Pipe Conveyor Installations

in the United Kingdom's

North East Coalfield

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CONTENTS

1. INTRODUCTION

This paper describes the selection process, installation, and experience with pipe conveyors in British Coal's North East Group within the United Kingdom. The installations in question being at Wearmouth and Westoe Collieries.

Wearmouth Colliery is situated within the City of Sunderland on the north bank of the river Wear and Westoe Colliery is situated within the town of South Shields on the south bank of the river Tyne.

Comment will be made on the unique problems of the environmental and safety requirements of the projects, in particular the 1.65 km conveyor from Westoe Colliery to Harton Staithes on the river Tyne. The route of this conveyor having particular problems as it passed through a residential area negotiating several horizontal and vertical curves.

This paper describes the original coal and shale handling system at Westoe Colliery and engineering detail of the pipe conveyors and operating experience to date.

The conveyors were the first to be installed in the United Kingdom, the Westoe installation being the second longest in the world at that time.

2. COAL AND SHALE HANDLING AT WESTOE COLLIERY (1900-1989)

Shale had been transported from Westoe to Harton Staithes on the Tyne since the beginning of the century via an overhead electric railway system (Figure 1).

The rail route from Westoe to the river Tyne was through the town of South Shields negotiating two 100 m radius curves and one 300 m radius curve. There was a maximum gradient in favour of the load of 1 in 25 with an average of 1 in 94.5 with twelve changes of gradient. There were also four changes of gradient against the load, with a maximum of 1 in 35. The route had a 150 m tunnel near the river and dock side. The distance from the colliery sidings to Harton Staithes is 1,658 metres. Coal in the order of 6,000 tonne/day and shale 3,500 tonne/day was transported by rail to the discharge hoppers and loading boom on the Staithes at Harton.

Because of a change in shipping policy by Central Electricity Generating Board, coal shipments to the river Thames were transferred to the new Port of Tyne facility where only 20,000 tonne ships would be used, replacing the 11,000 tonne (maximum) ships from Harton Staithes.

A rail rapid loading arrangement was introduced for coal only in August 1988, resulting in the overhead electrical railway system dealing with the shale only (Figure 2).

The rail system was manpower intensive some 100 men were employed in the coal and shale operation. In the last year of operation some 60 men were employed in shale handling by locomotive through the various cuttings, sidings and tunnel to the staithes and ship loading terminal.

The rolling stock and track were nearing the end of their useful life and in urgent need of replacement. It is a credit to the original manufacturers of the overhead electric system that it worked for over 80 years giving very reliable service. The original electric locomotives were 240 HP and of German manufacture. The longest serving ran from 1913 to 1988. The remaining 400 HP locomotives were bought in 1950 from English Electric. The five larger capacity locomotives were required for the wagon fleet that was changed from 10 to 21 tonne, to cater for the colliery's increased output.

The fines discard system of road tankers to old mine shafts some distance from the colliery was also in urgent need of replacement.

3. SELECTION OF THE NEW CONVEYING SYSTEM

As stated earlier the existing rail system at Westoe had reached the end of its useful life. Manpower and maintenance costs were excessive. Replacement of rolling stock, rail track, wagon sheds and maintenance facilities would have totalled a minimum of £3.5m over the next five year period.

Any new shale system had to meet the following parameters:-

- Convey 3,500 tonne of shale per day
- Ensure that environmental and safety aspects are protected, with particular reference to a route through a town, with the need for a clean, spillage free system.
- Minimise the number of conveyor junction houses or transfer points (at least 7 transfer points would be required for a conventional system).
- Installation time for the equipment through the route would be limited to 2 weeks.
- Address concerns regarding vandalism and trespass.

Studies and reports had been carried out by British Coal and Davy McKee Ltd, on the many options and alternatives available to replace the complete rail system for coal and shale. One of the recommendations for shale disposal was a pipe conveyor produced by Bridgestone Engineering of Japan (formerly JPC). Technical tenders were appraised from several conveying and materials handling companies for the complete installation at Westoe colliery. The favoured option was for one pipe conveyor, as against 7 conventional conveyors (Figure 3).

Other non-conventional systems were discarded because of lack of world wide experience or impracticality of installation. Bridgestone Engineering had experience of over 300 conveyors world wide at that time, and, in particular, 2 conveyors in America, one at over 2,000 metres and one at over 1,300 metres, running 10 hours/day. The Westoe installation would be the second longest in the world, running 24 hours/day.

Before being committed to major expenditure at Westoe, a trial conveyor was introduced at Wearmouth to gain working experience.

