon being drawn to and fro under the rakes by wire ropes from an under-floor reversing winch. Trains of trams hauled in over main haulage lines were broken up for shunting to holding lines in the cane yard. The trams were manually weighed over a weighbridge using an electric winch to fill a supply line leading to a tip at the cane carrier. A steam winch pulled the trams onto the tip. A set of unloading rakes was also provided above the tip for partial unloading of trams before final tipping (45°) to improve load distribution on the cane carrier. A workforce of ten men per shift was used at the receivals and unloading station including weighbridge clerk, tram weigh-in and winch attendants and a greaser. A significant number or trams had plain bearings and the greaser's duty was to top up oil in axle boxes and to identify trams in damaged condition.

1987:- All cane was now supplied in billet form transported in bins on steel trams. Cane trains now continued on from main line haulage to the cane yard with locomotives passing over the tram pushers to allow the leading tram to be engaged with a pusher before uncoupling. The locomotive then reversed through a set of points to an escape line to return between storage lines. Bins were emptied into the carrier by inverted tipping on a two bin tippler. Tipping was initiated by sensing change in level of cane on the carrier, to maintain a continuous feed, with automatic spotting of trams from the supply line between the relocated weighbridge and the tippler, the weighbridge clerk controlling the operation of the weighbridge spotter to fill this line. Trams from the cane yard moved in step with this spotter with the next rake being pre-selected to follow on. Trams leaving the tip had gravity run-off through points to empty lines assisted by reciprocating pushers operating continuously. Manning comprised the weigh-bridge clerk and an un-coupler.

*Cane Preparation*

1956:- Preparation was by two sets of knives and a shredder. The first knife set was located on the carrier beyond the tip and was driven by electric motor. The top knives and shredder were mounted on an elevated steel staging at the head of the carrier above the first mill hopper and were also driven by electric motors.Total motor power was 700 Kw. The elevating cane carrier terminated under the top knives and was driven by a steam engine. Variations in the depth and density of the cane on the carrier resulted in considerable surging in power demand. Cane preparation was relatively coarse by present day standards.Knives were provided with hardened steel cutting edges and the ends of shredder hammers were hard-surfaced. All were replaced each week. The advent of harvesting practices using front end loaders in the sixties resulted in considerable quantities of soil and stones in the cane. This caused severe wear and damage and resulted at times in mid- week stops for replacement.

1987:- With cane in billet form, it was now possible to obtain high levels of preparation with a heavy duty shredder driven by steam turbine. The shredder is now mounted at mill floor level discharging into an elevating conveyor which delivers the prepared cane into the first mill feed hopper. Flow of cane to the shredder is now uniform and loadings are steady. The shredder is powered by a steam turbine of 4500 kW. Shredder hammers are now fitted with detachable sintered carbide tips which with good harvesting conditions can have a service life of up to 200 000t.

*Milling*

1956:-The milling train consisted of four units,the first having 2.12 M rolls and the remainder 2.17M with elevating rake conveyors between mills. All mills were driven by large slow speed single cylinder steam engines. The first three mills were fed from open chutes fitted with reciprocating beams operating in the open mill feed hopper above the mill entry working alternatively with sliding platens below, intended to compact the cane/bagasse into the front openings of the mills. The pushers were actuated by crank shafts rotated by heavy hemp rope pulley drives from the mill gearing shafts. The final mill was fed by an early design pressure feeder from an open chute fitted with a hinged plate to level the feed and give indication of feed in the chute. Rate of discharge from the shredder to the first mill hopper was regulated by the operator of a small steam engine driving the cane carrier. The operator was located on a platform to give him line of sight into the first mill hopper. A hand wheel on the end of an extension to the engine throttle valve spindle allowed him to vary the carrier speed. The shredder had recently been remounted to discharge backward into the top of the mill chute to improve feed distribution.Maintenance of the milling train was complicated by having overhead cranes which spanned the milling units only and by the practice of re-grooving rollers while mounted in a mill. The roller being re-grooved was turned using a demountable gearbox and chain drive. In dismantling a mill the larger components removed were loaded on wagons for temporary storage on a rail line outside the mill building. A work force comprising two engine drivers, a clutchman (carrier driver), a mill greaser (responsible for the lubrication of mills, gearing, steam engines and conveyor bearings in the milling train area) and a "Cush-Cush" attendant were employed on each shift. All mill juices were strained over screens, the bagasse retained on the screens being removed by elevating paddle conveyors discharging to the carriers between mills. The Cush Cush man's duties included supervision of the operation of these screens as well as attending to the operation of pumps and valves, the control of the maceration system and milling train housekeeping.

