The Organising Committee
International Materials Handling Conference
P O Box 95194
Grantpark
Johannesburg
2051
SOUTH AFRICA

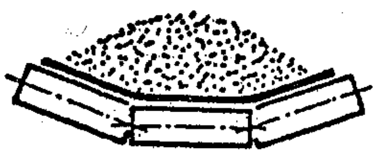
Telephone (011) 728-4562

STEELCORD DRIFT CONVEYOR AT SELBY COLLIERY

P W COMELY
ANDERSON STRATHCLYDE
UNITED KINGDOM

18 - 19 MAY, 1983
MILNER PARK
JOHANNESBURG

BELTCON 2



BELT CONVEYORS - DESIGN, OPERATION AND OPTIMIZATION

The Institute of Materials Handling — The Institution of Mechanical Engineers — The Materials Handling Research Group (University of the Witwatersrand)

<u>Steelcord Drift Conveyor at Selby Colliery</u>

<u>P.D.H. Comley, C.Eng., M.I.Mech.E.</u>

Chief Engineer, Selby Project, Anderson Strathclyde Limited.

----- o o O o o -----

[redacted]

A troughed belt conveyor, or conveyor system, is an integrated piece of equipment and must be treated as such in both design and operation.

Like a car, a conveyor is made up of a variety of parts, many of which are designed and manufactured by outside suppliers. Unless great care is exercised in engineering these individual items to meet the particular requirements of each conveyor, than an unsatisfactory result will ensue. The performance and reliability of the completed installation will therefore suffer as a direct consequence.

In High Speed Conveying this assumes even greater importance, and the overall care and attention to detail design of the system cannot be too highly emphasised.

In the conception of the system the following factors must be taken into account:-

~~Reliability~~
Safety

Optimum Life Ratings

Maintenance Requirements

Protection

Economics

In the design of the system the following items of equipment require to be studied and evaluated with the greatest care:-

The Belt

The Drive Unit

The Tensioning Gear

The Support Structure and Idlers

The Feed Point

The Transfer or Discharge Point

[illegible]

Reliability

This is probably the most important factor that has to be considered. There are very few operations to-day, if any, that are not going to involve a serious financial loss, either directly or indirectly, due to a lack of reliability, and a consequent breakdown in the equipment.

Consider what will happen if the main surface drift conveyor at a colliery breaks down. Most, if not all the coal will be brought to the surface by this conveyor, and once the feed and bunkering system in-bye has become saturated, all further coal cutting operations must cease until the drift conveyor is put back in operation.

At a process plant the breakdown of the main feed conveyor may well result in the shut-down of the plant, once stock-piles of the material to be processed have been exhausted. The employment of large stock-piles may overcome this problem, but the feed system not only maintains throughput but minimises the requirements of intermediate stocking.

When one considers the cost of operating major mines or process plants, and the value of the product, breakdowns in production can be extremely expensive. Loss of production for a few days may well be equal to, or greater than, the piece of equipment in question. Therefore the cost of ensuring reliability may be very small compared to the potential loss of production.

What do we mean by reliability? Firstly, the fewer units the less likely there is to be a breakdown. If one conveyor will do the job, why specify two or more? The reliability factor is increased in direct proportion. A belt conveyor is basically a simple machine. This characteristic goes a long way towards making it reliable, and its reliability is further ensured if its major components are of robust and proven design, and care is taken to preserve the quality of simplicity by giving detailed consideration to each item of the equipment:-

> Drive arrangement that keeps the accelerating torque as low as possible, and extends the accelerating time to the maximum, thus minimising the starting force in both belt and mechanical equipment. Where appropriate, using a variable speed drive so that the conveyor runs at that speed necessary for the particular loading. This permits a saving in energy, a reduction in wear and tear, and increases the operating lives of all components.

> Tensioning arrangements that automatically adjust to match the various load circumstances, starting and running on the one hand, and decelerating (braking) on the other.

Conveyor structure and idlers that are adapted to the load and speed, and in which both troughing and return sets can be accurately aligned.

Receiving points designed to transfer the product onto the conveyor in such a manner as to minimise wear or damage to the belt.

A conveyor belt that is chosen for its suitability for the application, to have a safety factor that is adequate for the duty, is properly supported and kept in a clean condition.

Reliability may be defined as the ratio of the actual operating time to the time for which the operator could have used the installation. In a conveyor system, operational reliability is inversely proportional to the number of parts constituting a conveyor, and to the quality and suitability of the constituent parts. The aim must always be to provide the highest 'Availability Coefficient' possible.

Safety

Safety covers two principal areas, the safety of the equipment and the safety of the personnel associated with the conveyor. In the latter case the safety of the personnel must be assured through strict compliance with The Health and Safety at Work Act. Many of the requirements of this Act are covered by BSI Safety Standards, and Safety Codes issued by main users.

With high speed conveyors the safety aspect must be given very careful consideration, and may well demand guarding, or prevention of access, to areas not normally considered hazardous on conventional conveyors.

Regarding the safety of the equipment, the design must take account of all areas where, if not suitably protected, severe damage could be caused by 'foreign' articles entering the system, for example, tramp iron at feed points could cause severe belt damage. Failure of major components subject to excessive overloads, or failure of components due to lack of lubrication: such failures must be avoided by suitable 'over-load' protection or monitoring devices. (See also under 'Protection').

Optimum Life Ratings

Having considered the requirements for reliability and safety of the equipment, these must now be related to the planned operating life of the equipment. Consideration has to be given to the cost of replacement, and the shut-down time involved in the replacement. From these considerations the optimum life ratings of the constituent parts can be established. Account must be taken of the tonnage to be carried, the nature of the material (lump size, abrasiveness, internal friction, etc.), the number of operating hours per annum, and the overall life requirements. Fixed or variable belt speeds must also be taken into account.