4. *TRIAL CONVEYOR AT WEARMOUTH COLLIERY*

The pipe conveyor possibilities had been discussed in detail up to January 1988, obtaining conveyor information on world wide experience with the system. It was decided in May 1988 to install an 85 metres long conveyor at Wearmouth colliery. The North East could then gain working experience with the system and assess its potential for use at Westoe.

With a diameter of 300 mm and a belt speed of 130 m/min it had a carrying capacity of 300 tonne/hour. The trial conveyor was run for a period of 12 months and carried colliery discard with a moisture content averaging 6%. The maximum size of produce being 150 mm. The belting used was Fenner Type 4 (solid woven) specially constructed for pipe conveyors, in conjunction with Dosco Overseas Ltd. The standard belting for pipe conveyors is from Bridgestone (Japan) and is rated at Type 2, but this does not comply with British Coal specification for fire resistance belting.

	Fenner	Bridgestone
Type	4	2
Tensile Strength	500 kg/cm	600 kg/cm
Construction	Solid Woven	Rubber Ply
Top Cover	2 mm	4 mm
Bottom Cover	2 mm	3 mm

The weft and warp strength at the outer edges of the belt are constructed so as to allow greater flexibility in forming a tube. The Fenner belt appears to be less ductile than that from Bridgestone. Contact between roller and belt is more on the edge of the belt. The Wearmouth belt lasted for 12 months having conveyed in the order of 1 million tonnes of coarse discard. Carrying the same tonnage rate, the maximum life of the previous conventional conveyor belt was about 6 months.

Spillage along the length of the conveyor was negligible because of the enclosed nature of the system. Considering the extremely difficult materials, in terms of moisture and stone/discard mix, the system performed better than a standard conveyor.

Because of the success of the 85 metre installation at Wearmouth, it was decided to extend the pipe conveyor to 300 metres. The extended system was commissioned in May 1989 and has continued to work satisfactorily. It is an excellent installation carried out by the colliery with technical assistance from Dosco Overseas Ltd. This installation had environmental benefits, eliminating transfer points, with manpower saving, and improving the working environment alongside the river Wear. As a result of the experience and confidence gained at Wearmouth, the Westoe installation was given approval.

5. *THE WESTOE PIPE CONVEYOR INSTALLATION*

5.1 DESIGN AND CONTRACT PARAMETERS

A contract was placed with Don Valley Engineering Ltd in January 1989 for the supply and installation of a shale transport system. Dosco Overseas Engineering Ltd as licence holders of the patent, were to be sub-contractors.

The main aspects of the contract were as follows:

- Feed conveyors and stock out facility from the coal preparation plant.
- Crusher house at tail end of pipe conveyor.
- 1,658 metres of pipe conveyor.
- Transfer house and feed conveyors to existing staithes facility at Harton on the River Tyne.
- The pipe conveyor belt to have a minimum life of 4 years, idlers and rollers to meet British Coal design life standards of 26,000 and 50,000 hours. Chute wear rate to be guaranteed for 4 years.
- The system would convey crushed discard, with a maximum lump size of 100 mm, from the Coal preparation plant at a rate of 300 tonnes/hour.

The conveying system would be designed to eliminate spillage at transfer points and convey moisture and scrapings throughout.

Environmental aspects were to be catered for with particular emphasis on the close proximity of residential property, and the need to keep noise and dust to a minimum. Guards were to be to a high standard to protect against vandalism, particularly in the remote parts of the conveyor run. An added benefit was to be the protection against extreme weather conditions.

The control system for material from the plant to pipe conveyor was to be automatic and linked to the coal preparation plant control room.

World wide experience was to be used in conveyor belt selection and structure design.

5.2 SITE PREPARATION

Contracts were due for completion in the two week colliery shutdown ending 7 August 1989. The colliery depended entirely on the rail system for shale disposal to the staithes. It was essential that the bulk of the installation work be confined to this two week shutdown. The rail system had to continue until the shutdown period, and was then used for the transport of equipment throughout the installation period.

Electrification equipment was removed and diesel locomotives were used from the colliery to the tunnel entrance. The overhead electrical power lines were used through the tunnel and onto the staithes.

Junction houses and transfer/stock out conveyors at the colliery were completed in several stages to allow stone disposal by wagon to continue. The construction of junction houses and part installation of the conveyor were possible at the staithes whilst the rail system was still in use. The tail drive junction and crusher house were also nearing completion before the start date of the main pipe conveyor installation.

On Wednesday the 19 July 1989, the last shale wagon was teemed at Harton Staithes, and the pipe conveyor installation started in earnest.

5.3 CONVEYOR INSTALLATION

It was planned that a total of 10 days would be required to install the remaining elements of the system, and then 5 days for tracking and commissioning. Installation of the pipe conveyor sections started from the Harton Staithes end by transporting and installing a batch of 37 sections of conveyor structure and welding these onto the existing rail track as a base. Then 390 metres of belting was installed onto the bottom section and vulcanised to the next length. The procedure was then repeated for the top section. This 37 section sequence was then repeated until all 157 sections were complete to the Westoe colliery crusher house.