1987:- The milling train now comprised six units the first having rolls 2.78 M long and in the remainder 2.17 M. rolls. All mills were now driven by steam turbines. The final two mills have the earlier design of pressure feeders and the remainder the heavier crusher feeder design. All feeders are provided with underfeed rolls and receive prepared cane/bagasse from closed chutes. Elevating rake conveyors continue to be used between mills. Upgrading of the *fust* three milling units and conversion of prime movers to steam turbines required replacement of existing slow speed drive trains with stronger gearing and the provision of high speed gearboxes. Deterioration of gear tooth faces occurred on new slow speed gearing during the first year of service. Keeping this gearing in service, while sourcing new gearing of improved design and material specification, turned out be a major project and required three seasons to be satisfactorily resolved. The crushing rate is set by the speed of the first mill. Speeds of other mills vary to maintain set height of material in closed feed chutes as detected by mushroom headed probes set into chute side walls. Juice and maceration flows are now handled by chokeless pumps with ni-hard iron impellers and liners;.and solids-removal from mixed juice is by rotary screen. All operating functions were controlled and monitored from a control room located between the first two mills with oversight over the train. Overhead traveling cranes are now available to service the milling floor areas. Rollers could be grooved in a large turning lathe.

*Steam Generation*

1956:- Steam generation was from six boilers of 20-30t/h steam output. One boiler was Stirling type watertube unit and the others of the B&W inclined tube and header design. Combustion in the boilers was in two stages. The first stage was the so-called "Dutch Oven" Furnace where initial burning of the bagasse took place to generate the volatiles which carried over for high temperature combustion into the combustion chamber exposed to boiler tubes. There were two furnaces on each boiler and these were provided with firing doors, furnace doors with pits under grates for the collection of ash. Boilers had no superheaters, economizers, air heaters or dust collectors. Boiler flue gas passed through boiler dampers to a common underground flue leading to two I.D. Fans and chimney stacks, one at each end of the flue.

The steam was at 880 kPa pressure. The only boiler water treatment had been to add milk of lime to the feed tank when feed water tested with low Ph. However an alkali/phosphate treatment and dosing system was about to be installed. Supply of boiler feed was from a weir type steam pump having a throw shuttle steam valve to maintain constant water pressure. An electrically driven multistage high pressure water pump provided backup. Grates and ash pits had to be manually cleaned at least once per shift with timing to suit boiler load and ash build up. The advent of the front end loader caused loss of combustion, severe ashing problems and clinker build up. Clinker build-up was severe enough, at times, to cause partial closure of the opening between Dutch Oven and combustion chamber and had to be removed during weekend cleaning with jack picks. Logs were used for supplementary fuel for initial steam raising and to stimulate combustion. The logs were loaded to a floor at firing door level from wagons on a rail line provided for that purpose. Bagasse for combustion was supplied from a long conveyor running above the firing floor.