As a general guide the following can be considered in ascending order:-

Idler Rollers	Easily replaceable items. Five to ten years life expectancy.
Pulleys and Main Bearings:	Require one or more days shut-down to replace. Should have minimum of seven to ten years life expectancy.
Conveyor Belt:	Generally the most expensive item of the conveyor. Life largely determined by wear and fatigue, therefore type of covers and joints must have special consideration. Solid woven or ply belts up to eight or ten years life expectancy. Steel cord belts have fifteen to twenty years life expectancy.
Drive Units and Gearboxes:	Should last life of conveyor. Ratings based on seven to ten years on replaceable items such as seals, bearings, gears, etc.
Conveyor Structure:	Should last the life of the conveyor.

Maintenance Requirements

Designing for maximum reliability and minimising the number of constituent parts helps to minimise maintenance requirements, but in no way precludes this most important aspect. For maximum reliability, reduction in wear and tear, cleanliness of the equipment, etc., planned maintenance is essential.

Lubrication, fluid replacement at specified intervals, etc. are an integral part of this planned maintenance.

Cleanliness must be given the highest consideration. The design must include the means for cleaning the belt, usually by mechanised means, and may also involve the inversion of the return belt or washing of the return belt. The design should also preclude the building up of dirt within the system, or if this is not possible, a safe means of easily removing such a build-up.

Dirt build-up can have serious consequences on the effective running of the conveyor and will be very costly. Build-up on idlers and pulleys will cause off-tracking of the belt, leading to edge damage and spillage. In the case of steel cord belts, build-up on pulleys can cause fracture of the steel cords.

Maintenance must therefore figure highly in the design concept. Parts requiring maintenance must be designed to ensure that the necessary maintenance can be carried out quickly, easily and safely.

Protection

A high speed and/or high horsepower conveyor represents a major investment and that investment must be protected. Reliability is a major requirement in the design, but in practice malfunctioning can and will occur, and parts will deteriorate due to wear and tear.

Optimum use must therefore be made of the various monitoring devices that are currently available to provide warning of a malfunction. Potential damage can thus be avoided by taking advance corrective action. Shut-down should be automatic in cases where continued running could lead to serious damage. Vital auxiliary units should be duplicated with automatic changeover gear.

Economics

Having considered the other major factors, the overall economics of the conveyor must be carefully studied. The capital outlay of the conveyor must be the minimum that is commensurate with its operating at the most economic level, taking due accout of running costs, operating staff and maintenance and replacement requirements.

If the conveyor is to be operational for many years, then the operating costs and the cost of replacement parts must be carefully evaluated. With inflation continuing to be a major factor, these costs are going to increase considerably during the life of the installation, adding to the selling price of the final product.

Initial capital outlay should never be the prime consideration in selecting the make-up of the conveyor.

In the long term, operating, maintenance and replacement costs, over the life of the conveyor, may well be the most important consideration. For example, a belt that will last the twenty years life of the conveyor in terms of wear and fatigue, without replacement, will be initially more expensive than one that will have a life expectancy of only 7 to 8 years. Over the full life of the conveyor this latter belt will require replacing twice and could well prove to be the more expensive alternative.

On high speed conveyors a variable speed drive may initially be more expensive than a standard fixed speed drive. However, as power is directly related to speed, the ability to run the conveyor at the minimum speed necessary to match the varying load conditions will give enormous savings in power consumption costs over the full life of the installation. In addition, this variable speed factor allows all moving components to operate for a longer total life than on a fixed speed installation, thus reducing or even eliminating costly replacements.

On steep uphill conveyors the slope weight of the belt has a very important influence, since it may, of its own accord, provide the necessary slack side tension for efficient drive. In this context a single drum drive is to be favoured on the grounds of reliability, minimum spares holding and therefore the most economic choice.

Where a multiple drive is chosen, economy of maintenance and spares holding will benefit from standardisation. As an example, if a 2 to 1 drive ratio is chosen, it is likely to be more economical to select three identical drives (2 on the primary and one on the secondary), instead of two drives of 2 to 1 power ratings.

There are many other areas that have to be considered in detail, but an indication has been given to justify the philosophy that has to be adopted.

DESIGN CONSIDERATIONS

The Belt

The choice of belt to be specified has to be considered very carefully, for in most cases it is the highest cost item in the conveyor. There are basically three types of belt available, the solid woven or single ply type, the ply belt and the steel cord belt. All three types can be used successfully on high speed applications.

It is a little difficult to state precisely at what speed a conveyor may be considered to be 'High Speed'. However, by today's standards any conveyor operating at 4m/s or above can reasonably be considered to be within this category. For all high speed applications the construction of the belt in terms of straightness, consistency of width and thickness, is most important, and the belt manufacturer should be made fully aware of the speeds to be achieved. Of even greater importance is the construction of the belt joints. These must be of the vulcanised type and be exactly square to the centre-line of the belt and conveyor. Consistency of thickness at the join is important and great care must be exercised in ensuring even load distribution over the joint; this is particularly important in the construction of steel cord belt joints.

For optimum economy the lightest practicable belt should be specified with a Safety Factor that takes full account of the stresses and flexures to which it will be subjected. The level of these stresses and flexures will be largely determined by the drive, tensioning gear and conveyor support structure, and will be discussed more fully under these individual headings.

The width of the belt chosen must take account of the feed arrangements, the troughing angle, and the important factor that spillage should not be tolerated. This latter requirement is of particular concern on high speed applications.

Great care must be taken to ensure that the belt will trough under all conditions of loading, as tracking alignment is very important at high speed, and tracking cannot be controlled unless there is good belt contact across both carrying and return idler sets. The heavier solid woven and ply belts tend to be less flexible in the warp direction, therefore imposing a limit on the troughing angle, whereas steel cord belts are flexible and sit well into the trough. In selecting the troughing angle, the belt manufacturer should be closely consulted and should, in any case, give his full approval to the type and construction of belt chosen for high speed applications.

