ALTERATIONS AND IMPROVEMENTS TO MOUNT EDGECOMBE MILLING TANDEM

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Introduction

To enable the throughput of the Mount Edgecombe Mill to be increased from 170 T.P.H. to 200 T.P.H., many major alterations and additions were undertaken during the 1964 Off-Crop.

Needless to say as with all new plant, many unforeseen problems were experienced during the first crop. In overcoming these problems however, valuable experience was gained and the purpose of this paper is to record all this information, and show how it was later used to improve the performance of the mill.

For simplicity this paper is presented in 4 sections as follows:

Section I

A summary of the original plant and the alterations and additions which were effected.

Section II

Modifications which had to be made during the first crop (1964) to maintain production,

and

Alterations made during the 1965 Off-Crop, based on observations and experience gained after the first season's operation of the new plant.

Section III

The 1965 Season and how the performance was improved by constant attention and, where required, further modifications.

Section IV

Conclusions and opinions based on a successful 1965 season.

Section I

Summary of Equipment

Comparison of Sketch No. 1 and Sketch No. 2 in conjunction with the following summary gives an indication of the magnitude of the alterations which were undertaken and which had to be completed within the 3-month period of the 1964 Off-Crop.

The 45 ft. long by 15 ft. wide cross carrier sited below the ground level and previously used for the Tramway System was removed and replaced with a "Loading Table" measuring 130 ft. long and 25 ft. wide. This table has a staging capacity of 150 tons of cane and is capable of comfortably feeding 200 T.P.H. of cane into the main cane carrier.

A second 15 ton 75 ft. Span Gantry was added to the existing off-loading equipment to feed this table and facilitate the change-over from Tramway System to Road Transport.

The main cane carrier was split just beyond the first set of knives and a new head shaft and drive fitted, the purpose of this alteration was to enable the second set of knives to cut on the turning point of the main cane carrier.

A Drag-type slat carrier was installed to elevate the cane from the discharge of the second set of knives into the new "Grueddler" shredder, which was placed in front of the Crusher and which replaced the 84" Searby which had previously been between the crusher and the first mill.

As with the shredder a Drag-type slat elevator was installed to convey from the shredder and feed the crusher.

All three of the above drives: Main Cane Carrier, Shredder Elevator and Crusher Elevator were fitted with Electro-Magnetic couplings for speed variation and to facilitate the Automatic carrier system which we installed.

The alterations which had to be made to the actual milling train were:

(*a*) The replacement on five mills of the Apron-type intermediate carriers with "Drag-type" slat elevators and "Vertical chutes".

(*b*) The replacement of all the existing feeding devices which we knew as "Apron Pusher Carriers" with Underfeed Rollers.

(*c*) The removal of the Searby Shredder and the re-routing of all mill platforms, catwalks and maceration piping.

(*d*) At the same time we decided much to our regret later on in the season, to do away with the cush-cush sieves and elevator and to pump the first expressed juice and mixed juice direct to the Peck-strainers and Vibro screens. The cush-cush being returned to the mill via a launder carrying the first mill maceration.

These then were the alterations which were undertaken and completed prior to the start-up of the 1964-65 Crushing Season.

Section II

Cush-Cush

The first equipment to give trouble after the 1964 start-up was the maceration and cush-cush pumping system.

In designing the mounting of the bearing supports for the Underfeed Rollers, use had been made of the brackets which were part of the casting of the "Mill Cheeks", and had previously supported the dead-eyes and side-plates of the Intermediate Apron Carriers.

Mounting the Underfeed Rollers on these brackets however, restricted their adjustment and prevented them being inter-meshed with the grooving of the front Roll of the mill.

This was a bad mistake as this left a gap between the rolls of as much as 2 in., consequently when any of the mills jibbed even momentarily, a blanket of

