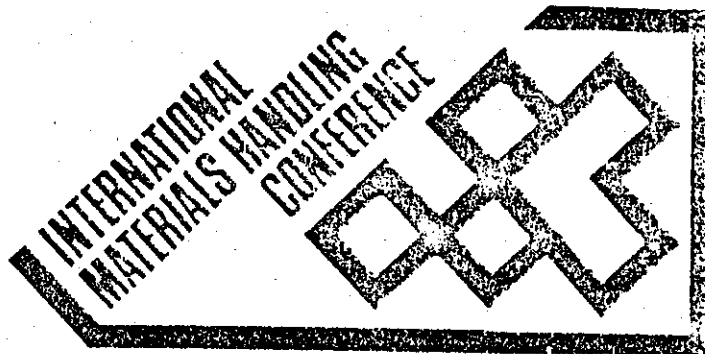


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THE CABLE BELT CONVEYOR AT  
SELBY MINE

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UNITED KINGDOM

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**BELTCON 2**



BELT CONVEYORS - DESIGN, OPERATION AND OPTIMIZATION

THE CABLE BELT CONVEYOR AT SELBY MINE

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## SUMMARY

The 10 million tonnes per year Selby Mine Complex of 5 mines has coal transportation centralised on two parallel 15 km surface drifts. One of these is equipped with a single flight Cable Belt conveyor with the highest power installed to date. The principal design problems and solutions are outlined, in particular highlighting differences between this installation and previous conveyors purchased by the United Kingdom National Coal Board.

The design concepts and details of the 8500 kW drive unit and its torque responsive braking system are described.

## THE CABLE BELT CONVEYOR AT SELBY MINE

During the 1960's the United Kingdom National Coal Board carried out an extensive exploration programme and in 1973 proved that there were new reserves of over 600 million tons of extractable coal located in the Barnsley seams of the North Yorkshire coalfield in areas outside the traditional coal fields. The existence of this eastward extension of the traditional Barnsley seam of the Yorkshire coalfield beyond the North/South fault had long been suspected but it was not until the completion of this exploration programme that the size and structure of the coal reserves was fully appreciated.

This coalfield consists of several seams, the Main seam averaging 1.2 metres to 3.3 metres thick. At the western extremity the seams are located at a depth of 300m gradually pitching to the east at an inclination of 1:17 to a maximum depth of 990m. To the south the field is bounded by a major fault. To the east the coal field appears to extend and form part of the N.E coalfield which extends under a large part of the southern North Sea, but at depths not workable by conventional coal mining techniques.

Due to the necessity of developing this new coal field without incorporating radically new technology it was decided that the Selby Mine Complex as it became known would be restricted to an area of 259 sq. kms with extractable reserves of 600 million tons.

The development of the Selby Mine Complex is a key element in the National Coal Board's "Plan for Coal" investment programme to replace near-exhausted and uneconomic mines with larger, high productivity new mines.

This complex was to be developed as 5 separate mines which would have a common underground transportation system to produce up to 10 million tons of coal per year delivered to a new rail loading facility at Gascoigne Wood located near Selby in Yorkshire. From this point the coal would be transported over the existing rail network to its customers, principally the Central Electricity Generating Board. As the coalfield is located under a low lying river landscape, a mining plan had to be devised to ensure that surface subsidence was minimised over the whole area and in particular in the area of the town of Selby where there is an historically important 12th century abbey. The plan eventually adopted led to the building of 5 mines at Wistow, Stilling Fleet, Ricall, North Selby and Whitemoor which were equipped with vertical shafts for transporting men and materials only, whilst the coal transport from all of the mines would be by means of two parallel inclined drifts which would be located under the coal seams.

As illustrated in fig. 1 the mines were located at the most convenient point for their area of the coalfield and the coal from each was to be transported "in seam" to the parallel inclined drifts located 60m under the coal reserves. In all there were to be 11 loading points to each inclined drift with 1500t bunkers at each point to allow a degree of storage between the mining operations and the trunk transportation system.

