

# INTERMEDIATE CARRIERS

By C. E. DENT

Intermediate carriers have tended to be regarded as unimportant, though absolutely essential, items of sugar mill equipment. This is borne out by the lack of information to be found on the subject of intermediate carriers in the earlier textbooks on sugar engineering.

Analysis of mill stoppages, however, show that breakdowns on intermediate carriers are responsible for a high proportion of the downtime on most milling plants, and the incidence of intercarrier failure has increased with increased crushing rates. This paper has been written in order to introduce the subject and to stimulate discussion in the hope that the pooled knowledge and experience of the technologists present will lead to improvements in intercarrier design and therefore higher mechanical efficiencies of milling plants. The curve in fig. 1 indicates clearly how the incidence of intermediate carrier failure has increased with increased throughput. These figures are taken from the 84-in. tandem at Tongaat.

The trend of intermediate carrier design over the past fifteen years (the span of the author's experience) will be reviewed and the various difficulties experienced with each type will be discussed.

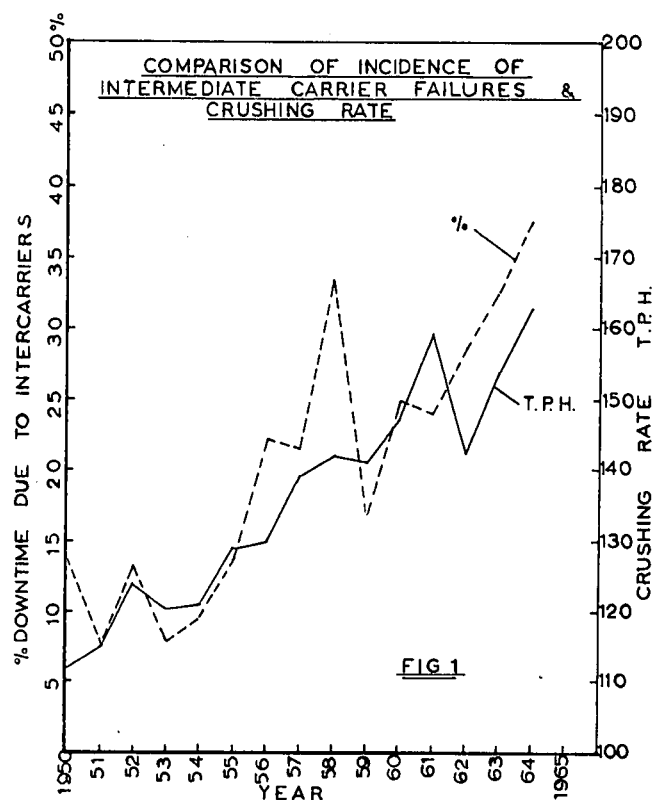
## Apron Type Intermediate Carriers

In 1950 the type of intermediate carrier most commonly used was the apron type of intermediate carrier as shown in figure 2. This type of intercarrier of which there are still a few in operation at the present time, uses overlapping steel slats riveted to three or four

strands of chain to form a moving platform on which the bagasse is conveyed. The chain slat assembly is driven by sprockets (A in fig. 3), mounted on the drive shaft and then passes round the nose shaft (B in fig. 3) on which idler wheels are mounted in order to form a moving inclined platform to feed the bagasse into the mouth of the mill. This type of conveyor is usually used in conjunction with either a fixed or floating feeder roller driven by the top roller of the mill and mounted above the inclined portion as shown in fig. 2, thus forming what should be a good feeding arrangement for the mill, and in fact, at lower crushing rates this arrangement worked well. With increased crushing rates, however, feeding the mill became more of a problem and it was found that the wear and tear on the chain slat assembly became excessive. This is due to the portion of the chain *ab* in Fig. 3 deforming under pressure to the line shown dotted, thus imposing a strain on the rivets securing the slat to the chain and causing the rivets to become slack. This is further aggravated by the assembly having to pass round the, of necessity, small diameter nose shaft, and also by the attack on the rivets themselves by the acids in the juice.

It is not uncommon when wear takes place in this type of assembly for the slats to catch in the chevrons of the feed roller of the mill and for the slat and or chain slat assembly to be pulled into the mill resulting in a stop of a number of hours.

In order to improve the feeding characteristics of this type of carrier, chains were sometimes run in the



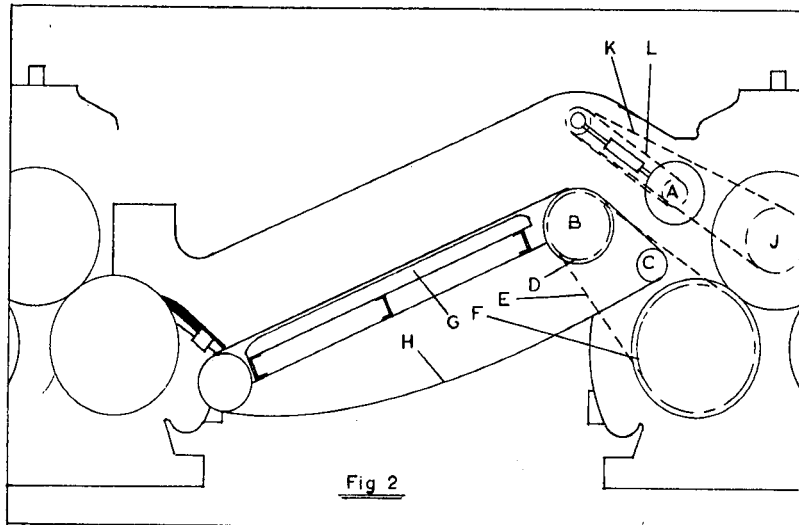


Fig 2

KEY TO FIGURE 2:

- |   |                            |        |                            |
|---|----------------------------|--------|----------------------------|
| A | Overslung feeder drum.     | D.E.F. | Drive sprockets and chain. |
| B | Drive shaft and sprockets. | G      | Chain runners.             |
| C | Nose shaft and idlers.     | H      | Chain Slat assembly.       |

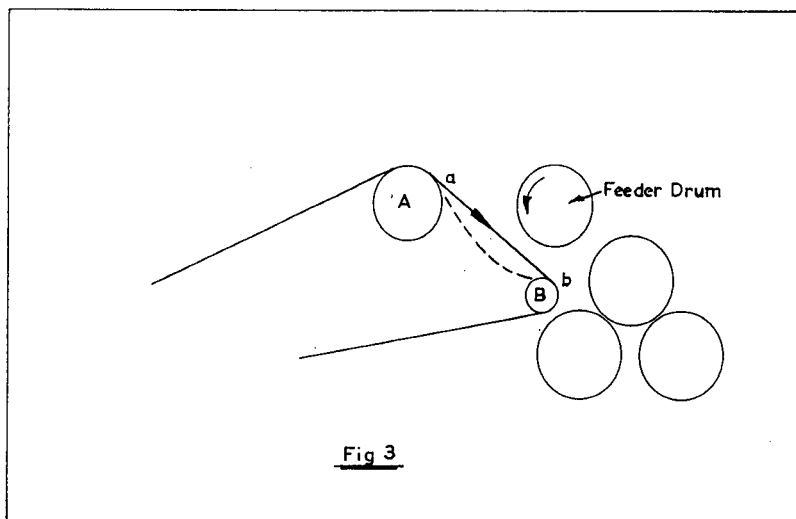


Fig 3

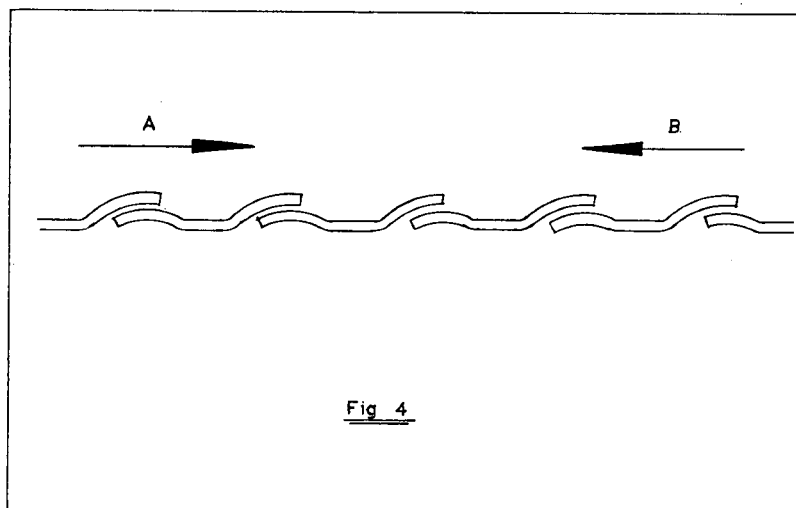


Fig 4

direction "A" shown in fig. 4 instead of the conventional direction "B", thus taking advantage of the greater friction effect in that direction. This, however, as is to be expected, increases the wear and tear on the rivets.

Increased throughputs brought about improvements in the design of the apron carrier as illustrated in fig. 5. The nose shaft was eliminated and the diameter of the drive sprockets materially increased. The chain slat assembly when wrapped around these large sprockets virtually became a feeder roller and because of the high pressure on the slats, it was found necessary to reduce the unsupported lengths of the slats between the sprockets by mounting broad rimmed support discs on the shaft between the sprockets. The elimination of the reverse flexing of the chain slat assembly considerably reduced the tendency of rivets to become slack. The increased number of sprocket teeth actually driving the chain further reduced the rate of chain wear.

These modifications to the apron type carrier have made the apron carrier reliable and, with the use of stainless steel chain and pins, the cost of operating this type of carrier is no longer excessive. While stainless steel chain is high in initial cost it has proved in the long run to be economic. In one Natal factory stainless steel chain is still in use after ten years of service.

This type of apron carrier, however, has not come into popular use because of the re-introduction of the Ramsay type carrier at about the same time.