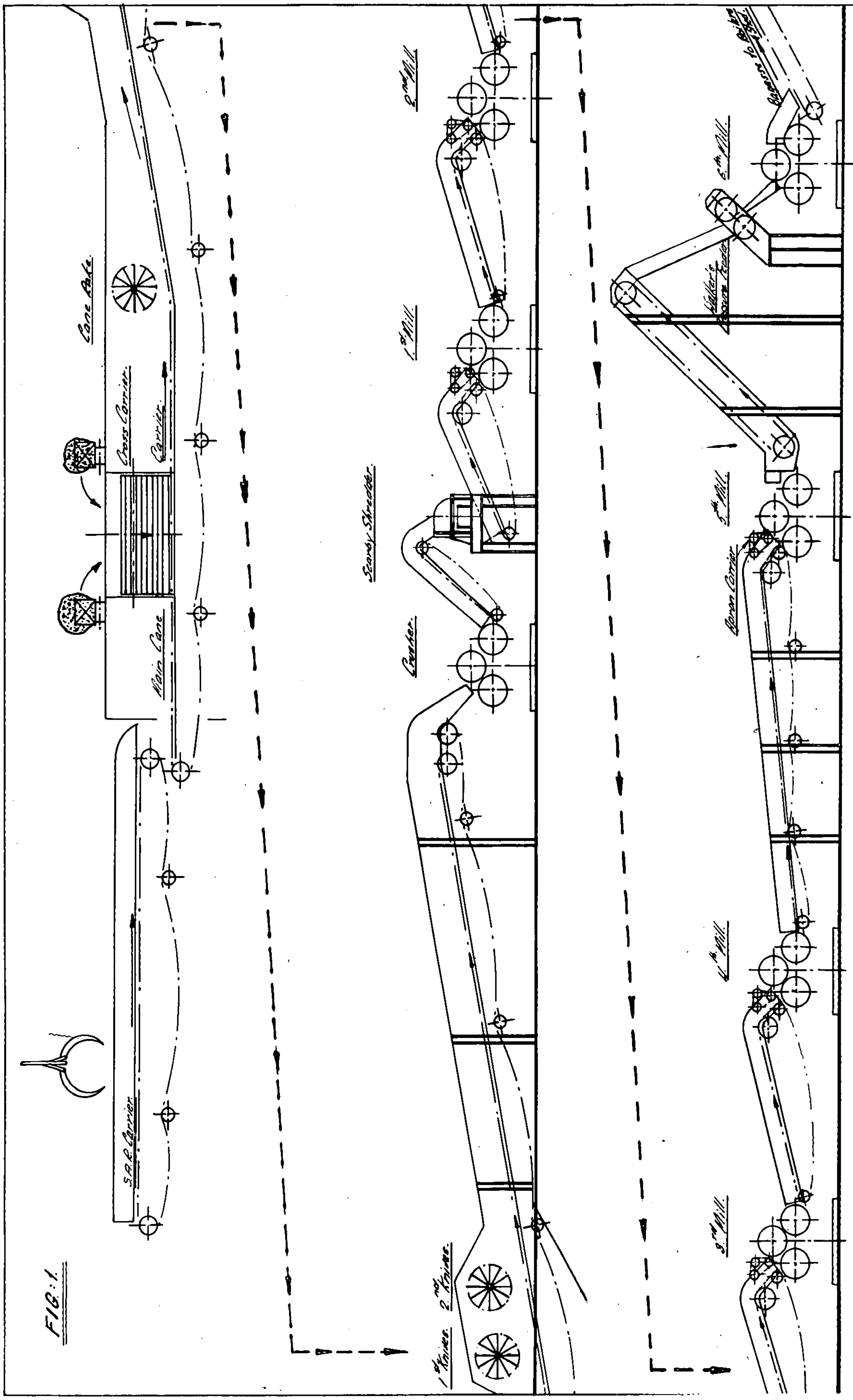

Cane Rake
Cross Carrier
Carrier
Main Cane
S.A.R. Carrier
1st Knives
2nd Knives
Crusher
Searby Shredder
1st Mill
2nd Mill
3rd Mill
4th Mill
5th Mill
6th Mill
Walker's Pressure Feeder
Apron Carrier
Bagasse to Boilers

FIG: 1.