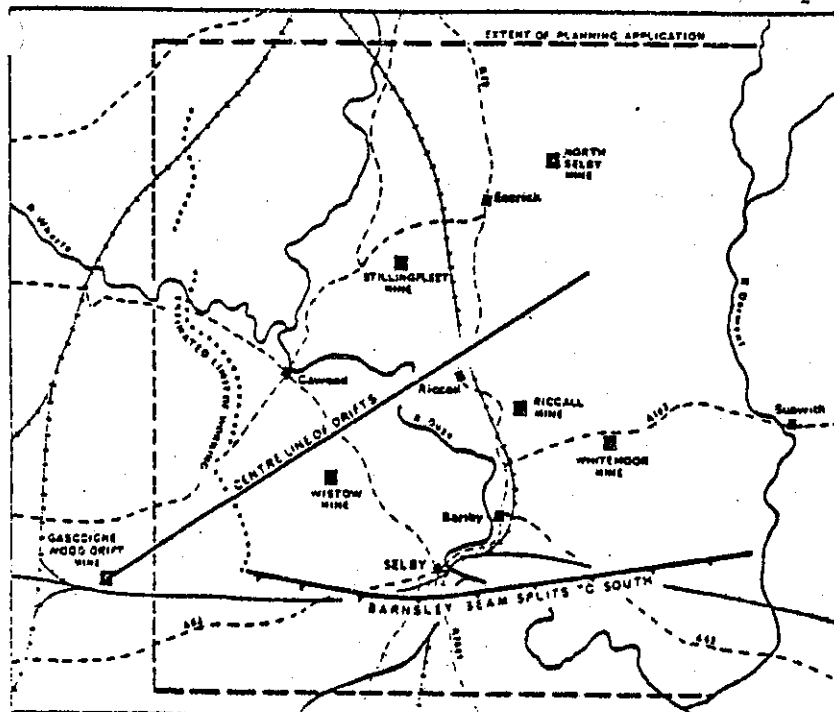


fig. 1

This concept is very similar to that first used by the National Coal Board at their Longannet Mine Complex in 1968 where three separate mines employed a single central coal transportation system to deliver coal into the Longannet Generating Station.

In that installation a 4.8m x 3.6m gallery was driven under the coal reserves and a single flight Cable Belt conveyor was installed drawing coal from 4 loading points. This system has recently completed 12 years of successful operation and is a forerunner of the Selby Mine Complex, with many of its features being directly translated into the Selby Mine. These included variable speed operation of the trunk conveyor, computerised control of the bunker loading facilities, as well as computerised blending of the coal from the different mines to ensure optimum ash content. As can be seen from fig. 2 there is a remarkable similarity in the concepts used at Longannet and Selby.

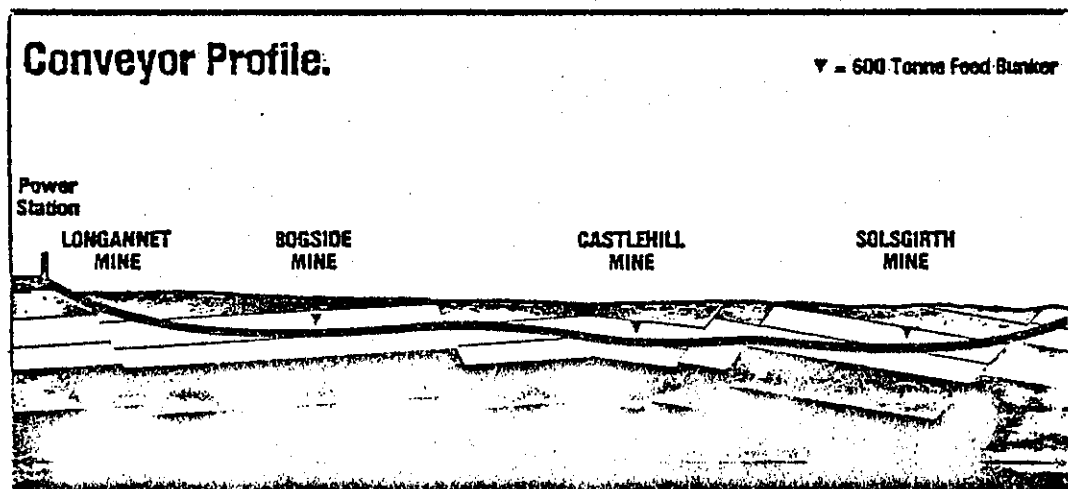


fig. 2

In 1978 the National Coal Board invited tenders for the supply of conveyor systems to be installed in the North and South Drifts. Both applications were to be identical as the intention was that each conveyor would normally handle half of the output but either system had to be able to handle the whole of the 10 million tonnes annual output.