This floor was located just clear of the arches of the furnaces at the boiler fronts. The flow of bagasse into firing holes in the furnace arches could be adjusted to maintain the desired height of the fuel bed. Fuel surplus to boiler demand was stockpiled over the firing floor using steam venturi blowers. The high fibred canes then favored required incineration of surplus bagasse which was discharged to blowers for pneumatic transfer to beehive furnaces in the boiler yard. Boiler station manning comprised a watertender, firing floor attendant and three firemen per shift.
1987:- Factory steam was now supplied from two boilers one of 210t/h output and one of 68t/h output. Both boilers are of the water wall type with suspension firing and mechanical de-ashing to bunkers. At each boiler, combustion air is supplier by forced draft, and secondary air fans with flue gas drawn from boilers by induced draft fans. All fans have electric drives with the exception of the larger boiler where the I.D. Fan is driven by steam turbine. Both boilers are fitted with superheaters and steam is supplied at l450kPa pressure and 254°C. The larger boiler was provided with an economizer which could be bypassed to reduce boiler efficiency to enable bagasse surplus to normal steam requirements to be burnt in the boiler. When by-passing the flue gas, its temperature was reduced before entering the dust collector, using atomized boiler feed water. This boiler also uses a steam/air heater to supply heated air for secondary air and feeder air to assist combustion. The smaller boiler is provided with an air heater which heats all combustion air. Both boilers have dry collectors of the multiclone type. Dust is extracted from collector hoppers by screw conveyors through rotary seal valve and wetting mixers to ash conveyors. Boilers were remotely controlled from a control room on the firing floor level and have full combustion control systems maintaining operating steam pressure. Two operators were in attendance each shift. An additional employee was engaged on day work to sample and analyze boiler waters to establish chemical balance by adjusting dosage of chemicals and boiler blow-down. Two additional samples are taken each shift to monitor water condition and are analyzed in the laboratory. As chemical dosage is continuous,sufficient chemical mixing has to be carried out to supply night shift requirements. Boiler water chemical control is by alkali/phosphate treatment.

*Power Generation*
1956:- Power generation was by a 750 kW turbo-set and four generators each of 180 kW capacity driven by compound steam engines. Distribution was at 415 V.The machinery area and switch boards were in a walled enclosure in the factor. The power house was under the supervision of a driver on each shift.
1987:- By 1987 all alternators in use in 1956 had been removed and replaced with three turbo-sets of a total of 8MW capacity. Distribution voltage was now 3.3 Kv. However the output of the oldest (1500 kW) of the three units was at 415 V. An emergency diesel generator of 425 Kw (at 415 V) had also been installed. The power house area was now fully enclosed and ventilated and provided with noise suppressant wall and ceiling lining. Overhead traveling cranes were installed for machine overhauls. The operation of the powerhouse was now remotely monitored at the milling train console.

*Juice Heating*
1956:- The Juice Heater Station consisted of five heaters of a total of approx 163m$^2$ heating surface, four in service and one cleaning. The heaters had a four tube pass with a chamber at each end, having partitions to divert juice flow through successive passes. The chambers were closed by a large hinged cover bolted to a flange around the outer end of the chamber and sealed by a lead sheet gasket fitted to the inside of the cover. One heater was cleaned each day by wire brushing after draining, washing and treating with caustic solution. This procedure was carried out by day labour. Heating steam was supplied from exhaust mains. Juice temperature was manually controlled.
1987:- The heater station had been enlarged with heaters at ground floor and on a staging at pan stage level. It comprises two dedicated Primary Heaters of approx 280m$^2$ heating surface using effet vapour, with a similar heater for optional use as a Primary or Secondary. Five heaters of approx l50m$^2$ are used for secondary heating also on vapour. Final heating is by two Tertiary Heaters on exhaust steam. Cleaning is carried out after 48hrs of service by caustic circulation with some steam heating. Optional cleaning with difficult scales involves baking, removal of front headers and dislodging cracking scale using air pulse blowers. Individual temperature control is provided at each heater.

*Clarification*

1956:- Clarification was carried out in three early-design Covered Cone Subsiders with mud scraper gear. Mud was discharged through variable throw cam operated trip valves. These clarifiers were at the limit of their capacity and were replaced in 1957 by a single unit of the multi-tray type which was considered to be the most efficient clarifier design on offer at that time.

Liming and mixing of mixed juice was carried out in a "Sumermix" ( a patented mixing tank having a high speed stirrer). Metering of lime was by a small bucket wheel dipping into a milk of lime tank and discharging over a flow splitting partition with its position actuated by the output signals from an electrode monitoring ESJ Ph. The milk of lime supply was batch mixed in a stirred tank using bagged quicklime at a mixing station. This procedure was carried out each day by day labour.