The pipe conveyor sections, each weighing 2 tonnes were loaded onto small purpose made bogies, and transported to site on the existing track. They were then lifted, the bogie removed, and the structure lowered, levelled and aligned, before welding to the track.

The 390 metre roll of conveyor belt, weighing 6½ tonnes was suspended in a purpose designed frame and fed by hand over the delivery end, and then formed into a tube configuration before being secured to the pulling rope by a specially designed bracket. The rope being threaded through the conveyor structure and secured to a diesel locomotive and flat car via a dynamometer. The belt was then slowly pulled through the completed structure, under the control of an operator on the flat car who was in touch with strategic points by radio.

Whilst the next batch of structure sections was being assembled, the belt joints were vulcanised ready for the next pull. The complete installation of the 1,658 metres of structure and belt took 9 days.

5.4 EQUIPMENT DETAIL

5.4.1 MAIN DRIVES

Two 75 kW drives were installed at the delivery end with one 75 kW at the tail end. Hansen gearboxes were used, driven by Fluidrive **A**cceleration **T**orque **L**imiting **C**ontrol couplings, (**ATLC**). Belt Speed was 133 metres/min. (Figure 4)

5.4.2 BELT TENSION

Belt tension was by gravity tower with a manual adjustment winch for weight position (applied tension 4.5 tonnes). The loop holds 4 strands of belt catering for 160 metres of travel. The driving drums were neoprene lagged.

5.4.3 CONVEYOR BELTING

The conveyor belt was by Bridgestone Engineering of Japan, 2 ply construction with 4 mm rubber top cover and 3 mm bottom cover. The weft and warp structure was reduced to make the belt fully flexible for the first 100 mm of the belt edges, belt strength was 600 kg/cm.

Vulcanising procedures were laid down by the Bridgestone Engineering to give a joint at least 90% of original belt strength. Vulcanising was carried out by Fenner Limited.

5.4.4 CONVEYOR STRUCTURE

The structure was fabricated from rolled steel angle with diaphragm plates at 1.8 m centre carrying 6 top and bottom idlers. The overall length of a section was 10.8 m. The cross section of the structure being 1.26 m high by 0.64 m wide.

Existing rail track was used wherever practicable as a base for the structure, using channel welded to the rail (Figure 5).

The idlers were fabricated from mild steel with 25 mm bearings fitted with labyrinth seals. Roller diameter was 89 mm. A tolerance of + 1 mm was allowed between idlers.

The Labyrinth seals were used to reduce frictional resistance in the system. Power consumption was obviously reduced, estimated at approximately 171 kW in comparison with standard lip seals. Note: Total installed HP was three 75 kW (225 kW); if standard lip seals had been used installed HP would have been three 132 kW (396 kW).

Special sections were provided at both ends of the system to open and close the pipe. The distance required to form the pipe being 25 times the diameter, i.e. 7.5 metres, inclined idlers were used to initiate the belt movement (Figure 6).

5.4.5 FEED CONTROL SYSTEM TO PIPE CONVEYOR

As mentioned previously the control systems for operation of the shale and pipe conveyor was linked to the coal preparation plant control room.

The feed control was based on advice from the Bridgestone engineers. A continuous feed from the coal preparation plant at around 200 tonne/hr would be sent directly to the pipe conveyor.

Existing 130 tonne bunkers were utilised via automatic changeover doors during pipe conveyor shut down at barge changeover, (approximately 30 minutes). Re-claim was by vibrator feeders under the 130 tonne bunker. An extra bypass facility or stock out for shale was also provided with a re-claim hopper for mobile plant recovery (Figure 7).

The system was controlled and regulated by 3 flow rate controllers and a Ramsey weigh monitoring unit. The operation ensured that a minimum feed to the pipe conveyor of 80 tonne/hr was maintained. In the event of low feed rates a system stop was initiated and a controlled shutdown occurs. A timed overload of more than 350 tonne/hr was permitted with a warning sound in the control room. The general philosophy being to keep the conveyor running with a consistent load for the maximum operating time. A 14 minute run down or emptying procedure was initiated on every controlled stop. This was to avoid water build up at changes of gradient and subsequent freezing or spillage problems.

Standard protection was provided for scoop insertions, belt slip, misalignment, high temperature, motor or starter failure.

5.5 COMMISSIONING AND TRACKING

Final engineering checks were carried out by British Coal, Main Contractors and Bridgestone Engineers 9 days after commencement of the conveyor installation.