Realising that any conveyor system would be at the limits of the then current conveyor technology, the National Coal Board looked at various solutions, but the primary criteria laid down were :-

- a) A single flight system, if possible, would be preferred.
- b) The use of new or unproven technology to be avoided as far as possible.
- c) The conveyor had to be able to handle the worst loading condition, which was to transport 1830 tph from the farther-most loading point located at 14920m from the discharge point.
- d) The belt width had to be suitable for a variety of other loading conditions due to the possible loading rate combinations from the other bunkers up to a maximum of 2800 tph.

After evaluating several alternatives the National Coal Board elected to place separate orders for the North and South Drift and in September 1978 an order was placed with Cable Belt Ltd., for the design, manufacture, supply and installation of a complete single flight Cable Belt conveyor in the North Drift.

This contract was valued at 1978 prices, at approximately £10.8 million. In the intervening period, whilst there have been no significant technical changes or additions, there has been significant inflation which will bring the eventual contract price, when the installation is complete, to £16 million.

Whilst this Cable Belt conveyor obviously had differences from the Cable Belt conveyors supplied previously, these were mainly of size and the detail engineering that flowed from that. All the design factors, parameters and practices, were in large part the same as those that were used in the previous installations.

This considerably reduced the risks and clearly identified the few areas where new technology, factors and design standards were required.

It was decided that in the case of the system design, no new factors or practices would be used at all. The conveyor friction factors, acceleration factors used in catenary design, and power calculation factors were all those used in the Cable Belt conveyors (87 in all) purchased and operated by the National Coal Board.

Due to the high tensions involved the only concession made in the system design was that a maximum speed of 7.62m/sec., would be adopted which was about 50% higher than Cable Belt conveyors actually in operation, and about 25% more than two Cable Belt conveyors that were then under construction and have now been commissioned.

As a result the system characteristics were eventually decided, and are as shown in table 1.

## System Characteristics

Length	14923
Lift	990
Capacity	1830 tph (from tailend)
Belt Speed	7.62 m/s
Belt Width	1050 mm
Drive Cable diameter	57 mm
Drive Cable Breaking Load	240 tonne
Factor of Safety	3.1
Line Pulley Pitch Top	4 m
Line Pulley Pitch Return	8 m
Drive Wheel Diameter	6.7 m
Loaded HP at full speed (at 1830 tph from tailend)	8173 Kw
Installed Power	8750 Kw
Empty HP at full speed	2080 Kw
Type of Surface Arrangement	Head Discharge

table 1

Figure 3 shows the arrangement of the various loading points and it is interesting to see from table 1 that the maximum required power is at a loading rate of 1830 tph from Bunker 11.