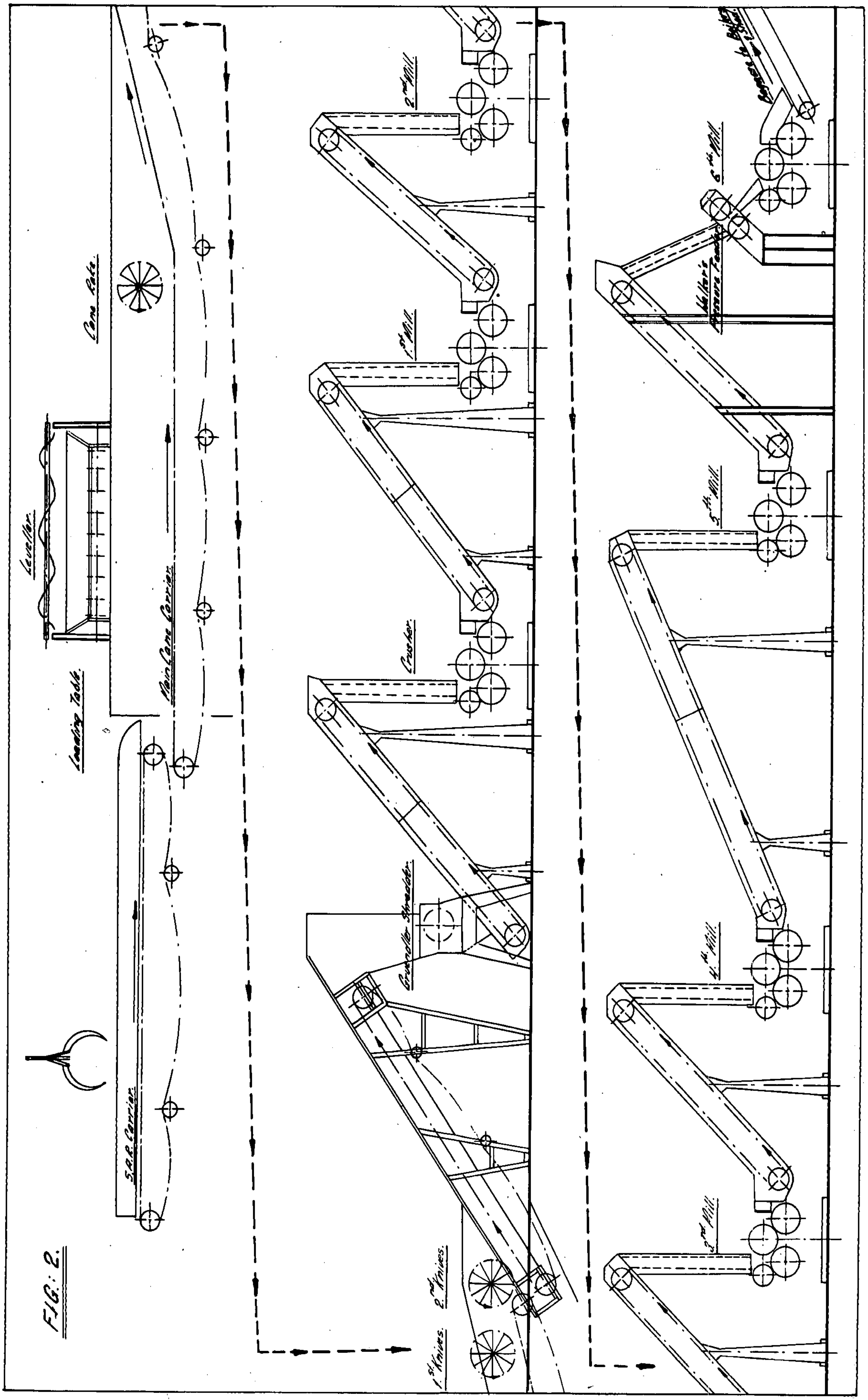

S.A.R. Carrier
Loading Table
Leveller
Main Cane Carrier
Cane Rake
1st Knives
2nd Knives
Grenadier Shredder
Crusher
1st Mill
2nd Mill
4th Mill
5th Mill
6th Mill
Walker's Pressure Feeder
Bagasse to Boilers

FIG: 2.

bagasse 84 in. wide and up to 2 in. thick would be discharged into the Juice Gutters.

The conventional type of chokeless pumps in use at the time were never designed to handle this quantity of cush-cush and bagasse, and even after repeated attempts at using different types and shapes of Impellors and Casings, we eventually had to make our own pumps to do the duty.

These pumps together with the external wooden trash-plates which we had fitted between the Underfeed Rolls and the Front Rolls, succeeded not in curing our problem, but in transferring it one stage further down the line to the Peck-strainers and Vibro-Screens.

Although this station was very much overloaded and inefficient operating under these conditions, we managed to keep it going until the close of the season.

During the 1965 Off-Crop, knowing where the trouble originated we modified the Mill Cheeks, burning off the original brackets and welding on new ones, this enabled the Underfeed Rollers to be re-positioned to allow the grooving to fully intermesh with the front Rollers of the mills.

To ease the load on the Peck-strainers and Vibro-screens and at the same time improve this station we installed three 6-ft. wide D.S.M. Screens with 1.5 mm. screen apertures as pre-screeners.

This system has worked exceptionally well and trouble free throughout the 1965 Season as shown by the following comparison of Mill stoppages and time lost:

Number of mill stops and time lost due to cush-cush pumping and screening plant:

1964-65 Crop	22 Stops	14 hrs. 2 mins.
1965-66 Crop		Nil.

Mill Elevators

When these elevators were designed it was arranged for the slats to be angled forwards on their attachment links to prevent the carry-over associated with slat elevators, and also to facilitate rapid and clean fall-off of the bagasse when the slat passed over the chute opening.

In testing the elevators however, we found that with the slat inclined at this angle, they would tend to compress the bagasse (see Sketch No. 3) when travelling around the tail shaft. To obviate this the chain was turned end for end, the edge of the slat now leading. This however was not entirely successful at crushing rates above 190 but worked well with high elevator speeds and lower tonnages (150 ft. per minute).

It was during this troublesome period that we established that: "Providing the centre of radius of the boot itself is established on the tail-shaft centre and minimum clearance is allowed between the plating of the elevator boot and the slats (see Sketch No. 4) then the elevator will perform efficiently irrespective whether the bagasse is discharged into the elevator in 'front or behind' the tail-shaft."

After we altered the elevator boots to comply with the above, very few major stoppages were recorded. We were however, continually troubled with minor stoppages due to broken slats, choked attachments, worn-out brushes, etc. All these faults were analysed and the following modifications were made during the 1965 Off-Crop to rectify them:

(*a*) The return flight "Runner bars" were removed from under the chains and repositioned under the slats, the rollers now only had to rotate while passing over the head and tail shaft sprockets. This has had the desired effect and has arrested the rapid wear which was taking place between stainless bush and steel roller.

(*b*) The wooden slats 6 in. wide and 2 in. thick were replaced with 6 in x $\frac{1}{4}$ in. M.S. Flat Bar backed with a $2\frac{1}{2}$ in. angle bar for rigidity, these in addition to being cleaner were lighter and less likely to break.

(*c*) With the elevator boots working effectively the speed was reduced to 110 ft. per minute further contributing to the life of the chain.

