AUTOMATIC CANE CARRIERS

By J. R. GUNN

Introduction

It has been universally agreed that the presentation of a uniform feed to the first milling unit or crusher of a milling train is of paramount importance if one wishes to obtain the optimum results. It can be argued that to attain this uniform feed at the crusher it is necessary to have uniform loading of the cane carrier at the point where the cranes and auxiliary carriers feed onto the main cane carrier. Such conditions would be ideal but are very difficult to achieve particularly at the Maidstone mill where the milling tandems are fed from so many varied forms of road and rail transport. Thus the loading of the main cane carriers can be disregarded for the time being provided we can drive the cane carrier in such a way as to present an even feed to the crusher.

Automatic Cane Carriers

The first principle of automatic cane carriers is that provided the crusher is fed with more cane than it can crush, it will accept only the amount that it is set to handle. However, if we continue to feed too much cane the crusher chute will choke up and no benefit is derived. Therefore, if a device is fitted to the cane carrier drive to supply more cane than can be handled by the crusher, it must have an overriding device which will produce a signal to slow up the feed when the accumulation of extra cane in the crusher chute reaches a predetermined level. Having slowed the carrier down, there must then be another signal generated by some means which will increase the speed of the carrier as soon as the quantity of cane in the crusher chute is too low or the feed is less than that which the crusher is capable of consuming. If we reach the state where the feed to the carrier can be maintained between these two points then we have the basis of an automatic cane carrier.

Unfortunately it is not quite as simple as that. The cane on the cane carrier requires certain preparatory treatment such as passing through the cane cutters or cane knives. If it were possible to obtain even loading of the cane on the cane carrier it would be natural to expect that the cane carrier would run at a constant speed and therefore the loading on the prime mover of the cane knives would likewise be constant. However, as no attempt is made or can be made for uniform loading of the cane carrier, it is obvious that to present a uniform feed to the crusher, the carrier speed must be constantly varying and therefore the load on the cane knives must be varying. It now becomes obvious that in order to successfully operate an automatic carrier, a device that will sense the load on the prime movers of the cane knives is essential and should this load increase to a point where the prime mover is overloaded, the carrier must slow down or stop until the load has eased itself.

At Maidstone where there are two tandems, the control apparatus was fitted to each cane carrier and during a period of weeks towards the close of the 1957 season one tandem operated completely automatically. The control on each tandem is entirely different due to the different types of drive employed.

Steam Engine-Driven Cane Carrier

The large 38-in. x 84-in. tandem is fed by a steam engine-driven cane carrier. Here, to achieve automatic operation, it is necessary to control the steam engine. There are two sets of cane knives operating on the cane carrier, one set driven by an electric motor and the other by a high-speed steam engine. Thus the steam engine control has to be sensitive to three factors, i.e. the feed to the crusher, the load on the electrically-driven knives and the load on the steam engine-driven knives.

Firstly we will consider the control of the steam engine driving the cane carrier. The steam supply to the engine is controlled by two valves in parallel. Closing both valves causes the engine to stop, opening one valve causes the engine to run slowly, opening both valves allows the engine to run at full speed. The two valves are of different sizes, the first being considerably smaller than the other so that when only the small valve is open the carrier speed will be greatly reduced. Both the valves are solenoid-operated.

The load conditions of the electrically-driven cane knives are detected by a current transformer on one phase of the motor. Current from this transformer actuates relays which either close the large steam valve or both depending on whether the load on the knives is 20 per cent overload or 40 per cent overload. Closing one or both valves causes a change in speed of the carrier and an immediate change in the load conditions on the knives. As soon as the load conditions return to normal the valves both open and the carrier proceeds as normal.

In order to detect load conditions on the steam engine-driven knives, a small electric generator is driven by the knife shaft. Variations in speed which can only be caused by load conditions, cause variations in the signal voltage. A drop of speed first causes the voltage to drop and to actuate a relay which closes the large steam valve, a further drop in speed causes the small valve to close and stops the carrier until the speed of the knives increases when the small valve opens and the carrier creeps forward. A further recovery of speed of the cane knives allows the large steam valve to open and the cane carrier is now back to normal running at full speed.

Running at full speed it is obvious that far too much will be delivered to the entry of the crusher. To prevent this happening it is necessary to be able to measure the depth of feed and from this measurement to regulate it so that there is always just too much presented to the crusher. This measurement is done by hanging an arm in the crusher chute so that the crusher feed passes underneath it and the heavier the feed the more the arm is raised. Movement of the arm actuates two cams which each operate limit switches in such a way that as the depth of feed reaches a predetermined height one cam causes the large valve to shut and the carrier slows down to creep speed. Should this creep speed cause the depth of feed to increase beyond a second predetermined level the second valve is shut due to the action of the cam actuating the limit switch. Should the crusher suffer a choke the carrier will stop automatically until the choke is cleared.