Reverse flexures of the belt should be kept to a minimum, thus ensuring the optimum fatigue life of the belt. In this context the drive pulley and all bend or deflector pulleys should be as large as is practicable, and pulley width should be 200 to 300 mm wider than the belt.

The overall design aim should be to provide the maximum care and protection of the belt under all operating conditions.

The Drive Unit

Having established for a particular application, the required belt speed (either fixed or variable), the maximum power requirements, and whether a single or multiple drive configuration is to be employed, consideration must be given to providing as soft and as smooth an accelerating force as is possible. In this way stress on both the belt and the mechanical components is kept to a low level, and surge of the belt and material is minimised or eliminated. For high speeds it is extremely desirable to maintain this smooth acceleration, not only through the full speed range on start up, but whenever speed is changed during running.

There are today many ways in which this soft and smooth acceleration can be obtained. On the lower powered drives the use of scoop controlled fluid couplings or eddy current couplings can provide the necessary control. However, there is a fairly wide range of these couplings and their control circuits, and the manufacturers should be consulted to ensure that the coupling best suited to the application is chosen.

For the higher powered drives, the acceleration and speed control should come from the drive motors of which there are a number of options available:-

<u>Slip Ring Induction, with Liquid Controller</u>

Provides a soft slow start-up of the conveyor, but is only capable of running, under full load conditions, at full speed rating. Can, however, be used for empty belt inspection, or maintenance purposes, with a slip power recovery system to provide continuous running at speeds between 1.5% and 10% of full speed.

<u>Cycloconvertor - Variable Speed AC Drive</u>

This type of drive provides the facility to start the fully loaded conveyor and run up to any value between 10% and 100% of full speed under controlled torque conditions. It thereafter permits continuous running at the selected speed against full load torque, with the facility to adjust the speed to any value within the permitted range.

<u>DC Winder Type Motor</u>

This type of motor is supplied and controlled by thyrister convertors and has the main advantage that it is slow speed, and there is not therefore a need to specify a reduction gear unit.

Extremely long, soft starts can be achieved, of several minutes duration, keeping starting torques at a very low level. The motors can be run continuously at full load torque, from zero to maximum speed, and can therefore provide precise control under all conditions of loading.

In addition, regenerative braking can be provided, with ramped slow down to precise limits, again under all conditions of loading.

By careful choice of motor and control gear and overall design of the drive unit, it is perfectly practicable to start up a fully laden conveyor with a starting torque that can be held to no more than 110% to 120% of full load running torque.

Not only does this mean that the rating of the belt can be kept low, and significant gains in belt weight and cost be achieved, but the rating of pulleys, shafts and bearings are all improved.

Belt slip is something which should be avoided on any conveyor drive, but assumes even greater importance on high speed applications. It is therefore vital to ensure that the drive has the optimum angle of belt wrap, that suitable slack side tension is maintained, and that slip monitoring, with suitable cut-outs, is provided.

The Tensioning Gear

Reference has been made in the last section to the importance of ensuring that slip does not occur between drive and belt, and to this end it is imperative to maintain correct slack side belt tension at all times. In order to achieve this, and to deal with belt extension and contraction during all running conditions, a belt tension or loop take-up unit is required. In this context the only correct place for the tensioning gear is behind the drive.

The belt tensioning should be automatic and its rate of operation must be commensurate with the rate of stretch of the belt. In this respect the gravity loop is the best and simplest arrangement, providing it can be accommodated. However, it is important to 'lock-in' the belt tensions on stopping the conveyor, therefore a braking system must be incorporated to hold the gravity take-up in position. The reason for this is to minimise belt sag occurring on the laden side of the conveyor whilst it is stationary with resultant detrimental results on starting torque requirements.

Where it is not possible to incorporate a gravity take-up, then an automatic powered loop take-up should be specified. This must be designed to operate at a rate commensurate with belt stretch, and here the type of belt chosen, and its stretch characteristics must be given detailed consideration.

A further alternative is the constant torque tensioning unit that is powered the whole of the time the conveyor is running. This handles the slightest change in belt tension instantly and is fully variable. It embodies many of the advantages of both the gravity and the auto tension loop. In special cases this type of tension unit can be combined with a gravity loop to provide instant adjustment under normal running, with the advantage of fast reaction on start-up with the gravity loop.

The Support Structure and Idlers

There are several important aspects which must be considered here, in selecting the most suitable design of structure and idlers, particularly for high horsepower high speed applications.

Dealing first with the structure, -this must be designed to permit very accurate alignment of the idlers to be made when the conveyor is installed. In this context the nature of the floor onto which it is to be mounted must be taken into account. If it is on stable ground, then suitable concrete mounting plinths can be specified for each stool. On the other hand where an in-fill is to be used, or floor movement can be expected, then some form of cross-roadway support steelwork should be employed, alternatively longitudinal girders can also be used with suitably embedded sleepers. In all cases, allowance should be made for packing the stools to permit initial alignment, leaving the idlers to be separately aligned.

Before leaving the question of the ground mounting of the structure, the ground may well have to be graded if there are undulations of varying gradients in the line of the conveyor. On drift conveyors in particular, the in-bye section may flatten out to a very shallow gradient. Great care must be taken to calculate all convex curves. The concave curves must be sufficiently large to ensure that under all operating conditions the belt is not lifted off the carrying idler sets.

For convex curves the belt component acting on the idler sets must be taken into account in the idler roller load calculations. If large radii are not possible then it may be necessary to close up the pitch of the idlers to reduce the imposed loads on the idler sets within the radius. This is of particular importance at the top of the drift where the conveyor may be required to level out before the discharge point. In this area the belt tension will be at the maximum.