1987:- Juice clarification was now carried out in a tray-less clarifier of the SRI Type 10.4 M. dia. As the operation of this type of clarifier requires the use of flocculating aids, juice flow should be as uniform as possible to avoid turbulence and the temperature of secondary juice needs to be controlled within close limits to ensure flash off of entrained gas in juice. Use was made of a surge tank to assist in smoothing juice flow. The SRI clarifier design also includes a new and effective type of flash tank. Automated dosing facilities were developed to ensure uniformity of dosing solutions and their accurate addition and mixing into juice flows at the most effective locations. Essential to these processes was a juice flow meter which provided control information for juice flow control and the addition of lime and flocculent. An automated batch mixing station for the supply of milk of lime is located external to the filter/clarifier area and uses bulk un-slaked lime pellets drawn from overhead bunkers. Bunkers are filled pneumatically from road transport. Flocculent is batch mixed and transferred to a supply tank.Filter mud is drawn off continuously through a pneumatically actuated diaphragm valve. Mud draw off is regulated by observing the condition of juice in observation ports and in sample flows from various levels.

*Evaporation*

1956:- A new set of evaporator vessels had recently been commissioned for 1954 season comprising four new vessels arranged as a quad set. The largest of these vessels was of 1040 sq.m. Brass tubes were used throughout. Boiling levels in vessels were set by overflow wells built into calandria top tube-plates with flow between vessels through balance legs. Juice feed to the set was by manually adjusting the valve in the ESJ supply line to suit fluctuations in the level of juice in the supply tank. The density of the liquor leaving the set was monitored by a brix spindle floating in a column of liquor kept filled with a sample flow supplied from the discharge line. Boiling rate was manually controlled by varying the opening of the heating steam valve. An Effet Boiler was employed for each shift. Most heating surfaces were brushed during W.E. shutdown after soaking overnight with caustic solution. On occasion the first vessel was boiled using a diluted modified acid which was then discarded. With this treatment scales were generally sufficiently softened to ensure removal by wire brushing.

1987:- The station had been re-arranged and additional vessels installed, the largest (final vessel) being of 3250 sq.m. The vessels were arranged as a quad station preceded by a Pre-evaporator. Older vessels were combined to form dual vessels for the second and third stages. Stainless steel tubes were used in the new vessels. The station was automated with boiling levels controlled to set heights in each vessel and heating steam flow controlled from the level in the ESJ supply tank. Syrup brix was controlled from the density head in a column of liquor established by a sample flow from the liquor pump. Juice was transferred from PE to the No 1 vessel by low head pump. An effet boiler and assistant were employed on each shift. The duties of the assistant also included monitoring of heater cleaning and filter operation. Cleanliness of heating surfaces was now restored by boil through with caustic solution, with the solution being returned to the head of the set to raise the solution strength and temperature. Follow through boiling using modified acid solution was also available (generally restricted to first vessels). Extensive use was made of entrainment baffling to avoid carry over to condensates.

*The Mud Filter Station*

1956:- Two rotary vacuum filters of 57 sq. m screen area had been commissioned for 1956 season.Mud removed from screens was transferred by screw conveyor to a paddle conveyor for discharge to mud bunkers. Bagacillo for conditioning mud in the mud mixer was drawn from coarse screens in the bottom of the bagasse conveyor and

pneumatically conveyed to a bagacillo separator above a mud mixer. The station was supervised by an operator on each shift. This operator was also attended to mud draw-off from clarifiers and monitored the clarity of ESJ.Blinding of filter screens was initially cleared using high pressure hot water blast cleaning but soaking in caustic solution was later found to be more effective.
1987:- Two additional filters of 180 sq.m, screen area had been added to the station with supervision by the effet operators. To ensure a reliable and adequate supply of bagacillo for mud conditioning a louvre type collector was provided in the bagasse conveyor system, the bagacillo being pneumatically conveyed to a cyclone separator above the mud mixer. Filter mud was now conveyed by slow moving belt conveyors and discharged to a new and larger storage hopper which also receives boiler ash.