The above system as explained is in operation, and has successfully controlled the crushing rate of the mill for some weeks. It causes the carrier to run at two speeds only, creep and full speed, the latter being regulated and set by a manual adjusting valve which once set need never be altered. In practice the carrier creeps for 70 per cent of the time provided there is a good feed at the loading end of the carrier. The high speed is brought into operation only if the feed drops and in general the carrier is either creeping or stopped.

Electrically-Driven Cane Carrier

The small tandem (34-in. x 66-in.) has an electric motor driving the main cane carrier. There are two sets of electrically-driven cane knives operating on the carrier. The control device in this case is a magnetic slip coupling similar to many such couplings already in use in Natal. When this slip coupling was ordered from the manufacturers, one condition of the order was that there should be an extra control circuit incorporated so that the carrier could be fully automatically controlled.

A magnetic slip coupling has a driven input part which rotates at a constant speed. The output part consists of a rotor with wound coils and slip rings. By feeding direct current *via* the slip rings to the coils a magnetic field is generated which couples with the constant speed input section. Depending on the mechanical resistance to which the output shaft is connected, the higher the input voltage on the slip rings the less slip there will be between the input shaft and the output shaft. Thus by varying this voltage an infinitely variable speed can be obtained at the output shaft.

Each cane knife motor has a current transformer on one phase to measure the electrical load absorbed by the knives. Signals from the transformers are amplified and fed to thyratrons which in turn feed signals to the slip coupling. Rotation of the slip coupling output shaft drives an Alnico generator which produces a balancing signal which acts as a speed control when conditions are normal. Should the cane knife signals be stronger than the balance, the carrier will slow down or even stop and will not speed up again until the balance signal is stronger than the knife signal. As an adjustment of the speed control, a hand-operated master control potentiometer is provided. This adjusts the maximum speed at which the carrier can run for any given setting.

From the above, it will be seen that when the cane knives are not overloaded, the carrier will run at the speed set by the hand potentiometer. With overloading of either set of knives it slows down. However, it is natural that if no overloading takes place and the carrier speed is set too high, the crusher chute will be flooded with cane. To overcome this feature a feeder plate, similar to that used in the larger tandem, is installed in the chute. This flap controls a cam which in turn operates a second potentiometer which negatives the effects of the hand-operated potentiometer and, should the feed become too high, slows down the carrier progressively until it stops if the feed becomes higher than a predetermined amount.

In a few factories this slip coupling is in use but the second controlling potentiometer is not included in the circuit. The author is of the opinion that with small modifications these installations can be made to be fully automatic. This can be done by having a flap operating a cam which operates two limit switches. One limit switch should be arranged to close at a certain feed lead, the closing should short out the hand-controlled potentiometer and leave in a resistance of, say, 2000 ohms. This will slow down the carrier but if that is insufficient then the second limit switch should be arranged to break the electronic amplifier switch circuit, thereby stopping the carrier.

Conclusion

Having described two different types of automatic carriers actually in existence, let us analyse what benefits can be derived therefrom:

1. Both controls prevent overloading and tripping of the cane knife motors. This in itself is a material saving, especially when throughput tonnages are increasing but the same powered motor is still used for the knives.

2. The feed to the crusher is maintained at a level of just too much cane but never so much that the crusher chute becomes choked.
3. It is possible to remotely control either type of carrier by placing press buttons or potentiometers at the central control platform.
4. Being purely electro-mechanical mechanism it does not suffer from human fatigue and cannot be distracted in any way.
5. It is labour-saving, for once it has proved itself to be comparatively foolproof, the cane carrier driver is no longer required.

Mr. Rault wanted to know if automatic control led to higher throughput.

Mr. Gunn replied that at Maidstone they did not crush more cane but it did lead to a reduced speed of the crusher for the same tonnage. In Australia they claimed a material increase in tonnage throughput.

Mr. Rault said this meant only an economy of one man per shift.

Mr. Bentley asked Mr. Gunn which type of control he preferred for the control of the cane carrier, steam engine drive with solenoid controlled valves or electric drive with a magnetic clutch.

Mr. Gunn said that the point was that when you had a steam engine driving a carrier, you were limited to three speeds—stop, slow and normal running. He did not think there was any advantage in either method of driving the cane knives, but, however, the automatic control was more efficient than manual control.

Mr. Walsh said he knew of one particular installation where the carrier was divided into two parts, the horizontal portion being fitted with hydraulic tippers with one set of steam engine driven cane knives at the nose of the carrier, the other portion of the carrier was inclined with a set of electrically driven knives before the crusher. Both carriers were electrically driven and had slip couplings. The whole of the controls, both for the tippers and the couplings, was operated by one man from an elevated platform. It was easy to see from Mr. Gunn's description that automatic control of the cane carriers would considerably improve the performance in such a case and would allow the operator to concentrate on the loading of the first carrier from the hydraulic tips.

Mr. Barnes said that knife chokes, and the tripping out of knife motors through overload, which had previously caused a great deal of lost time, had been practically eliminated at the Frome Factory in Jamaica by similar methods of control.