(*d*) The attachment links and wearing plates have also been altered, but neither of these have been in operation long enough to warrant comment.

Comparison of Mill Stops on the mill elevators is:

1964	178 Stops	$40\frac{1}{2}$ hrs. Lost
1965	12 Stops	$5\frac{1}{4}$ hrs. Lost

Shredder Elevator

This Drag-type elevator between the second set of knives and the shredder was the cause of many mill stoppages, the partially knifed cane travelling on the bottom of the cane carrier would either bridge across the lower slats and choke around the headshaft, or bridge at the discharge from the knives and choke the boot of the elevator.

Only after repeatedly unsuccessful attempts to modify this elevator did we reach the conclusion that for a Drag-type elevator to work effectively on unshredded cane, the preparation by the cane knives has got to be of a very high standard. Unable to improve our preparation due to the H.P. available being marginal we decided to replace the elevator during the 1965 Off-Crop with a conventional apron-type carrier smilar to our existing cane carrier.

Comparison of Mill Stops due to this elevator:

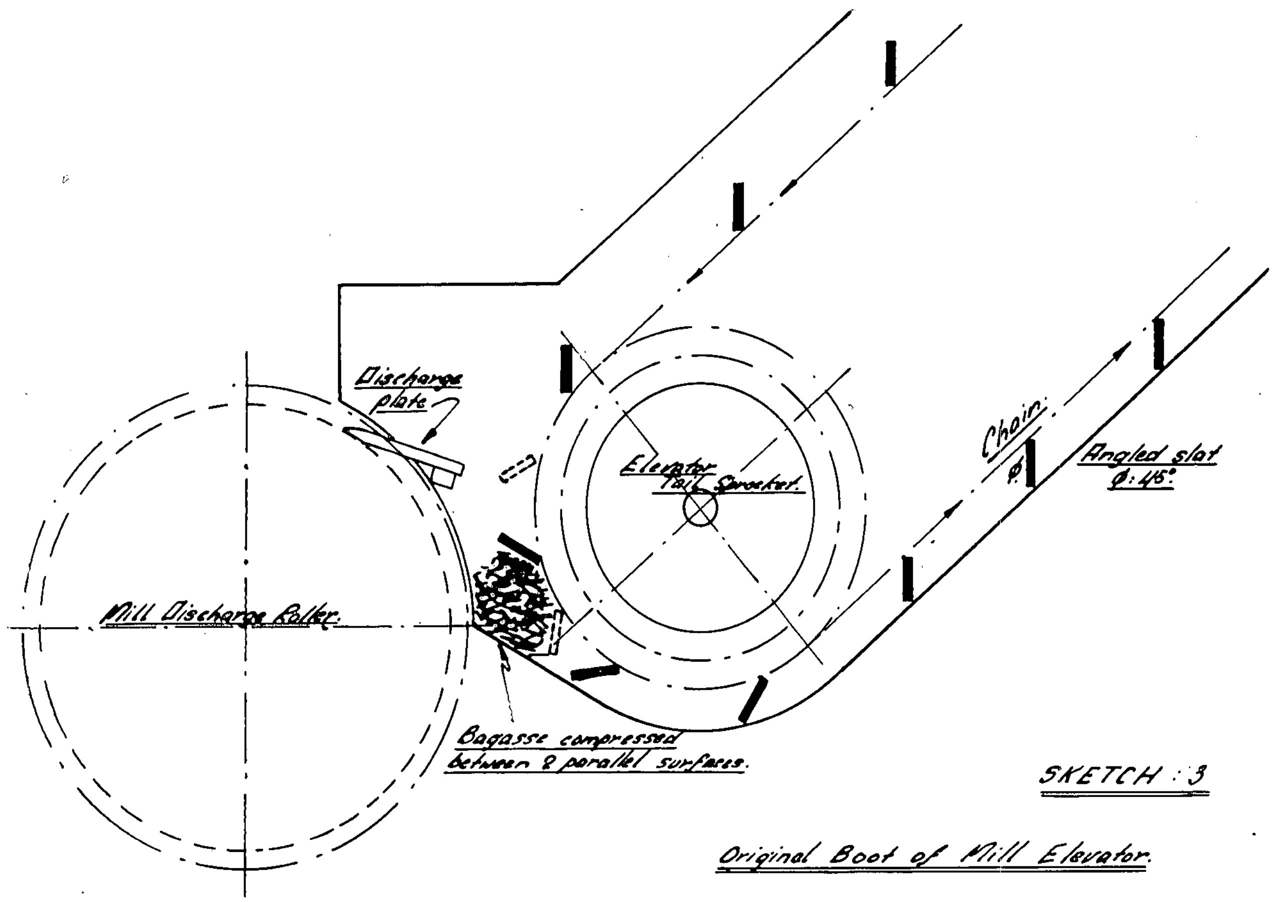
1964	68 Stops	$28\frac{1}{2}$ hrs. Lost
1965	18 Stops	8 hrs. Lost

Mills

In spite of the extensive arcing which we did on the rollers, considerable difficulty was experienced throughout the 1964 season in getting the mills to feed properly.