A decision must be taken at an early stage on whether a conventional type structure is to be employed, with the idler sets mounted on the stringers. A preferred system is to design idler stands with the troughing sets mounted on each stand and the returns on either every stand or alternate stands. In this type of conveyor structure, stringers are still required to act as [illegible], communication and telemetry wires.

The need to keep belt sag as small as possible has been stressed. In this context therefore there is considerable merit in designing the conveyor to have idlers close pitched at the tail end and gradually increasing the pitch until a practicable maximum is reached, the remainder of the conveyor having the idlers pitched at this upper limit (except at convex curves).

The mountings for troughing and return sets should be designed to permit individual alignment. This is of particular importance to reduce belt scrubbing and belt wander on high speed applications. On major installations the use of shimming may well pay dividends, which combined with slotting provides fine adjustment both vertically and horizontally.

The design of the structure should be such that there is no possibility of [illegible] the free running of the idlers.

Turning now to the idlers, the aim here must be to ensure the maximum life rating allied with the minimum resistance to turning and the virtual elimination of maintenance requirements. To this end the idlers should be of the 'sealed for life' type, and should desirably have labyrinth seals where there are virtually no rubbing elements. Rubbing type seals create resistance and naturally are subject to wear. Any ingress of dirt will rapidly break down the sealing lips. Generally speaking the most important element of the seal assembly is the grease. Not only does it lubricate the bearings, it provides also an excellent, low friction means of sealing. Choice of grease is therefore vital, particularly if extremes of temperature are to be experienced, when the grease should be of the type that has the least viscosity change at these extremes.

Great care in the choice of idler must be taken as the idlers will largely determine whether the conveyor is or is not economic. Any unnecessary resistance to turning will add considerably to the power requirements and hence operating costs. Seals must provide for long life and the type of bearings chosen must be the best to ensure adequate load carrying and long life rating. It may well be more economical to choose an expensive, high capacity bearing, rather than a standard low capacity unit. If by choosing the higher rated bearing the number of idler sets and mounting stools can be reduced, the gain in power reduction requirements, and the lower number of sets needed, may well offset the increased cost of bearings.

For high speed applications, the accuracy and concentricity of the idler rollers is most important. Eccentricity will cause the belt to be oscillated vertically and this will cause vibration which will increase power requirements, as well as leading to premature failure of the idlers.

Finally, the idler sets must be designed to ensure the optimum alignment of the belt and minimum resistance to running. Return sets should preferably be of the 'V' type, and carrying sets of the 3 or 5 roll type. In both cases forward tilt of the wing rollers should be kept as low as possible or even eliminated. Weight of the moving parts should also be kept low, consistent, that is, with long life expectancy.

<u>The Feed Point</u>

A conveyor may be fed at the tail end or at both the tail end and intermediate points. The design of the feed point will very largely determine the wear life expectancy of the belt. If a belt is fed directly from a chute then impact is involved, the material must be centralised and it has to be accelerated up to the full speed of the belt. With careful design of an in-line chute, good impact sets and well designed skirt plates then a reasonable receiving unit/feed condition can be achieved. However, with feeds coming on, other than in line, problems can be created if the material is not fully turned in line with the run of the conveyor before leaving the chute and in high speed applications, the problems will be magnified.

With the best designs of feed and receiving units it is inevitable that the belt will be subject to wear due to impact of the material, and more particularly due to the need for the belt to accelerate the material. Skirt plate rubbers cause belt edge wear and add to power requirements, and all of these factors take on greater significance the higher the speed of the belt. There is therefore a strong argument, particularly for high speed applications, that the feed should not be directly onto the main belt but onto an accelerator or intermediate feed conveyor. This unit would be mounted above and in line with the main conveyor, and should run at a speed equal to or about 75% of that of the main conveyor. In the case of the main conveyor being variable speed then the accelerator would also have to be proportionately variable and would have a speed loop inte-connected with the main belt.

The advantages of the accelerator conveyor are that the material is already centralised before being transferred, therefore spillage and off-tracking of the main belt is eliminated. The material is already moving at speed so that there is a minimum requirement to accelerate it and by careful adjustment of height, impact can be reduced to a minimum.

The skirt plates of the main belt are clear of the belt and have no rubbers, therefore there is no rubbing, wear is eliminated, as well as a reduction in power requirements.

Finally, if there is a chute blockage, or a piece of steel or wood becomes jammed into the belt at a feed point, then the main belt is stopped and, in the latter case, much expensive damage will have been done to the belt. With an accelerator the problems are limited to this unit only and only a short low cost belt is damaged. The main belt can continue to run and receive material if there is more than one feed point.

The Transfer or Discharge Point

At the discharge end the conveyor may be discharging onto another conveyor either in line or indirectly via a chute. With high speed applications the trajectory of the discharged material requires very accurate plotting to ensure that the receiving hopper or chute is suitable designed.

If the feeding conveyor is of the variable speed type, then both minimum and maximum trajectories must be considered, also the effects, if any, of degradation of the material.

Dust may also be a problem at high speed and suitable dust extraction equipment may have to be specified, together with suitable hooding of the discharge points.

The belt changes from the troughed shape to a flat shape at the discharge pulley and the length and design of this transition area is critical. Severe belt damage can be caused here where the belt is at maximum tension, if there is incorrect design of this transition. This can cause ply separation on ply belts and cord fracture on steel cord belts.

Finally, the carrying side of the belt should be cleaned immediately after discharge of material and before the belt passes over any bend or deflector pulleys. Keeping a high speed conveyor clean on the return run is of particular importance as any dirt build-up on return rollers or pulleys will cause off-tracking of the belt and possible serious edge damage.

If it is not possible to provide adequate cleaning with mechanical belt scrapers or cleaners then the return belt should be inverted over the full length of the return run. Alternatively the dirty side of the belt can be high pressure washed and dried.