#### Ramsay Type Drag Carrier

Because of high maintenance costs experienced with the apron type conveyors, Darnall in 1954 re-introduced the Ramsay type carrier. Tongaat followed in 1957 with the type of carriers as used in the sugar industry in Mauritius. This type of carrier, illustrated in fig. 6, makes no contribution to the feeding of the mill and is therefore used in conjunction with the now

very popular underslung feeder roller. Note that this carrier was driven by the previous mill by a chain drive. The bagasse is conveyed over fixed bottom plates by slats attached to two strands of chain. Chain speed was about 45 ft./min.

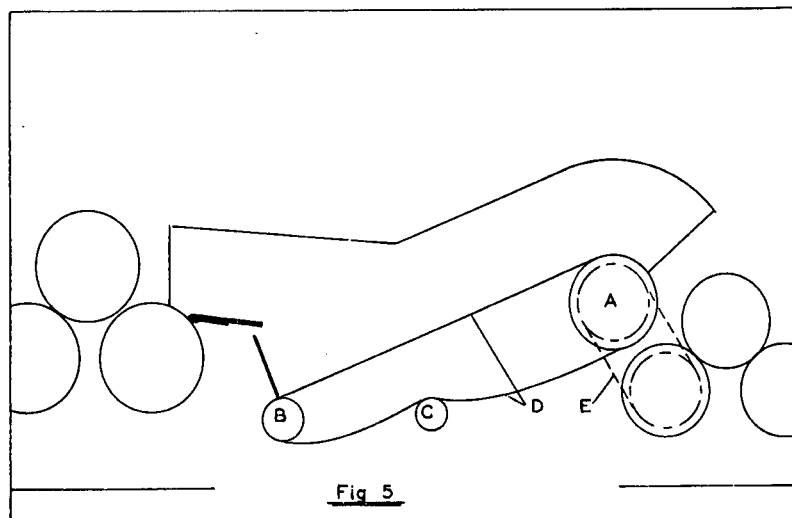
Darnall initially used 604 chain which gave considerable trouble. This was replaced by another chain thought to be 704, which was also troublesome and finally 6140 was selected and this chain gave good results.

The chain selected for these carriers at Tongaat was also 6140 with K2 attachment links. The K2 links, however, "blocked up" and special attachment brackets were fitted in order to prevent this happening. C3 attachments were then tried and found to be an improvement. The C3V attachment was a further modification which again proved to be a great improvement.

As the result of a visit by Dr. H. Kerr, from Australia who advocated the use of high chute plates in order to improve the feeding characteristics of the mills, there was a change in the inclination of these carriers in 1958. The chain speeds were increased to about 60 ft./min. to cope with the higher crushing rates. This modification, shown in fig. 7 proved to be very successful and in fact two of this type of carrier are still in use at Tongaat at the present time.

In 1958 Tongaat pioneered the independent electric carrier drives arranged for remote control using direct on line starters from a central control panel. This system of cane carrier drive has proved very successful and is now used in a number of mills.

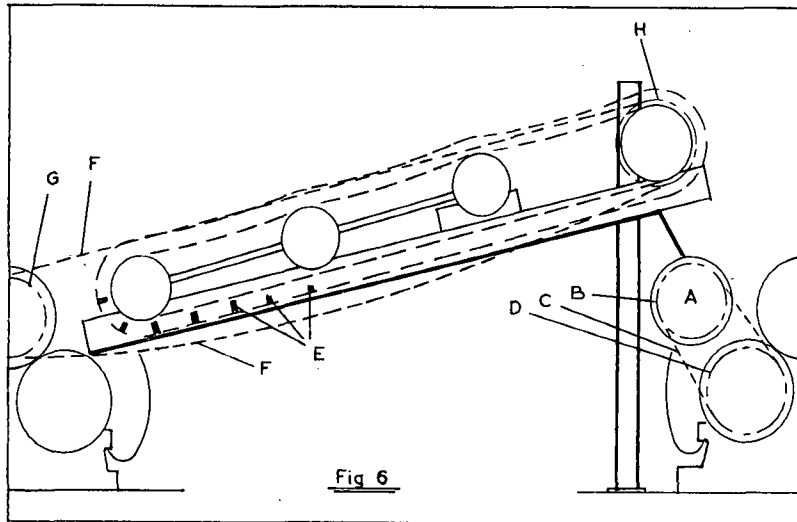
In 1959 Darnall modified their carriers to the Tongaat type. The next phase in the development of the drag type carrier was brought about in 1962 by the introduction, at Darnall, of the Donnelly chute. The success of this Australian invention in improving the feeding characteristics of the mill resulted in the installation of the Donnelly chute in a number of mills. Its



KEY TO FIGURE 5:

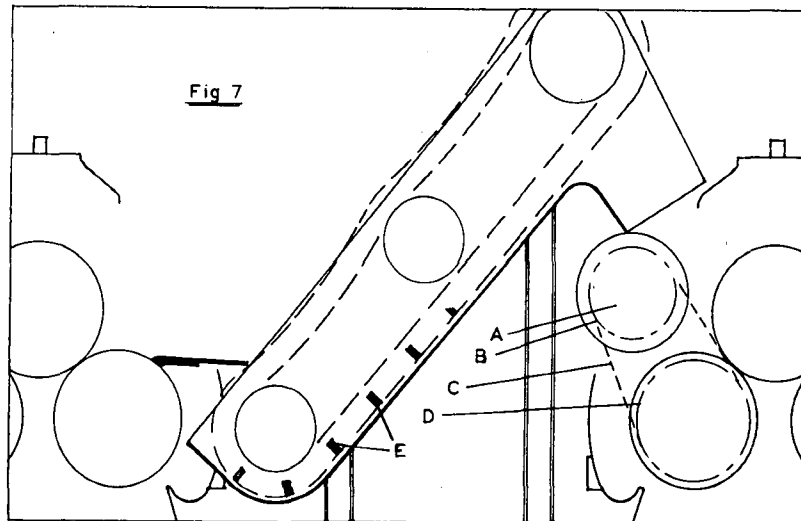
A Drive shaft and sprockets.  
B Tail shaft and idlers.  
C Return idler.

D Chain slat assembly.  
E Drive chain.



KEY TO FIGURE 6:

- |  |   |
|--|---|
| A Underslung feeder roller.            | F Intercarrier drive chain.               |
| B.C.D. Underslung feeder roller drive. | G Intercarrier drive sprocket.            |
| E Slats and chain assembly.            | H Intercarrier drive and driven sprocket. |



KEY TO FIGURE 7:

- |  |                            |
|--|----------------------------|
| A Underslung feeder roller.            | E Slat and chain assembly. |
| B.C.D. Underslung feeder roller drive. |                            |

effect on the design of the intercarrier was to increase both the angle of the carrier and the shaft centres. This type is illustrated in fig. 8. In some cases the carriers are inclined at angles of as much as 55° to the horizontal which in the opinion of the author, is the maximum permissible angle of inclination of a drag conveyor feeding a Donelly chute. In order to prevent choking at the narrow mouth of the Donelly chute it was found necessary to increase the speed of the conveyor so as to feed the chute with smaller dollops and speeds as high as 200 ft./min. are used in some cases.

At about this stage much trouble was experienced with locally manufactured malleable chain and 09060 steel chain became commonly used. A great deal of trouble has been experienced with this type of chain for various reasons. It has been found that the rate of wear not only of the pins, but also of the bush is excessive, the bush becoming slack in the side plates

after only a few weeks of service. Once the side plates become slack trouble is experienced with shearing of the split pins securing the carrier pin and of course the chain collapses, resulting in a mill stoppage. This problem was successfully overcome at Tongaat by welding a washer to the carrier pin in place of a split pin as shown in fig. 7, thus making a non-detachable link chain. At the same time the bushes which had become slack in the side plates were welded to the side plates. This naturally meant that replacement of bushes was no longer possible but the side plates were in fact too far gone to fit new bushes in any case. These problems together with an excessive rate of pin wear experienced with 09060 chain proved it to be unsatisfactory, as an intercarrier chain when fitted with carbon steel pins and bushes.

09061 was then tried in an endeavour to find a more reliable chain amongst those available in South Africa. 09061 chain is fitted with heat treated pins, bushes

and sidebars dimensionally the same as the 09060 chain, but tensile strength increased from 60,000 lb. breaking strain to 100,000 lb. breaking strain. While apparent wear on this chain was negligible, after only five weeks of operation corrosion fatigue failures started to become common and all pins in this chain had to be replaced. 09060 pins were fitted and being more ductile did not break. This is yet another case of chain manufacturers trying to satisfy the needs of a customer by resorting to heat treatment instead of supplying chains with more generous pin diameters and increased bearing areas.

At the beginning of the 1964 season a carrier of the type shown in fig. 8 and 10 was installed on the 66 in. tandem at Tongaat using 0906 chain (tensile strength 40,000 lb.) fitted with stainless steel pins and bushes and AS2 attachment links. The total elongations in this chain after one season's operation was 4 in., the carrier shaft centres being 27 ft. 3 in. Also in 1964 a non-detachable Renold chain of 85,000 lb. breaking strain fitted with stainless steel pins and bushes, which had already completed three full seasons (1959, 1960, 1961) on the Shredder Elevator of the Maidstone tandem was installed on a similar carrier to the one shown in fig. 8, and completed the season without giving any trouble. This chain will again be used in the 1965 season. At the time this chain was considered to be expensive, but its reliability and long life have proved its purchase to be an economic proposition.

At Darnall experiments were carried out during 1964 using 09060 chain fitted with stainless steel pins and bushes and also stainless steel inserts in the rollers. This chain has given every indication of satisfactory service. From the above it would appear that for the modern intermediate carrier, chains fitted with wearing parts made of stainless steel, of the right quality, are required if the intercarrier is to be a more reliable piece of sugar mill equipment.

Many sugar mill engineers are not in favour of using non-detachable chain, but after experience gained in using this type of chain the author is now disappointed by the fact that it is no longer obtainable.