Mr. Gunn, replying to Mr. Barnes, said that one interesting feature of the control at Maidstone was that it was almost identical with that at Frome. One variation, however, was that the one set of knives on one mill was steam driven, whereas at Frome they were all electrical. Replying to Mr. Walsh, Mr. Gunn said that he had seen an installation in Mauritius comprising a cane carrier with two cross carriers, both the cross carriers being fitted with slip couplings controlled by a cane levelling device. The motor-driven cane knives were under-powered and this factor allowed for a very good control of the two cross carriers. There was a boy at the carriers but he had nothing to do as the slip couplings are remote operated and actually controlled the feed on to the cane carrier.

Mr. Rault said he had noticed in a recent publication that Central Romana with mills of the same size as Natal Estates and Maidstone, was claiming to crush 7,000 tons per day. Anything that could be done to improve the preparation of cane and the feeding at the first part of the crushing would be of great benefit because this was where the major stoppages occurred.

Mr. Gunn explained that at Maidstone last year the two tandems were set to crush more than the factory could handle and the throughput of the mills was reduced to suit the factory capacity. He was emphatic that with an automatic control fed carrier, more cane could be crushed, for instance, the possibility of the cane knife choking was greatly reduced, chiefly because the control device is mechanical and does not get tired. In Australia they had experienced an increase in throughput when the controls were properly adjusted.

Dr. Douwes Dekker asked Mr. Gunn if it was necessary to have three types of control, or would it be possible to leave out, say, one, to make the device more simple.

Mr. Gunn said that the controller must be sensible to the amount of feed. He considered that the crusher should be run at one fixed speed only. If the feed to the crusher was slightly more than it could accept, the feed in the crusher chute would increase. An arm bearing on this increased feed and could operate a control to regulate the carrier speed. Similarly, if the feed was too light the arm would create a signal to increase the carrier speed. Most modern mills had two sets of knives, levellers and those going right down to the carrier slats. On occasions, even with automatic control, cane knife motors would trip, or almost trip. Although the levelling knives should keep the feed constant, this does not happen in practice, because of the varying cane carrier speed, and even if the feed were level at the levellers, it could be too much for the second set of knives, hence the necessity for three sets of controls.

Mr. Gunn, replying to a question by Mr. Munro, said that his experience was that only if there was a big choke at the levelling knives, did the crusher suffer from a shortage of cane.

Mr. Rault enquired how the system would work with the Australian method of feeding, that is to say with a longer and steeper chute.

Mr. Gunn said the carrier speed control would not work under those conditions. In the case of one mill in Australia, the cane first went through a shredder, but a control was fixed, however, between the shredder and the first mill.

Mr. Nickson said that this automatic control must have given them a more even feed and therefore led to an increased extraction.

Mr. Gunn said he could not say from the figures obtained whether it should, or should not, give a better extraction.

Mr. Munro asked if it would not be an improvement to have two carriers, as had been described, with the levellers on one and the knives on the second or inclined part of the carrier. Combined with this, one could use a levelling device on the chute from the first carrier to the second, and this would probably eliminate the big bundles of cane which went through the levellers on to the second carrier and which might cause some interruption in the operation of the second carrier, if it was controlled by a cane levelling device on the first crusher.

Mr. Gunn said that the aspect of two carriers had been considered at Maidstone, but they had not the space to install them. He thought that where there were two sets of carriers, the idea of having a levelling device, as described by Mr. Munro, would be an advantage.

Mr. Munro said his idea of a leveller was that the knives would be set at a considerable distance from the cane carrier slats. If the first set of knives were arranged so that the cane was cut before it fell on the main carrier, and if there were two narrow carriers, levellers could cut the big bundles of cane which would then be fed on to second carrier and then the feed could largely be regulated by this first carrier.

Mr. Gunn agreed that with two carriers, a set of knives at the end of one carrier feeding on to the second carrier and a means of controlling the second carrier, one would get a level feed on the main carrier.

Mr. Munro said he would do away with the main cane carrier driver but a lot still depended on the auxiliary carrier driver. If huge bundles were dropped in the main cane carrier there was a possibility that the knives would trip when going at high speed. This would not happen with two carriers.

Mr. Ross stated that the system described by Mr. Munro was in use in Trinidad, at the Breckin Castle Factory. Cane was dumped on to the primary carrier which was the same width as the main carrier and running at right angles to the main carrier. A set of levelling knives was installed on the primary carrier. At the point of discharge from the primary to the main carrier there was a turnplate arrangement which tipped over the cane so that any long canes were cut by the secondary knives and preparation to the crusher was excellent.

Mr. Walsh said that Mr. Gunn had given the combination of a steam engine driven carrier with steam engine driven knives and the electrically driven carrier with electrically driven knives. He asked if Mr. Gunn could give his views on the performance which could be expected from an electrically driven carrier with a slip coupling working with a set of steam engine driven cane knives.

Mr. Gunn said he considered a slip coupling would be able to control a steam engine even more effectively than the method he had mentioned because it was very sensitive and very quick to register a change in power.