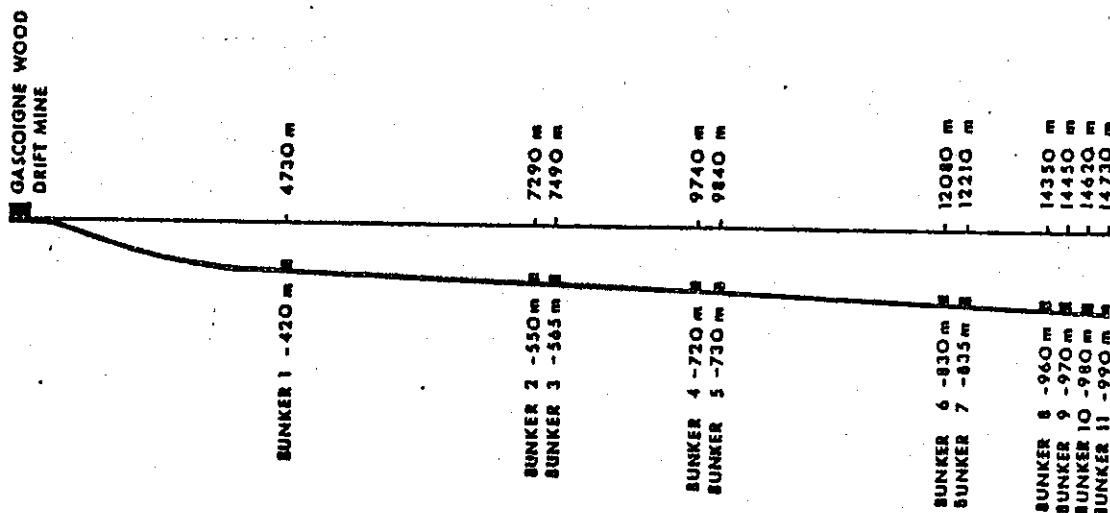


fig. 3

The other table 2 also shows clearly the capacity that this power can carry from each of the other loading points ranging from 1830 tph when loaded to the full length of the conveyor, up to 4420 tph when loaded only from the first loading point, Bunker 1, with the rest of the conveyor empty. Obviously there are many other possible combinations of capacities with varying feeds from the 11 bunkers but the maximum power and rating is the 1830 tph for the whole length of the conveyor.

The conveyor is at its most efficient when fully loaded at its maximum capacity of 1830 tph from bunker 11 where the power consumption per tonne lifted to the surface is 4.47 Kw equivalent to 0.30 Kw per tonne/km. At all other loading conditions it is less efficient (due to the power consumption in running the conveyor empty at full speed) and the power consumption per tonne will be higher.

Power consumption, and efficiency is at its lowest, when running empty when it absorbs 2080 Kw.

Bunker No	Capacity when loaded only from bunker using maximum horsepower available
1	4420
3	3212
5	2483
7	2136
11	1830

Table 2

Of the main equipment for the conveyor there were many items which were standard Cable Belt items that only required minor modification to suit this duty.

These in the main were :-

Belt  
Linestands

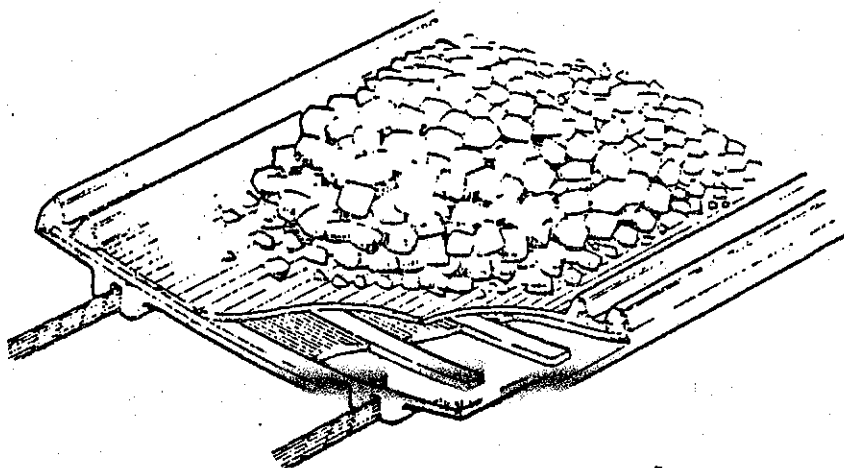


fig. 4

Fig. 4 shows the neoprene based belt construction which is the normal Cable Belt construction used by the National Coal Board. It was not felt that any special features, such as extra cover thickness needed to be included as the NCB experience with this belt over a long period was that a life of 15 years should be easily achieved. Their experience indicated that based on the average life obtained on all of their installations, a life could be achieved considerably in excess of this.

It is worth noting that this belt as well as meeting the normal NCB specification 158 (1980) fire resistant specification covering items such as anti static properties and flame tests, also had to meet the new European belt standard for the propane burner gallery test. In this test the NCB adopted the more severe version of this test.

The type of linestand adopted is shown in fig. 5 and is the normal linestand with 4 pulleys on the top line at every linestand and 4 pulleys on the return line every second linestand.