*The Pan Stage*
1956:- There were seven pans on the boiling floor including two early designs mechanically stirred pans, an oval coil pan and four calandria pans, the largest of which was 54 cu. m. capacity.
Holding tanks for liquor, A and B molasses were of bolted cast iron panel construction of limited capacity. Magma slurry was held in a small mechanically stirred receiver of C.I. construction located on the pan stage floor. Surplus magma was re-melted in a stirred tank at ground floor level for return to the syrup tank. The support structure carrying pans and receivers was very congested with little head room under pans. The heights of more recent additions to the pan stage had encroached on roof truss steelwork with condensers protruding above the roof line and housed in small enclosures. All pan stage operations were performed manually by a pan boiler and assistant on each shift. Most pans were provided with cuitometers to guide the pan boiler in determining the level of exhaustion and crystal formation.
1987:- The pan stage had been increased in capacity by the addition of four new pans carried on new supporting structures including new covering buildings. The largest of the new pans was of 114 cu.m. boiling volume. With the exception of one *unit* all pans boiling high grade masscuites were mechanically stirred. The original coil pan was removed from service. A new stirred magma receiver was mounted at main pan floor level to service the seed pans for A and B footing material. This receiver overflows to new re-melt station with automatic brix control.
New liquor, A and B molasses storage tanks erected at pan floor level early in the pan stage expansion program were now used for liquor only. New vertical tanks for A and B molasses were provided mounted at ground level. An upper chamber in these tanks was kept full by recirculation to ensure constant head for pan feed. An elevated hot water head tank also supplies water at constant head. Molasses conditioning to give constant brix for pan feed has been introduced. A continuous pan of 120 cu.m. internal volume was located and housed external to the main pan building. This pan has seven cells and is served with material from a dedicated seed pan discharging to a stirred seed masscuite vessel. A variable speed pump delivers a controlled flow of material from this receiver to the pan. The operation of the pan stage has been automated with pan boiling of batch pans following a pre-determined boiling program controlling feed, steam flow vacuum (temperature) .and the initiation of cut-over, dropping of pan, steam-out/wash -out and draining. Pan drop doors and masscuite valves were hydraulically operated. Automatic control of the continuous pan involves the use of a conductivity profile defining desired levels of conductivity in each cell as measured by probes. Molasses and water feed are varied to suit, while calandria temperature and steam flow are held constant. C masscuite is discharged continuously over a screen to a receiver for pumping to the crystallizer station. Pan boiling operations are monitored and controlled from a centrally located control room. The station is supervised by a crystallization supervisor and assistant on each shift. The ground floor under pans and centrifugals is drained to a sump for recovery of spillages to process. To improve working conditions on the pan floor, large updraft ventilators were provided in the pan house roof and ducted fresh air was directed to pan working faces.

*Cooling of Condenser Water*
1956:- A spray pond was being used for cooling condenser water. The spray pond was located along the side of the crushing house and was restricted in area. A hot well receiving condenser water from the underground drainage system connected to condenser wells and the cold well receiving cooled water returning from the spray pond area were located in a covering lean-to structure attached to the crushing house building. Five axial inlet pumps were used to circulate the water to spray pond and condensers, one pump being connected for use as a stand-by for either

system.
1987:- Spray pond pipework had been dismantled and the pond area filled and leveled. Cooling was now carried out using two updraft cooling towers, one of four and one of two cells located away from the mill building inside the arc of the empty tram line area. The previous hot well was now connected by an underground drain pipe to the hot wells at the cooling towers and tower cold water overflows were returned by large box culverts to the original cold well. An additional five pumps were provided at cooling tower pump wells. Capacities of all pumps were increased by fitting larger impellers and providing motors of greater power.

*The Crystallizer Station*
1956:- This Station consisted of three units of the rotating water-cooled disc type each of 60 cu.m.capacity. Water circulation to cooling elements was not possible in all units due to leakage caused by corrosion of the elements and the units were operated as air cooled crystallizers. They were located at ground floor level and were operated to batch cool the C masscuite which was then pumped to C centrifugal minglers.Crystallizer drive worm gearboxes were belt driven from a line shaft.
1987:- The earlier crystallizer station had been removed and replaced by a new station at pan floor level carried on an elevated staging along the side of the new pan stage building with the pan house roof line extended to cover the station. The station now comprised five rotating coil water cooled crystallizers each of 73 cu. m. capacity. It was intended that the units would be operated continuously with C masscuite flow split evenly to each, with final overflow gravitating to the low grade centrifugal supply header. A facility to add final molasses to the incoming material was provided to "lubricate" heavy masscuites and avoid high stressing of coils and drives. Water circulating through the crystallizers was cooled in a small updraft cooling tower. A small steam heater was also provided to provide circulating water for heating if required.