#### Rubber Belt Intermediate Carriers

In 1962 Reviere type intermediate carriers illustrated in fig. 11, were installed between the 3rd and 4th mills and between the 4th and 5th mills on the 66 in. tandem at Tongaat. This type of intercarrier is a high speed rubber belt carrier running at about twenty times the peripheral speed of the rop roller of the mill. In the case of Tongaat this speed was 425 ft./min. The theory behind the high belt speed is that the bagasse which should theoretically be evenly spread in a thin layer about 1½ in. thick is fed into the mill in a steady stream at a velocity imparted to it by the belt. An underslung feeder roller, which is part of the equipment, is fitted as an emergency device only and is not intended to act as a feeder. The even distribution of the bagasse on the belt is effected by means of a multibladed rotor which rotates at about 300 r.p.m. in a maceration box. Part of the maceration is fed into the box to be intimately mixed with the bagasse and part cascades down the face of the box on to the

bagasse on the belt. These conveyors were installed with a two fold purpose:

- (a) To reduce the high maintenance costs of the apron type conveyor and;
- (b) To improve maceration efficiency.

Neither of these objects were achieved as:

- (a) Wear and tear on the belt due to the problem of keeping the belt properly aligned resulted in short belt life and belts are by no means cheap, nor are they readily available and;
- (b) the expected improvement in imbibition efficiency was not achieved.

It was thought that the reason for the lack of improvement in imbibition efficiency was the uneven feed which was achieved on the belt and for this reason in 1963 a Meinecke chute was fitted to the discharge of No. 3 Mill and the macerator fitted at the discharge end of the Meinecke chute. This achieved the desired result of evening out the feed to the 4th Mill and in consequence of this the feed to the 5th Mill was also improved, but there was no improvement in imbibition efficiency and so at the end of the 1963 season the Reviere carriers were discarded and replaced with the Drag type carriers and Donnelly chutes mentioned earlier, which have proved so successful. It must be stated, however, that time lost with this type of carrier was in the main limited to chokes of the macerators and not due to belt failure.

#### Slat Attachment Links on Drag Carrier Chains

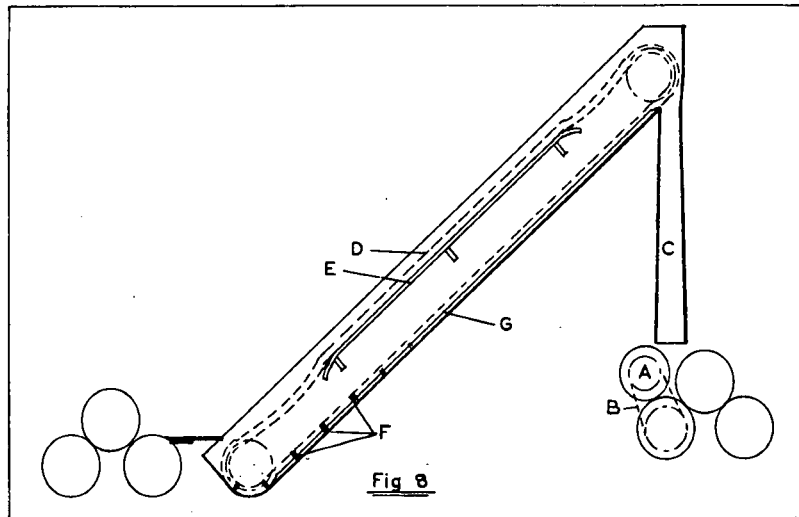
When the 6140 chain was used K2 links were originally fitted. As mentioned earlier these were replaced by C3 and ultimately by C3V due to blocking. As a result of this experience the 09060 chain was originally fitted with a C3 attachment welded to the chain and, incidentally, supplied welded on in such a way that the chain had to run in a direction opposite to that intended by the chain manufacturers. This, however, had little effect on chain failure. The C3 type of attachment was supplied in two forms:

- (a) Upright;
- (b) Leaning backward, and;
- (c) By running the chain in the correct direction, leaning forward.

All three arrangements have been used at Mount Edgecombe. This form of chain attachment has a number of disadvantages and these are enumerated as follows:

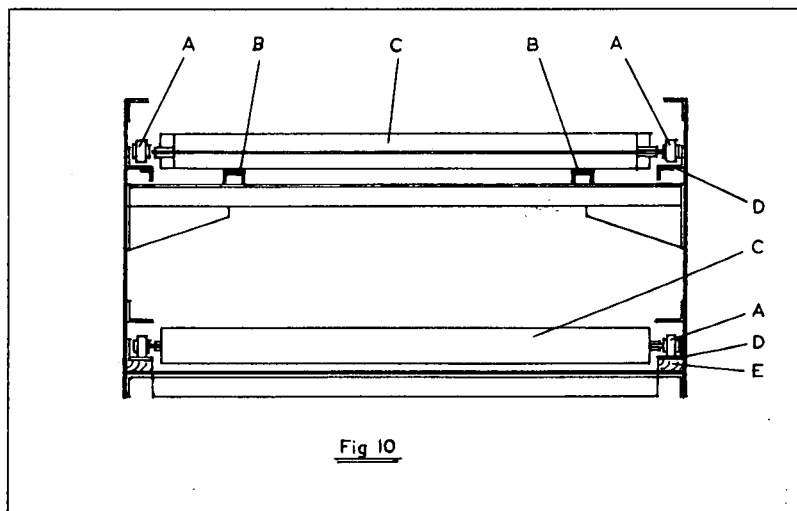
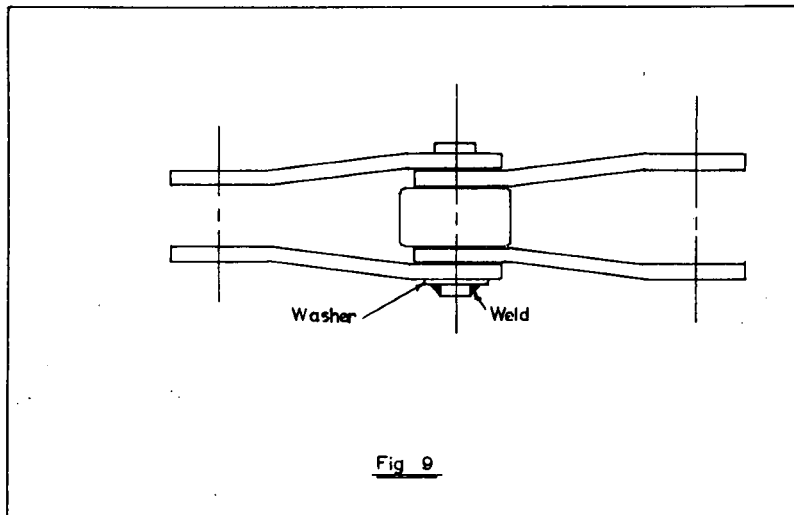
1. When breakage of a slat occurs it is necessary to remove eight nuts and remove four bolts.
2. Any malalignment or uneven stretch of the chain imposes a strain on the attachment links which result in excessive and rapid and uneven wear of the attachment link pins. This strain also tends to distort the side bars and causes the bush to become slack.

In the event of slat breakage, however, this type of attachment does give some support to the slat and enables the carrier to be stopped or emptied before excessive damage is caused. The AS2 attachment is an alternative. This has the advantage of not imposing



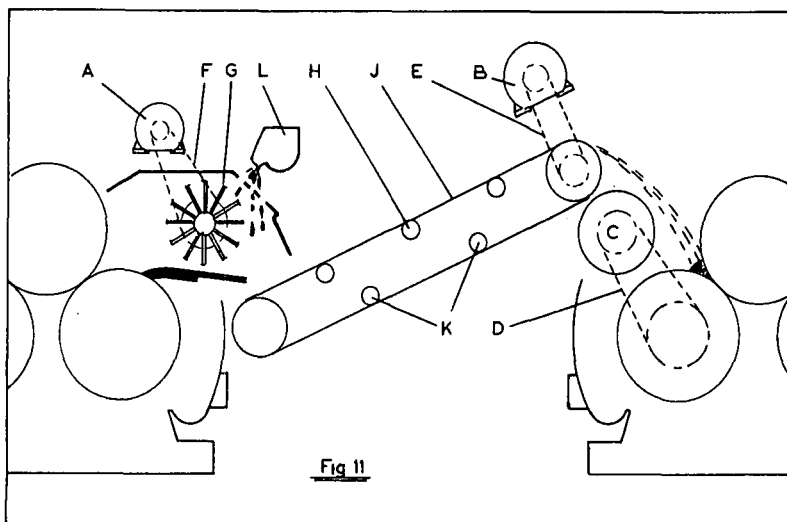
KEY TO FIGURE 8:

- |                             |                            |
|-----------------------------|----------------------------|
| A Underslung feeder roller. | E Slat support runners.    |
| B Drive.                    | F Slat and chain assembly. |
| C Donelly chute.            | G Bottom plate.            |
| D Chain runner.             |                            |



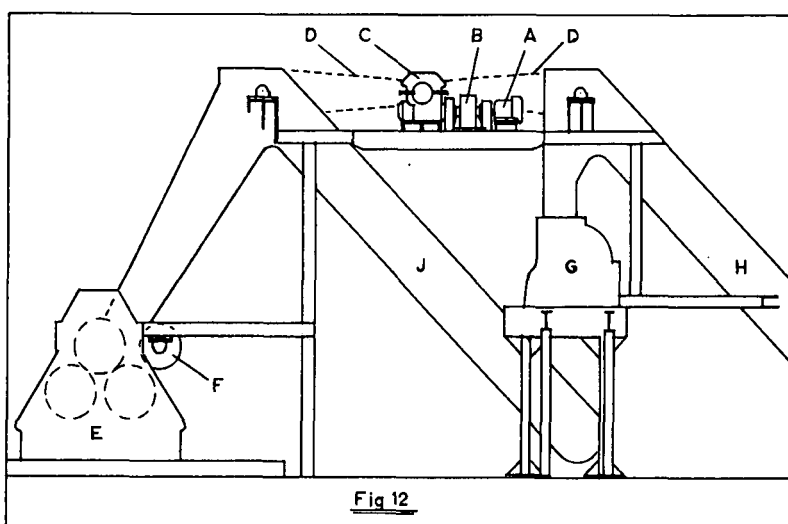
KEY TO FIGURE 10:

- |                        |                   |
|------------------------|-------------------|
| A Chain.               | D Chain runner.   |
| B Slat support runner. | E Wooden packers. |
| C Slat.                |                   |



KEY TO FIGURE 11:

- |                                       |                      |
|---------------------------------------|----------------------|
| A Macerator drive motor.              | G Macerator.         |
| B Carrier drive motor.                | H Idlers.            |
| C Underslung feeder roller.           | J Rubber belt.       |
| D Drive for underslung feeder roller. | K Return idlers.     |
| E Intercarrier drive.                 | L Maceration trough. |
| F Macerator drive.                    |                      |



KEY TO FIGURE 12:

- |                            |                             |
|----------------------------|-----------------------------|
| A Drive motor.             | F Underslung feeder roller. |
| B Variable speed coupling. | G Shredder.                 |
| C Gearbox.                 | H Shredder elevator.        |
| D Chain drives.            | J Crusher carrier.          |
| E Crusher.                 |                             |

strains on the attachment links due to small misalignments of the chain due to uneven stretch. In addition slats can be easily changed simply by removing two attachment pins.

Unfortunately, every coin has two sides and likewise the AS2 attachment, favoured by the author, is not without its drawbacks. These are:

- (1) In the event of slat breakage the broken slat is unsupported and can cause serious damage by fouling parts of the conveyor.

- (2) Due to the weight of the slats the AS2 attachments tend to open up, thus shearing the split pin securing the attachment pin and when this occurs it can mean trouble. Bolts and nuts in place of the attachment pins can overcome this problem.

- (3) With this type of fixture the slat becomes a beam simply supported at each end instead of a beam fixed at each end as in the case of the C3 type of attachment. Slat failures, as a result of the inability of the slats to withstand the increased

bending moment in this arrangement, have caused numerous slat failures. Aluminium T-bar slats 5 in. by 4 in. in place of wooden slats are to be used at Tongaat next season. These slats will withstand a maximum bending moment of 9,800 lb. inches as against 3,333 lb. inches in the case of the 5 in. by 2 in. wooden slats. The weight of the aluminium slat is 23.2 lb. as against 66.5 lb. for the wooden slat.

#### Shredder Carriers

With the repositioning of the shredder ahead of the mill a number of mills have used drag type conveyors to convey the shredded cane to the first mill and in fact similar carriers have been used to feed the shredder. In some instances one or both of these carriers are fixed speed carriers. This means that when there is a choke at the mill, either all the cane in the carrier has to be discharged before the choke can finally clear or, alternatively, both carriers must be stopped until the choke is cleared.

By using a common variable speed electric drive for these two carriers and by interlocking the drive with the main carrier by means of tachogenerators, and sensing devices and by fitting a killer plate in the chute to the mill, a very simple and effective means of control is obtained. This arrangement is illustrated in fig. 12.

#### Feed Point

Finally, before leaving the subject of intermediate carriers a point of great importance for the successful operation of drag carriers is that the bagasse is fed into the carrier at a point slightly beyond the tail-shaft. This prevents excessive loading of the slats due to bagasse packing between the curved plate of the carrier boot and the slat and resultant slat breakages.

#### Conclusion

The conclusion to be drawn from this resumé of intercarrier development and design is that where one has intermediate carriers one has chain and where one has chain one has trouble. However, the selection of all stainless steel chain in the case of the apron type carriers and stainless steel fitted chains in the case of drag type conveyors, appears to be the solution to the mill engineer's problem and while these chains are initially more expensive, this extra expenditure is warranted in the long run.

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**Mr. Cargill** (in the chair): A speed of 200 feet per minute seems very high for intercarriers. We have two similar carriers at Mount Edgecombe, one running at 60 and one at 140, both conveying the same quantity of fibre, which shows that 60 ft./min. is sufficient for our tonnage.

**Mr. Dent:** I agree 200 feet per minute is high. We run usually at 140, but sometimes as low as 100. High speeds were introduced to reduce loading on the slats and to facilitate better feeding into the narrow entrance to the chute.

**Mr. Hurter:** Aluminium slats sound like a good idea, but there is danger of corrosion between it and the steel.

**Mr. Dent:** We will accept this possibility of electrolytic corrosion but feel sure that this will not be too serious and that we shall get at least a full season's wear out of the slats.

**Mr. Ashe:** At Umfolozi we had metal slats on a rake carrier for our boilers and when a slat bent it pulled the chain inwards and then off the sprocket at the end.

The advantage of a wooden slat is that when it breaks it does not affect the chain.

**Mr. Dent** has mentioned strengthening wooden slats with angle iron — will this stretch right across the slat?

Spacing of slats has not been mentioned. We started at two feet centres and ended with four feet centres.

We have apron carriers except for the pressure feeder and crusher and they are very dirty.

**Mr. Dent:** We have experienced bending of both metal and timber slats and the effect of pulling the chain off the sprockets. We used angle iron behind the wooden slats to strengthen them to prevent bending and breakage.

The centres we use are two feet six inches, although on the shredder carriers we have had gaps up to five feet.