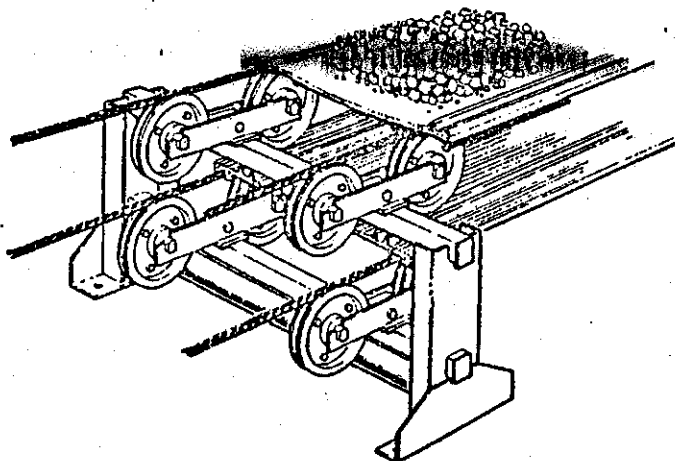


fig. 5

Typical 8 Pulley Linestand

This linestand and rocker arrangement caters for the various misalignments that will undoubtedly occur in an underground operation. Misalignments in all three planes are catered for in the main by automatic adjustment and only for large misalignments will require manual adjustment.

The drive cable is a normal Langs lay 6 x 19 round strand I.W.R.C. rope with the following design :-

Nominal diameter	57 mm
Breaking Load	240 tonne
Outer Wire diameter	3.7 mm
Steel Grade	180
Strand Construction	6x19 (12/6 x 6F/1) IWRC
Core Construction	Steel

This, at the time was a slightly larger diameter than any other operating Cable Belt and therefore it was extensively tested to ensure that the same operating performance would be obtained as in the 51mm ropes already successfully in use.

This testing covered a full range of bending fatigue, tensile and friction coefficient tests as well as full scale testing of the splices. During this testing it was confirmed that the normal type of splice, but of a length of 60 metres, was suitable. It is interesting that in two conveyors recently commissioned, with this size of cable, the field splicing only took 10 hours per splice.

Because of the relatively high speed and the larger rope diameter it was decided to make a POLYRIM pulley with a slightly larger tread groove diameter, 300mm against 270 mm, than the standard pulley, with a deeper polyurethane tread substantially increasing the service life.

Other than this change the basic design as outlined in fig. 6 is similar to the standard POLYRIM pulleys used on all other Cable Belt installations.

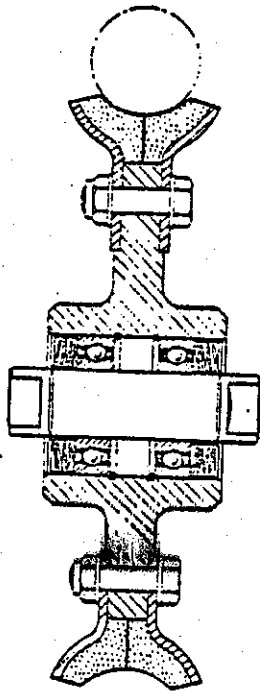


fig. 6

The single item in the conveyor system which required a completely new design was the Drive Unit. The National Coal Board decided that, despite the substantial extra cost they preferred 60 rpm DC electric motors made generally to their standard Mine Winder design. This necessitated the complete redesign of a single reduction Drive Unit which still had to contain a differential.

Due to size of the equipment and the torques and loads that had to be transmitted it was designed as a single reduction set with the differential gear mounted on the input shaft driving both of the final gear wheels. The complete gear train is supported on a substantial ring beam. The main drive casing is not used as a support for the gears but is in effect an oil bath for the gears and bearings.

The high torques and loads experienced on the drive unit advanced the design concepts to new fields regarding fatigue considerations.

The input shaft, housing the differential assembly weighs some 95 tonnes and is preassembled prior to installation into the drive unit. The shaft itself is 7m long and up to 1.2m diameter.

The first motion pinions, are 2.3m diameter with a face width of 0.72m and the differential wheels which together with the differential pinions and carrier complete the first motion shaft assembly, are 2.77m diameter having a face width of 0.46m.

The 5m long final shafts fully assembled weigh 97 tonnes each and comprise a gear wheel and koepe wheel on each shaft. The shaft weighs 29 tonnes and has a maximum diameter of 1.13m, designed to give a maximum deflection under full load of 0.15mm. The final gear has a face width of 0.72m and is 6.23m diameter whilst the koepe wheel incorporating a braking path on its outer most periphery is approximately the same diameter as the final gear.