*The High Grade Centrifugal Station*
1956:- The high grade centrifugal station consisted of one semi-automatic electric drive machine processing most of the B masscuite and seven elderly belt driven units. These latter units were driven by flat belts from a line shaft through spider friction clutches. With these machines the functions of stopping, starting, charging, washing of charge (using a dipper filled from water tubs), discharging and clearing of baskets (using a wooden paddle), and screen wash (by hot water hose), were carried out manually. As a consequence the station was served by three operators on each shift. Sugar was conveyed from machine discharge to the sugar drier elevator by screw conveyors.
1987:- The belt driven centrifugals had been removed and replaced with five automatic machines having D.C. drive motors, together with an additional unit similar to the existing semi- automatic machine. The two groups of machines were fed from separate minglers which could be supplied with either A or B masscuite. Oscillating trough conveyors initially installed with the new machines were replaced with a screw conveyor under the centrifugals discharging to a belt conveyor. Water mist sprays combined with cleaning scrapers were used to prevent the formation of sugar crust on the surface of the belt conveyor. The machines were controlled and monitored from a control room on the station platform supervised by one operator on each shift. Regulation of basket speed, basket charge, duration and timing of crystal wash, duration of fugal cycle, basket discharge and screen wash can all be varied as required.

*Curing and Handling of Shipment Sugar*
1956:- For 1956 season the small sugar drier previously in use was dismantled and replaced by a new and larger rotary flight unit together with elevators and bagging hopper. The drier was equipped with an induced air flow fan. Sugar was shipped in hessian bags weighing approx 72 kg. The bag was attached to the end of a steelyard which lifted with the required weight. The filled bag was released to pass for closure through a sewing machine head. The bags were stacked in two large sugar storage sheds which could hold 12 000 tonnes. The bags were delivered to stacks by a series of portable elevators and conveyors, and breakdown of stacks also involved the use of timber slides. Serious delays in shipment of sugar at this time required the storage of up to 2000 tonnes on a raised pad under tarpaulins outside the sugar sheds. The bagged sugar was transported to wharves by contractor's motor transport.
1987:- The change to handling of shipment sugar in bulk took place in 1958 season. Although there was some concern that raw sugar would not readily flow a restricted outlet on a storage silo, this design was selected and a holding bin

of 400 tonnes nominal capacity was provided for filling the transport boxes on semi-trailers used to convey the sugar to the shipping terminal. An elevating belt conveyor system conveyed the sugar from drier to bin. A batch weigher was initially used to weigh the sugar transferred to the bin but its accuracy was not reliable and it was subsequently withdrawn from service. To meet specifications for moisture content in some export sugars a steam heater was fitted to the drier air entry. The suppression of dust when conditioning these sugars required the provision of a wet scrubber on the fan outlet. The capacity of bin was increased to 430 tonnes by raising the conveyor head and its discharge points. A second bin of 1000 tonnes capacity was subsequently added and conveyor speed increased to handle increased sugar make.

*The Low Grade Centrifugal Station*

1956:- This station consisted of seven gear head centrifugals in two banks each with its own mingler and drive motor. The units were fitted with hand operated mechanical plough out gear.

Water was added to discharge screw conveyors to produce a slurry for pumping to the pan stage using lobe pumps. Purging of masscuite and washing of baskets was to the operator's judgment. The station was manned by two operators per shift. Molasses was pumped by reciprocating steam pumps to a 200 tonne storage tank with provision for filling tanks on motor lorries on an adjacent loading pad or railway tankers positioned on a spur line providing access to the tank. A combined road/rail weighbridge recorded the weights of loads.

1987:- Following successful trials with a 750 mm. continuous centrifugal installed for 1964 season, the station was converted to this type of machine. By 1987 there were four 1000 mm,machines of this type in use on a raised staging for discharging into a screw with paddle mixer using B molasses to form a slurry for pumping to the pan stage magma receiver. Screw pumps of the 'Mono" type were used for pumping magma and molasses. "C" masscuite leaving the supply header was reheated in fined tube heaters. Feeding of baskets was through an iris valve around a feed probe. Purging of the layer of material moving up the screens was by fine water sprays the amount of water being regulated by rotometer. Rate of feed was varied to maintain motor loading. This station was not manned. Start-up shut down and setting adjustments were carried out by the shift process superintendent. A 2000 tonne storage tank had been provided for molasses storage with facilities for loading 30 tonne road tankers. A mixing tank was used to adjust molasses brix using hot water and the molasses was cooled in a finned tube heater to avoid gasification during storage.