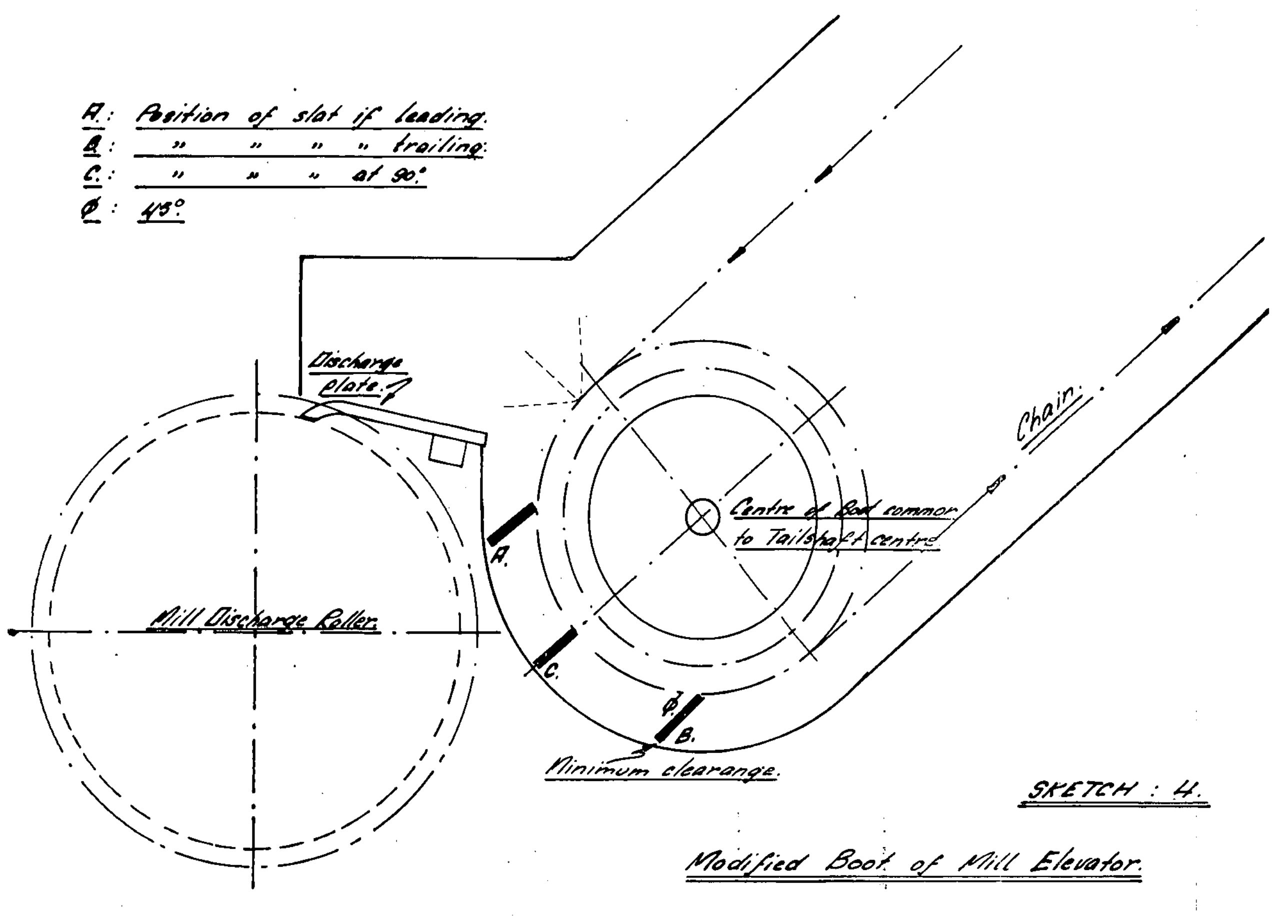
This condition was not particular to one mill only, but was general throughout the milling train, and at no time was it possible to load up the mill "Hydraulics", and obtain good performance. Improvements were certainly made to "Feed chutes" (see Sketch No. 5) settings, etc., but the results obtained were never entirely satisfactory.

From observations made and the comprehensive records kept of each choke or breakdown we were however, able at the end of the season to determine



SKETCH : 3

Original Boot of Mill Elevator.



SKETCH : 4.

Modified Boot of Mill Elevator.

that our feeding problems throughout the milling train were due to:

(*a*) Insufficient adjustment on the vertical chutes.

(*b*) Feathering of the mill trashplates due to excessive plate wear, the result of intensive arcing of the rolls.

(*c*) Heavy arcing damage to rollers.

(*d*) Incorrect mill, chute and underfeed roller settings and ratios.

(*e*) Underfeed and Front Rollers not in mesh.

All these faults were rectified during the 1965 Off-Crop, viz.:

(*a*) New "Vertical Feed Chutes" were made that could be adjusted to suit mill ratios, which experience obtained during the previous season, had taught us were conducive to good feeding.

(*b*) All Front Rollers were re-grooved with messchaerts in every groove, not only for drainage, but to permit the cast iron trashplates, the use of which we had adopted, to be adjusted into the front Rollers while the mill was running, without the fear of the Trashplates "Bottoming" in the valleys of the Front Roller grooving. Continual adjusting in this way prevents the slightest gap from forming between the roller grooving and the teeth of the Trashplate, and therefore prevents any "Feathering" occurring.