In order to keep the tread pressure on the drive wheel within acceptable proven limits a diameter of 6.7m was required for the two koepe wheels. The tread lining is the Cable Belt standard polyurethane composite material giving friction coefficients in excess of 0.80 even under wet and oily conditions.

All the shafts of the drive units are supported in split roller pedestal bearings located directly on to the heavy fabricated steel ring beam and outboard base frames all mounted on a concrete plinth.

The lubrication of the gears is by a positive displacement spray system over the full face width of the gears and for safety each spray nozzle is individually monitored for flow and pressure. Because of their low rotational speed the pedestal bearing are greased.

Drive is transmitted from the motors to the drive unit via double engagement gear couplings.

It can be seen from fig. 7 that whilst the equipment is larger it follows the general pattern of the other Cable Belt drive units.

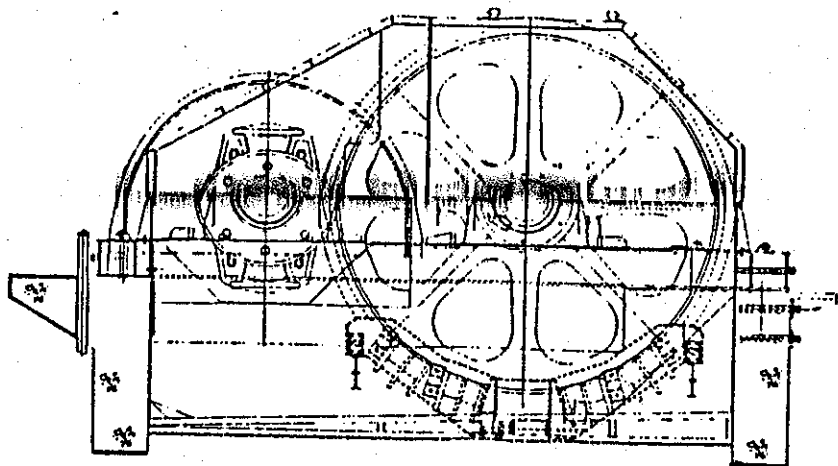


fig. 7

As there are very high runback torques particular attention was paid to the braking arrangements, and in common with most of the other large inclined drift Cable Belt conveyors that have been built, disc brakes incorporated into the final drive wheels are used as standard. These brakes are of the torque responsive type, not being released until the drive motors have built up sufficient torque to overcome the conveyor runback load. Sprag clutches or similar non return devices are not now used on CABLE BELT conveyors.

These disc brakes are arranged to act directly onto each Koepe Wheel rim. The calipers are mounted on a brake frame assembly mounted below each wheel. Braking loads are detected by load cells and the brakes are not released until sufficient driving torque is available. The brakes are partially applied at a small percentage speed whilst the conveyor is stopping naturally, and fully applied when completely stopped.

The brakes are fail safe, in that they are spring applied and hydraulically released.

The general arrangement of the discharge point shown in fig. 8 which is of the Head Discharge type to allow separation of the electrical drive system from the coal discharge point.