THE SELBY REQUIREMENT

The Selby Coalfield is located between the town of Selby to the South and the City of York to the North, and it lies to the East of the A1.

Fig. 1 shows the general layout of the coalfield, the area of take being approximately 100 square miles. The Barnsley seam dips from the South West to the North East, and the five mines of the coalfield are indicated by the numbers in the circles.

No coal will be brought to the surface at these mines, these being solely for men and materials. The coal will be brought to the surface at Gascoigne Wood Mine, which lies to the South West of the coalfield. From Gascoigne Wood, two drifts, 70 metres apart, are being driven which will run diagonally across the coalfield for a distance of nearly 15 kilometres, and these are indicated in Fig. 1 by two thick lines.

Fig. 2 shows the way the two drifts dip at 1 in 4, and then radius out until they are 60 to 70 metres below the coal seam. The drifts, or spine roadways, then follow the line of the coal seam, dipping to the North East, until at their furthest extent they are nearly 1 kilometre below the surface. The two spine roadways are interconnected to one another by cross-slits approximately every kilometre and are also interconnected at the bunker feed points. These bunkers are located at the ends of the main trunk roadway, as shown in Fig. 1, and there are eleven staple bunkers in all. Number 1 is located approximately 5 kilometres in-bye, thence in pairs at roughly 2.5 kilometre intervals. The final four are grouped together. Bunkers 10 and 11 receiving coal from roadways that parallel the spine roadways and interconnect with trunk roadways at the extreme North East of the coalfield.

Fig. 3 shows the typical staple bunker layout, located midway between the spine roadways. The coal is discharged from the bunkers via 2-way chutes, variable speed feeders and short cross conveyors, and is transferred to either the conveyors in the North or South drifts via chutes that interconnect through slits into the spine roadways. When the Selby Coalfield is in full production output is expected to be 10 million tonnes per annum, with 5 million tonnes being brought to the surface at Gascoigne Wood from each spine roadway. A conveyor system was therefore required in each spine roadway that would receive coal from any of the 11 staple