(*c*) Concentrated arcing was confined to the valleys of the roller grooving only, thereby preventing the tips of the grooving from being burnt off and the grooving becoming rounded.

(*d*) With the inter-meshing of the Underfeed rollers and the front rollers, we were able to remove the wooden Trash-plates previously required to prevent excess cush-cush, and thereby eliminate the possibility of any chokes originating from this source.

(*e*) A full season's observations and experience had given us a better understanding of what mill settings and ratios were required with vertical feed chutes and Underfeed Rollers.

(*f*) In addition to matching roller diameters in a given mill and thereby eliminating as far as possible, slip and the subsequent polishing caused by it, we re-adopted the use of chevrons in the Top Rolls of each mill and reduced the angle of the grooving on the Crusher (or first Unit) to 40 degrees.

The latter being done for two reasons:

(i) to decrease the roll centres for a given setting so that existing pinions could be used even with wide settings.

(ii) To take advantage of the greater wedge effect and increased surface area (friction area).

Comparison of the following mill stops recorded during the 1964 and 1965 seasons indicate the effectiveness of these alterations:

Number of Mill Stops and time lost due to mill chokes:

1964	329 Stops	61 hrs. Lost
1965	8 Stops	2 hrs. Lost

Underfeed Roll Driving Chains

In common with the other mills using this type of feeding device, frequent mill stops were recorded owing to broken driving chains, and as a result the time lost due to these stops was extremely high during the 1964 season.

To ensure that the best possible use was being made of the chain fitted, the P.C.D. of the sprockets on all these drives was increased to the maximum permissible within the existing centres, thereby increasing the chain speed and reducing the load on the chain.

Although this may have been a contributory factor, I am of the opinion that the correct use of these rollers as "Simple" feeding devices, and not "Pressure Feeders" or "Fourth Mill Rollers" gave the following results in 1965.

Number of Mill Stops and time lost due to chain breakages:

1964	97 Stops	$34\frac{1}{2}$ hrs. Lost time
1965	3 Stops	$\frac{1}{2}$ hr. Lost time

Section III

1965 *Season*

Within the first three weeks of crushing an extraction of 95.59 per cent was obtained although the final moisture was relatively high at 53.6 per cent.

From previous experience however, it was quite apparent that this performance could be improved upon if two very obvious faults were rectified.

The first one being unsatisfactory preparation by the shredder, preventing the bagasse from being formed into a compact mass in the vertical chute of the "Crusher", (first Unit) and consequently affecting the performance of this unit. The extraction of which at this period was 62 per cent, with a back Roll moisture of 57 per cent.

The second fault was insufficient drainage on the discharge of the last Unit resulting in a final moisture of 53.6 per cent and an extraction by this unit of only 27.9 per cent.

As the greatest benefit was to be derived from the crusher the improvement of the shredder performance was tackled first.

It was thought that if the knifed cane could be made to tumble or slide gently into the shredder, instead of breaking off from the cane blanket and falling in, in bundles, the preparation on the cane would be improved.

The headshaft of the carrier feeding the shredder was subsequently repositioned, the angle of the chute plate made shallower, and the carrier speed reduced.

This alteration had the desired effect and improvements in the preparation of the shredded cane were immediately noticed, and the benefit derived from this alteration was apparent throughout the milling train.

We did however, strike one snag as a result of this improved shredding. Fortunately this was only particular to one variety of cane.

This cane after shredding has a very light and stringy texture and difficulty was experienced in getting it to fall clear of the slats and into the Feed Chute of the crusher, this being particularly noticeable when the elevator was running fast.

To rectify this the headshaft of the elevator was repositioned well back and clear of the opening to the feed chute, this reduced the velocity of the bagasse as it left the slat and allowed it to tumble freely into the chute opening. (See Sketch No. 6.)

This alteration has proved so successful that the rest of our elevators are being modified to this design during the present off-crop.

With the Crusher (first Unit) extraction at 68 per cent the overall extraction rose steadily until the eighth week when a 96.51 per cent was recorded.

The high moisture of ±53 per cent however, plagued us right through until the 11th week, when we were at last able to fit a new discharge roller "with messchaert grooves" into the last unit. This improved the drainage and cured the second fault. (None of our rollers had been machined with messchaerts for the 1965 crop.)

The moisture in final bagasse immediately dropped by 2 per cent to 51.3 per cent and the unit extraction rose to 41.3 per cent.

Encouraged by these results and of the opinion that still better performance could be obtained from this unit, a new chute was designed to keep the pressure feeder full under all conditions, and allow the mill to be run at a more constant speed.

This chute was designed and fitted with the added facility of automatic speed control of the mill. Both were an immediate success, reducing the speed of the last unit by 20 per cent with a subsequent reduction in moisture of 1 per cent and enabling the moisture to be maintained at ±50 per cent for the rest of the season.