*Factory Raw Water Supply Services*

1956:- Raw water supply was from borehole pumps drawing water from an underground water table some 10 kms from the factory, supplemented with water from a large brick lined well nearby using a multi-stage pump mounted in the well. Water was pumped to the factory through a 100 mm.N.B. underground pipeline. The piping was of C.I. spigot and faucet design and had been laid by Chinese indentured labour when the factory was upgraded in the 1880's. However by 1957 the available supply from this system was hard-put to meet increasing demand. On occasion pipeline failure had interrupted supply and build-up of deposits in the pipe was affecting flow rates. The pipeline discharged to an elevated storage tank of 300cu.m.capacity supplying gravity supply mains to servicing the factory area. Fire hydrants on these mains were provided at the crushing house, boiler station, and sugar room.Mains pressure could be increased using a booster pump. Machine cooling water was drawn from supply mains with re-circulating pumps returning the warm water back to the overhead tank. A supply line from the tank supplied an underground system for reticulated water connections to offices, barracks, kitchen, staff housing and the small Farleigh township.

1987:- By 1987 a new pipeline from bore pumps in 150mm.N.B. "Fibrolite" piping had been laid. To further secure factory water supply this pipeline was extended to the Dumbleton weir on the Pioneer river also using "Fibrolite" pipe with a size increase to 200mm N.B. Water was drawn from the river using a 150mm. high pressure pump mounted to enable it to be drawn above flood level by winch. A new storage tank of 400cu.m.capacity was provided located on elevated ground near the factory. The previous storage tank and its staging were removed from their unsatisfactory location adjacent to the power house building. (This tank was later relocated within the factory to serve as a condensate storage tank). Water flow to the tank was recorded by flow meter. A 3OOmmN.B underground main was laid connecting the new storage tank to factory service mains.A I50 mm.N.B. fire main was provided to service the milling train and boiler station cross connecting to a second main for the pan stage and machine shop buildings. The fire service system was provided with electric and emergency (diesel driven) booster pumps.

*Workshops*

1956:- The engineering workshop was located within the factory building and comprised machine shop, boiler shop and blacksmiths shop. Metal working machinery of early vintage and was driven by belt drives from an overhead line shaft. The workshop bay which had no lifting facilities was in a location difficult of access and was in the way of projected additions to process plant. The plumbing carpentering and electrical workshops were similarly located. Makeshift facilities for motor vehicle maintenance were in a large barn originally used as a stable and grain storage for plantation draft animals and later as a bulk items and spare machinery store. The loco shed was a wooden building at the end of the empty tram holding yard and had originally been intended to service steam locomotives.

1987:- A new engineering workshop complex was provided located outside the factory buildings on the site previously occupied by the barracks. This facility was of two bays at right angles, one housing the metal working machinery and the other a welding/fabricating workshop. The buildings were equipped with overhead lifting facilities which in the latter bay extended over a steel storage yard. The machinery workshop included a number of new machine tools.A dining room, change rooms and shower and toilet facilities were provided. A new electrical repair shop was located adjacent to the engineering workshop. The height of this building was made to enable the removal of cores from transformers using an overhead crane. Equipment included cleaning, varnishing and drying facilities for electric motors. The building height allowed for two floors at one end, to house supervisors offices, stores and an instrument repair workshop. The building services workshops were located beside the engineering workshop. This workshop was equipped with woodworking and sheet-metal machinery and materials storage racks. A new locomotive and rolling stock maintenance complex was provided on the site of the original loco-shed. These facilities consisted of a locomotive servicing and overhaul building, a motor vehicle workshop and a tram repair workshop. The locomotive maintenance building can house six locomotives on two through lines and is equipped with overhead lifting crane, wheel drop and service pits and is equipped with bulk storage and dispensing services for engine oil and fuel as well as a tool room, spares storeroom, dining room and toilet facilities.The tram repair workshop services three lines holding damaged trams/bins and has overhead lifting facilities and access pits.