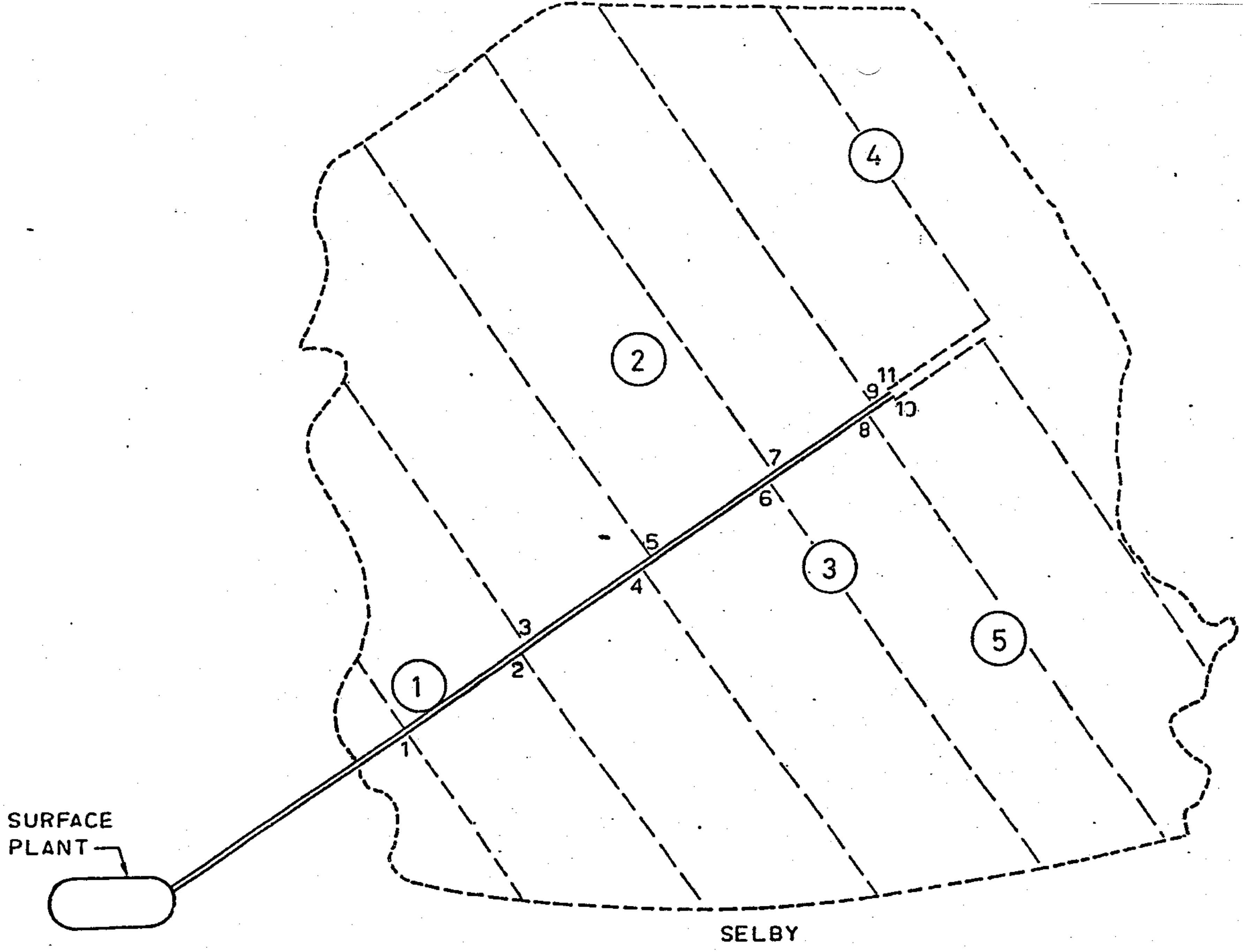


Fig. 1 LAYOUT OF MINING AREA

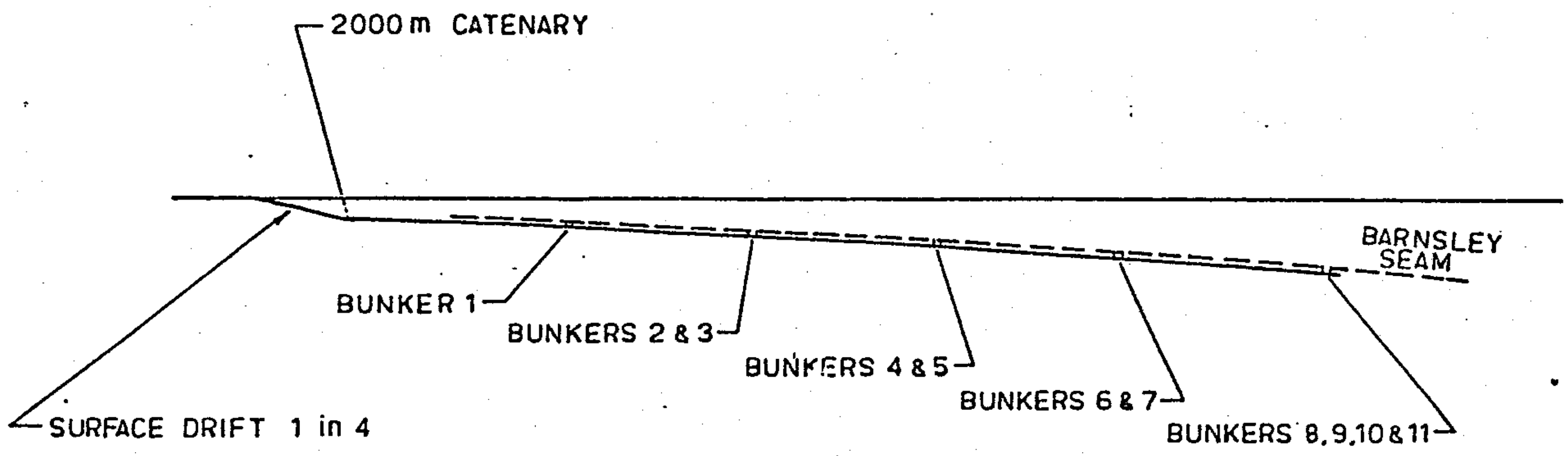


Fig. 2 PROFILE OF DRIFT AND SPINE ROADWAY

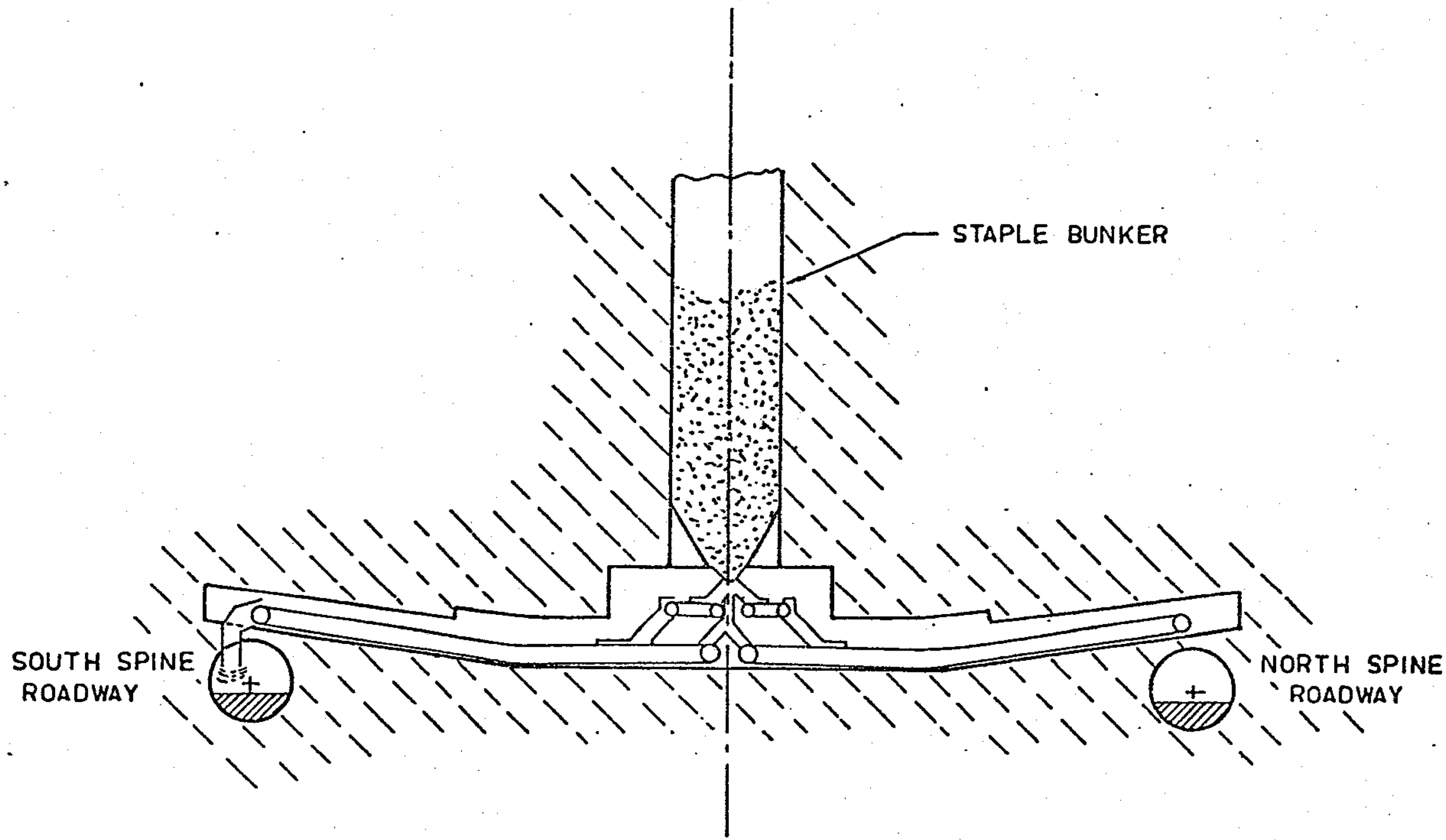


Fig. 3 LAYOUT OF TYPICAL DOUBLE OUTFEED AT UNDERGROUND STABLE BUNKER

bunkers and bring it to the surface at Gascoigne Wood. Gascoigne Wood will incorporate a ROM system of twin conveyors that will take the coal via a number of intersections, either into a 50,000 tonne covered-in storage area or via cushion bunker arrangements to a Rapid Train Loading System. This paper is not concerned with the ROM Plant, but merely the drift and spine roadway conveyor system. However, it is of some relevance to make reference to the surface handling system.

The drift conveyor system therefore had to deliver the coal onto the ROM conveyors, and it was specified that the discharge should be 132 metres from the portal mouth and at a height of 10.75 metres above ground level. This latter dimension was to accommodate a hopper/chute that would have a suitable cushion capacity, and would incorporate a 2-way chute system to feed onto the twin ROM conveyors.

Each drift and spine roadway therefore had to have a conveyor system to handle:-

a). Five million tonnes per annum.

b). Operate for 5000 hours per annum.

c). Receive coal from all or any combination of the 11 staple bunkers.

d). Handle 1800 TPH from the in-bye end, with increasing capacities from out-bye bunker combinations.

e). Receive coal at a rate of 150 to 750 TPH from any of the 11 bunker feed points.

f). Must not appreciably add to the ambient temperature of the spine roadway, which is expected to be at least 25 to 30°C.

g). In the event of the conveyor system being out of action in either spine roadway, the other system must be capable of handling the average output of the whole coalfield.

h). The conveyor systems will also be expected to handle spoil from the various trunk and roadway driveages of each of the 5 mines.

j). The whole of the coal clearance system will be computer controlled and programmed to:-

i) take into account the state of each bunker;

ii) take into account the quality, i.e. ash content;

iii) take into account the carrying capacity of each part of the conveyor system, and

iv) adjust the feed rates from each bunker as dictated by the considerations i), ii) and iii) to maintain optimum flow through the system.

k). The conveyor system to be offset to one side of the drift and spine roadways to accommodate a transport system. This transport system to be rope hauled in the drift and thence by diesel locomotive in the spine roadway. To maintain statutory clearances between conveyor and transporter systems the overall width of the conveyors is limited to 1625 mm.

A full and detailed specification was issued by the NCB in 1977, that incorporates all these requirements without limiting the type of conveyor system which could be offered.

THE SELBY SOLUTION

In considering the National Coal Board's requirements for the drift and spine roadway conveyors at Selby, Anderson Strathclyde, in conjuction with their Associate Company, Realisation Equipements Industriels of Paris, took due and detailed account of the factors outlined at the start of this paper, that is:-

Reliability
Safety
Optimum Life Ratings
Maintenance
Protection
Economics