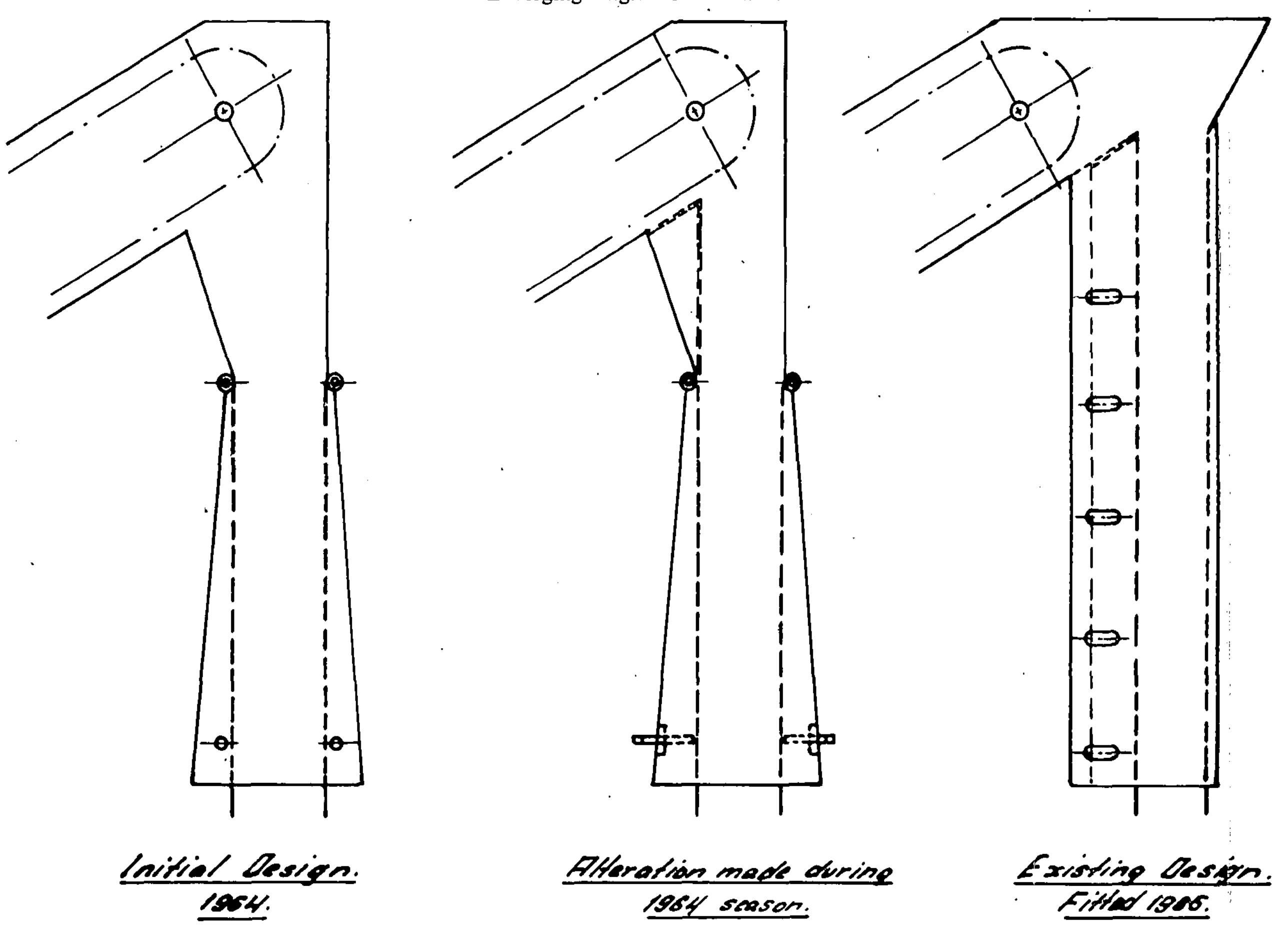
The alterations made to this unit alone had the effect of reducing the final moisture by a full 3 per cent and emphasised the importance of messchaert grooves in the discharge roll of the last (drying) unit of a milling train.

Several other smaller alterations were undertaken during the season, viz:

(i) The conventional type of maceration discharge trays were replaced with our "Weir" type of tray to ensure an even distribution of maceration across the carriers. (See Sketch No. 7.)

(ii) Special nozzles were fitted onto the imbibition water supply to assist the water to knife into, and penetrate the bagasse.

Diverging Angle min 2° max 4°



VERTICAL FEED CHUTES. SKETCH. : 5

As shown, the limitations are quite low and the risk of surpassing them should under no circumstances be taken. The only technically sound solution, therefore, is to generate power at high tension. It is general practice on the continent to use 6,000 Volts and the following examples and calculations are based on this voltage. However, the resulting conditions practically apply for 6.6 KV which would be preferably chosen in this country. If a higher voltage, say 11 KV, is used the possibility of supplying large motors directly is reduced to quite an extent. For insulation reasons the minimum limit for 11 KV motors is about 400 KW, while it is about 150 KW for 6.6 KV motors.

In Fig. 7, three different examples are given to indicate the minimum sizes of HT cables required to withstand the short circuit conditions which may be expected.