Breakdowns of intercarriers are almost certainly the commonest cause of stoppages throughout the sugar industry.

**Mr. Renton:** The intercarriers at Darnall are sloped at 60°, not 55° as stated in the paper.

We use metal slats entirely and have been completely trouble free.

The chain that wore out was a main carrier chain running under dry conditions, with stainless pins and bushes and stainless bush rollers. The stainless bushed roller wore out the outside of the stainless bush.

In the intercarriers, with 09060, the stainless parts have worn very well.

We have had trouble with feeding at Darnall and have installed what is almost a Meinecke chute on the discharge scraper to get enough elevation of the bagasse to drop it and deflect it clear of the chain.

**Mr. Dent:** At Tongaat we had a Meinecke chute on the discharge end of the crusher. It caused endless trouble because of uneven feeding and we have now done away with this.

On the discharge end of the 3rd mill of the Tongaat tandem there is a properly designed Meinecke chute which discharges ahead of the tail shaft.

**Mr. Pole:** The carrier running from our shredder to the first mill is inclined in excess of 60° and runs at 100 feet per minute. We initially had trouble with bagasse and trashy cane going into the inlet of the feed chute. We have angle iron cleats attached to each slat and by raising the runners on which the cleats travel they drop about an inch when they move over the apex and this shakes the bagasse off into the chute.

**Mr. Cargill:** In the same manner at Mount Edgecombe we give a two inch jar to the slat as it enters the feed chute at the top of the carrier.

**Mr. Ashe:** How is the leaning forward slat working at Mount Edgecombe?

**Mr. Turner:** In the middle of the season we changed to mild steel slats,  $\frac{3}{8}$  in. by 6 in., backed with an angle iron, and ran the chain backwards. It seemed to line itself up as it reached the sprockets.

We had trouble with bagasse piling up in the boot and breaking slats. We turned the slat attachment links around so that as the slat came round instead of presenting a flat surface to the bagasse coming off the discharge plate it was digging in.

**Mr. Saunders:** The feed into the intercarrier is most important. It may be possible to overcome some of the difficulties being experienced at Darnall by lengthening the discharge plate. Scraping can also be done on the upper strand of chain.

Chain manufacturers are tending to specialise in materials and in heat treatment instead of increasing the size of chains. The most successful chains are those with the greatest bearing areas.

As regards the dry running of chains, it is our experience that cast iron rollers, instead of steel rollers with stainless inserts, are both cheap and efficient.

**Mr. Cargill:** Why did Renolds discontinue the manufacture of stainless steel chain of the type that was so successfully used at Tongaat?

**Mr. Saunders:** It is still being manufactured. Owing to its price we have met resistance when trying to sell it to the sugar industry but we intend to reintroduce it.

**Mr. Ashe:** We are introducing more Donelly chutes. Should the headshaft be ahead of the opening, behind it or on the edge?

**Mr. Dent:** I think the headshaft should be slightly ahead of the centre of the chute. There must be no type of wedge at the top end and the best way to make the bagasse fall away prior to the chute is to introduce a radius plate on one side or a short inclined plate.

In a Donelly chute there should be a definite relationship between all the openings and the bottom of the chute and it should have a  $4^\circ$  taper.

**Mr. Hurter:** Why do not chain manufacturers follow the lead of the automobile manufacturers and use nylon bushes to overcome the wear problem of steel on steel?

**Mr. Saunders:** There is terrific pressure on the bearings used and I do not know if nylon would stand up to it.

**Mr. Dent:** Chain is being worked in very dirty conditions, with lots of grit and abrasive material about and it is possible that this would lodge in the nylon bush and wear the pin very rapidly. As an example, in motor mowers with nylon bushes in the wheels, the axle wears first.

**Mr. Jones:** I had the experience once where steel pins were being used in bronze bushes under very dirty conditions, and they lasted only a few months. We switched to nylon bushes and solved the problem. Data is available for designing bushes from nylon to get correct bearing pressures and dimensions.

Dry lubricants might also be used, such as PTFE.

**Mr. Hill:** What is the difference between a C3 attachment and a C3V?

At Renishaw some years ago we bought C3 attachments from two different suppliers and had trouble. We then realised that in one case the attachment was in the middle of the link and in the other at the end.

**Mr. Dent:** In the C3V the attachment is mounted over the pin, in the C3 it expands the middle of the link. The advantage of the C3V is that there is less tendency to pack as bagasse can work its way out.

**Mr. Cargill:** In Figure 12 in the paper a simple way is shown of controlling the speed of two carriers simultaneously.

At Mount Edgecombe we regard the shredder as a good tramp iron finder and when a piece of tramp iron goes through the shredder we immediately stop elevator J and H simultaneously until we have found it. Then elevator J is slowly driven.

In this drawing both H and J would be driven, unless a clutch is placed between them.

**Mr. Dent:** There will not be a clutch between them but in the sprocket boss there will be a shear pin which can easily be removed.

**Mr. Turner:** Referring to Figure 10 we find that most of our chain wear takes place between the roller and the outside of the bush. To obviate this we have put runner bars on the slat so that the rollers do not turn at all on the return flight.