and came clearly to the proposal for a single flight conveyor, with the drive and tensioning equipment located at the surface.

The advantages of this proposal are as follows:-

a). There are no transfer points with all the inherent complications and complexity of monitoring that are an integral part of a tandem or multiple conveyor system.

b). No major underground excavations required for intermediate drives, tensioning and transfer requirements.

c) No power cables required to be installed over considerable distances, and the accommodation of large and expensive FLP Switchgear.

d). Heat generation from intermediate drives eliminated in a roadway where the ambient temperature will be high and any major increase will lead to serious ventilation [illegible].

e). With all the drive and tensioning gear located at the surface, the major items of equipment can be installed in a properly designed drive house. This drive house can incorporate cranes and maintenance equipment that permit these units to be serviced easily and in the best possible environment.

f). All switchgear can be non-FLP and can be located in properly designed and ventilated switchgear rooms, again with maximum ease of maintenance.

g). Manpower requirements are kept to a minimum.

h). A single flight conveyor lends itself to the ease of being incorporated into an overall computer controlled system.

j). Other than the conveyor structure and supporting idlers, the only major items that require underground maintenance considerations are the 11 transfer points and the tail end unit.

k). Reliability Factor is maximised with one belt, one drive pulley and two drive motors, allied to a single tensioning system. A single motor and gearbox was initially proposed, but the NCB decided to standardise within the Winder Programme and two 'E' type DC Winder motors satisfied this requirement and were therefore specified.

l). By using this type of drive, several major advantages are obtained:-

i). A slow, soft start of several minutes can be achieved, limiting the starting torque to a very low level, and thus permitting lower than normal belt safety factors to be applied.

ii). The conveyor can be run continuously at any speed up to a maximum. The advantages here are ease of belt inspection and belt maintenance, but more importantly the ability to provide a constant torque drive.

This latter feature means that, by linking the drive into the [illegible] [illegible] [illegible], the belt need only be run at that speed commensurate with the rate of loading. This reduces wear and tear on the belt, the idlers, pulleys and all other moving parts, thus usefully extending their operational lives.

iii). Power consumption costs are kept to a minimum commensurate with the loadings, and consequently will show considerable savings when compared to a fixed speed installation.

iv). Ramped shut-down will ensure smooth and controlled stopping of the conveyor, irrespective of the load.

m). By careful design of the surface installation it is possible to install the whole of the belt from the surface. This avoids the complications of taking large rolls of belt underground Joints can therefore be made in a permanently installed location with precise control of operations, with crane facilities and powered services for the various pieces of equipment involved. This means that factory type quality joints can be obtained, with all the benefits of long life and reliability that accrue.