In all three examples the voltage of the busbars from which a cable is fed is 6 KV. As may be observed, the time constant of the circuit breakers (the period taken from initial switching operation to the moment of contact opening), is decisive for the size of the cables, as a prolongation from 100 to 200 milliseconds means that the next larger cable size is required. In consequence a doubling up of the generation capacity and thereby of the short circuit current calls for a larger cable size, as indicated in example 2. If a further supply source feeds into the system, as shown in example 3, it influences the required cable size to a considerable extent. As the impedance voltage of the transformer is only 6%, the additional supply source boosts the rupturing capacity to twice the value of example 2. Consequently the cable required, must also be twice the size of the cable of example 2.

Fig. 7 indicates the power which the various cables used in examples 1–3 could carry if subjected only to normal continuous operation without being subjected to short circuit stresses. At the same time it clearly shows the extent of overdimensioning which is required to ensure short circuit stability. For instance, in order to transmit a load of 350 KVA, as shown in Fig. 5, a cable with a cross section of 6 mm^2 would suffice to handle the current, but a far larger size must be chosen for reasons of short circuit stability. The cross section would range between 10 mm^2 and 50 mm^2, depending on the impedance involved, i.e. 2–8 times the size actually required if chosen to carry the normal current only. The comparison of prices for PVC cables shows that a maximum of 3 times the price would be required, in the example given, if the size 10 mm^2 is considered as costing 100%. Similiar aspects would of course also apply for LT cables but as the currents involved are considerably greater the minimum cross sections required for stability reasons are usually given anyway, when chosen to cope with the normal current.

It appears from the foregoing that HT motors with a rating as low as 150 kW are not a cheaper solution than LT motors. This question is investigated in Fig. 8.

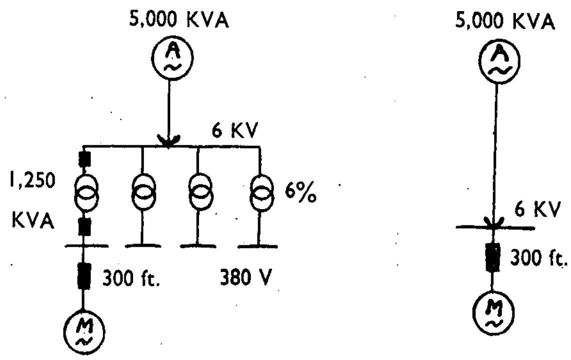


FIGURE 8

Comparison of LT and HT motors. Schematic Diagrams

The motor is situated 300 ft. away from the switchboard. The circuit breakers and cables between the alternators and the HT busbars in this comparison can be neglected as they are required in both examples. For the HT part therefore, only the price of the circuit breakers, with overload protection, and of 300 feet of cable need be taken into account, while for the LT part the additional prices for circuit breakers on the primary and the secondary sides of the transformer and the portion of the transformer costs, corresponding to the motor power, will go into the calculation.

In Table III, a comparison between a 180 kW motor with a rating of 230 KVA (20% of the transformer rating) and two motors of 240 kW and 500 kW is given. The 240 kW motor is rated 310 KVA (25% of the transformer rating) while the 500 kW motor is rated 610 KVA (50% of the transformer rating).

TABLE III

Comparison of prices of HT and LT motors of different ratings

	180 *kW*		240 *kW*		500 *kW*	
	LT	HT	LT	HT	LT	HT
Price	100%	111%	100%	95%	100%	65%
Break-up of prices	100%	100%	100%	100%	100%	100%
Motors	46%	71%	44%	73%	40%	80%
Cables	12%	4%	14%	3%	17%	2%
Fuses, circuit breakers	5%	25%	5%	24%	6%	18%
Portion of price of transformers and transformer circuit breakers	37%	—	37%	—	37%	—

The result may be seen in the first line of Table III. In each example the LT solution is considered as being 100%. While the HT solution is 11% more expensive with the 180 kW motor, the HT solution is cheaper by 5% with the 240 kW motor. The HT solution is considerably cheaper with the 500 kW motor, namely by 35%. Both HT and LT solutions are about equal in price with a motor of 200 kW and the larger the motor is from there on, the greater is the difference in price to the advantage of HT.

The cost of components are broken up and their percentages of total prices are given. The prices of the transformers are about 37% of the total costs in the LT solution. This is the reason for the LT solution becoming more and more unfavourable with the increase in size of the motor. The portion of the LT cables is between 12% and 17% and must not be overlooked, while the portion of the HT cables to the HT motors is only 2% to 4% and therefore nearly negligible. This calculation clearly shows, that it is still economical to use HT as long as the motors are not smaller than 200 kW.

This paper has dealt with fundamental considerations of the electrical supply system of a sugar factory. It has in fact only touched the many problems involved in designing an entire electrical system so as to give the most practical and economical layout.

Summary

General aspects of designing the electrical equipment of a modern sugar factory to arrive at most economical and practical solutions are discussed. Emphasis is placed on the importance of power involved and short circuit conditions occurring. The influence of the physical layout of the factory with regard to the electrical system is mentioned.

The dimensioning of alternators, switchgear, cables and motors is discussed in detail.

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