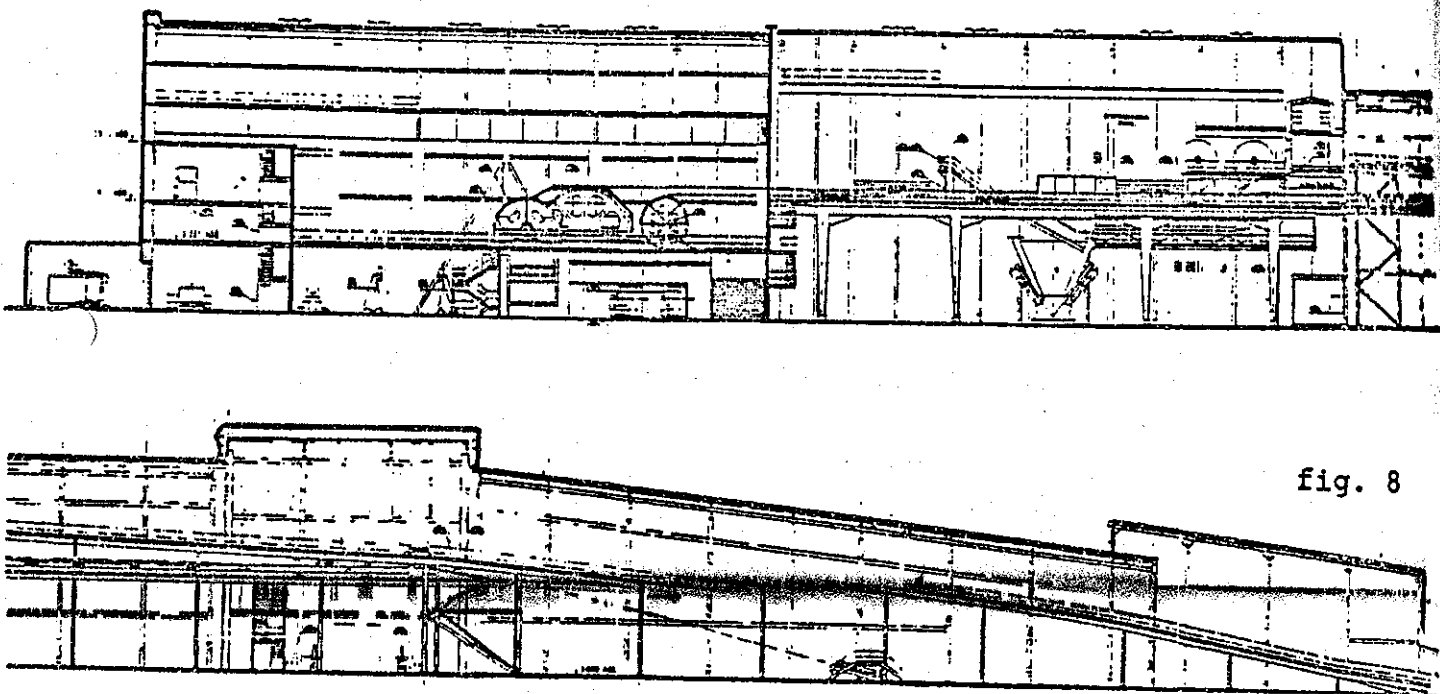


fig. 8

Apart from the size of the individual components most of which are now in use on a 52 kms conveyor system. There were no significant problems on the design or manufacture of this equipment.

Particular attention was paid to the belt cleaning which is of the combined scraper and rotary brush type. Belt washing is not felt to be necessary. In order to make maintenance of the discharge point easier the discharge equipment was mounted on a platform of reinforced concrete, with a lower platform in the area of the belt cleaning equipment for access. Fine material removed from the belt is fed by a scraper chain conveyor into the main hopper.

The tension is applied both to the drive cables and the belt at the tail end of the conveyor and is of a gravity type operated by means of a weighted drive cable carriage. It is simple and is contained within the normal dimensions of the shaft.

The design of the other ancillary mechanical equipment was straightforward, with the main exception being the use of variable speed accelerating conveyors at the loading points. Subsequent testing of these accelerating conveyors, which were added to the original proposal instead of chutes, has shown that they have no advantage over correctly designed chutes and may even be less satisfactory.

The drive motors and control gear are generally to the standard D frame series NCB 60 rpm mine winder DC motor complete with thyristor control giving a completely variable conveyor speed from 0 - 7.62m/sec.

The safety monitoring system along the length of the conveyor utilises standard pulleys and the standard Cable Belt detection devices at intervals of 90 metres.

Fig. 8 also shows the extent of the buildings necessary for such a unit and it can be clearly seen that less than 50% of the area is required for the Cable Belt drive and discharge arrangements. The rest is merely required for aesthetic reasons or to contain the men and materials haulage.

Due to delays in the driving of the drifts the project which had been scheduled to have Phase 1 (5 km) operational by March 1982 has now been delayed to January 1984 with the final extension to the full length of 14.9 km being delayed from December 1984 to December 1986.

One possible advantage is that all of the Selby equipment, which is now available on site ready for installation, has already been in use at other installations, particularly at the 52 km Cable Belt conveyor in Australia which although ordered after the Selby project has in fact now been fully commissioned.

We now have clear evidence that all of the equipment at Selby, with the exception of the Drive Unit which is unique, operates as designed.

The Author would like to thank the North Yorkshire Area National Coal Board and members of the Major Projects Group of the National Coal Board for their help in preparing this paper.