In addition, by combining the feature of creep speed on the drive with the belt tensioning equipment, it is practicable to replace worn or damaged belt, all from the surface.

n). The conveyor will be initially commissioned at a length of 5.0 kilometres and can be employed to bring to the surface the spoil from the tunnelling machine which will drive the spine roadway through to the full 15 kilometre length.

By taking full advantage of this being a single flight conveyor and having the belt vulcanising and installation features outlined in m), the conveyor can be extended as the tunnelling machine advances, this being done at either week-ends or holiday periods.

p). Cleanliness of a conveyor belt is of the utmost importance both in extending the life of the belt and idlers, as well as eliminating spillage. Again, full advantage is taken of the single flight and the surface drive house to build in a belt washing and drying system located on the return belt side, between driv and fixed pulley .. the loop.

q). The belt tensioning equipment is located at the point where it can ensure that correct drive tension is maintained under all circumstances - starting, running and stopping.

This equipment, which comprised a gravity weight to ensure that slack belt is taken up at a rate at which it is formed during start-up a constant torque tensioning device to maintain running tension under all conditions of loading and a locking device to lock-in belt stretch on stopping. This latter feature means that belt sag is held to a minimum and thus overload on re-start is kept at a low level permitted by the extended acceleration time given by the DC motors.

Again, maintenance of all this equipment is enhanced by it being at the surface and in a suitably designed drive house.

r). Monitoring of all major items of equipment is primarily contained at the surface. This avoids the use of IS or FLP equipment and means that cabling is kept to a minimum, and servicing and maintenance is made easy. The only monitoring underground is limited to the requirements for the tail end, the 11 transfer points and suitably spaced 'Belt Wander' switches.

s). The structure comprises linestands with carrying and return idler sets mounted on each stand. The idlers are to a high rating capacity and manufactured to a high standard in relation to the fast maximum speed of this conveyor. This minimises the number of sets needed, allowing up to 6 metres pitching in the main run, closing up to 1½ metres pitching at the tail end, where it is necessary to minimise belt sag.

Both top and bottom sets are individually aligned and shimmed, and by the use of optical alignment settings the profile of the conveyor can be maintained at a very high level. This has considerable benefits in reducing both idler and belt wear and permits very low operating resistance.

t). Each feed point will be fitted with an Accelerator Conveyor. This will be of short centred length, be located in-line and above the Main Conveyor, and receive material from the Bunker Cross Conveyor via a 90° chute. Its advantages are:-

i). Pre-accelerates the material to ¾ of main belt speed. The Accelerator has a variable speed drive that is loop controlled to vary with the speed of the Main Conveyor.

ii). The material is centralised before being transferred onto the Main Conveyor.

iii). Impact on Main Conveyor is reduced to a minimum.

iv). Chute blockage, or damage due to tramp iron, only affects one feed point, and only damages a relatively low cost belt.

v). Taking account of these factors the Accelerator Conveyor eliminates spillage and reduces wear and tear on the costly main belt to an absolute minimum.

vi). By specifying a total of twelve conveyors and using unit construction, any one of the 11 accelerators can be quickly replaced and removed for overhaul, repair, or replacement of its belt.

There are many other features of this single flight system that are of importance, but the above are the principal ones.

The initial capital outlay of this conveyor is high, but the low overall operating costs, ease of maintenance, long life of all components (up to 15 to 20 years forthe belt) make this proposal a very economic proposition for a mine complex that has a 30 year life expectancy.

During this operation life it is reasonable to expect that mining machinery and mining techniques will improve, in the same way as they have done over the last 15 to 20 years. The same applies to the belt. Thus, there is the prospect that when the belt comes to the stage of being replaced, it may well be replaced with one that will be lighter and can operate with lower Safety Factors than would be allowable today. This means that more of the installed power could be usefully employed, permitting increased tonnages, which, combined with improved machinery and mining techniques would increase annual output in the South Drift to well in excess of those envisaged today.

SOUTH DRIFT CONVEYOR - SELBY PROJECT

Technical Specification

Length of Conveyor	14,930 metres
Vertical Lift	990 metres
Belt Speed - Coaling	Variable 2.5 to 8.4 metres/second
Belt Speed - Inspection	0 to 2.5 metres/second
Belt Width	1300 mm
Carrying Capacity	1800 tonnes/hour from tail end, up to 3200 tonnes/hour Out-bye of Bunker No. 1.
Feed Points	Eleven, each capable of delivering 150 to 750 tonnes/hour.
Installed Drive Motors	Two 'E' type DC Winder Motors each rated at 5050 kW
Required Power at Full Load	9500 kW
Motor Speed	0 to 60 rev/min
Type of Belt	Steel Cord ST 7100
Belt Construction	28.3 mm thick, 13.3 mm diameter cords
Operating Tensions	T1 = 184 tonnes T2 = 68 tonnes T3 = 3 tonnes
Idler Sets	168.3 mm dia., 3 roll Trough, 2 roll Return.
Pitch of Idlers	1.5 metres at Tail end increasing to 6 metres.
Tensioning Arrangement	Gravity (150 tonne) plus Constant Torque Capstan.
Main Drum and Shaft	2670 mm dia. Drum; 1600 mm Shaft, Single Piece Forging - 90 tonnes weight
Main Bend and Snub Pulleys	1500 mm dia.
Drift and Tail End Pulleys	1000 mm dia.
Accelerator Conveyors	Eleven installed, 1050 mm Belt Width Steel Cord Belt Variable Speed Drive Belt Speed 1.875 to 6.3 metres/second Capacity 150 to 750 TPH at any speed.