Tracking of the conveyor belt had always been considered an essential and exacting process, specially following reports from the 2,000 metre American installation. Where in the early stages of that project, 2.5 turns of rotation had been experienced and several weeks of tracking were required. The pipe has a tendency to rotate at the curves, tracking was carried out by packing between idlers and frame (Figure 8).

The overlap of the joint tends to move or rotate depending on load. The top pipe was considerably more difficult to track especially towards the main drive end of the systems. It rotated some 270 degrees. The bottom non-loaded pipe consistently ran with the overlap at 6 o'clock after initial tracking, with only one mishap when the belt turned over on the tail driving drum.

It took 5 days to track the belts in the empty condition, before any attempt was made to run shale through the system. At one stage in the process, special vertical tracking idlers were fitted on the ramp to the main driver house. These were removed on final commissioning. Fine stone dust was applied to the belt overlap to assist tracking, and reduce friction between overlapped belt.

Essential parts of the control and feed system were a crusher which controlled the product size to -100 mm and a gate in the collecting hopper which ensured the correct feed rate to the pipe conveyor.

5.6 CONVEYOR PERFORMANCE

As expected the belt took several days to track with sufficient confidence to run loaded and unsupervised. Bridgestone design engineers estimated a two to three month settling in period for the belt. This in fact happened, tracking being necessary in small amounts for the first four months. All the packing was eventually removed.

Initial belt stretch was 20 metres (0.6%) before loop adjustment and the making of the final vulcanised joint. Belt tension was lowered to 4 tonne in an effort to contain the effect of pipe diameter reduction on some curves and at change of gradients. This reduced diameter made tracking difficult.

The scoop couplings and drives were balanced and timed after initial trials to start as follows - start no 2 drive; then 1 second interval no 1 drive; then 6 second interval to start the tail drive. The ATLC couplings give a smooth start with the gravity loop tension adequately moving slack belt. Power sharing of all three drives was equal, at approximately 60 kW at 300 tonnes/hr.

The system adequately carried the rated 300 tonnes/hour and, in short overload peaks, over 500 tonnes/hour had been noted. The control system ensured no prolonged overload, i.e. shale was diverted to stock until load decreased. The automatic control system detected the overloading of more than 350 tonnes/hour and underloading of less than 80 tonnes/hour.

In the underload condition the bunker system started and made up the required tonnage rate. The intention was that the conveyor would only run empty on planned shutdown, i.e. for maintenance or barge change over at the river staithes.

Belt cleaning using "HOSCH" wipers and "squeezy" type, mangle rollers, had proved to be very successful throughout the shale system.

The pipe conveyor was completely guarded. Solid galvanised sheet was used from the exit of the Colliery to the tunnel entrance before the staithes. Open mesh guards were used towards both drives at the more supervised areas. Signal and lockout keys were located at intervals inside the guards (both sides) and all control cables were under the top guard.

On Monday the 7 August 1989, the Colliery started normal production, and although work continued in commissioning and tracking, the conveyor carried all the discard to Harton Staithes. The internal railway system was now totally eliminated which resulted in a manpower saving of 60 men.

JOB DESCRIPTION	PREVIOUS MANPOWER	PRESENT MANPOWER	SAVING
Wagon Handling	18	0	18
Drivers and Guards	14	0	14
Traffic Control	5	0	5
Wagon Repairs	3	0	3
Craftsmen	15	6	9
Foremen	4	1	3
Labourers	7	3	4
Staithes	9	6	3
Crossing Keeper	1	0	1
TOTAL	**76**	**16**	**60**

The 16 men retained cover all maintenance and operations of the belt system and Staithes operations.

A saving of £1.20 per tonne was made in dirt disposal costs.

The cost of the scheme being £2.7 m.

5.7 OPERATIONAL EXPERIENCE

There was one major incident of belt over rotation and overlap on the main driving drums and a similar minor incident in the first month of work. One of the reasons was a build up of fines on the idler and drive drums. Although belt scraping was good, the natural curvature of the belt edge was more difficult to clean. Attention to detail cured the problem.

The environment of the conveyor route was much improved through the town compared with the previous locomotive traffic. The conveyor being virtually silent.

Vandalism and trespass were a potential problem with several reported incidents previous to, and during installation, since installation the system was trouble free.

6. SUMMARY

Both pipe conveyors have been very successful in that:

1. The have carried shale effectively from the Coal Preparation Plant to the disposal point at the planned rates.

2. Manpower savings have been considerable, with resulting savings in the cost of dirt disposal.

3. The system has provided a safer method of dirt disposal.

4. Improved environmental conditions have been achieved, particularly in the case of Westoe Colliery where the conveyor runs through a residential area.

The views expressed in this paper are those of the author and not necessarily those of British Coal Corporation.

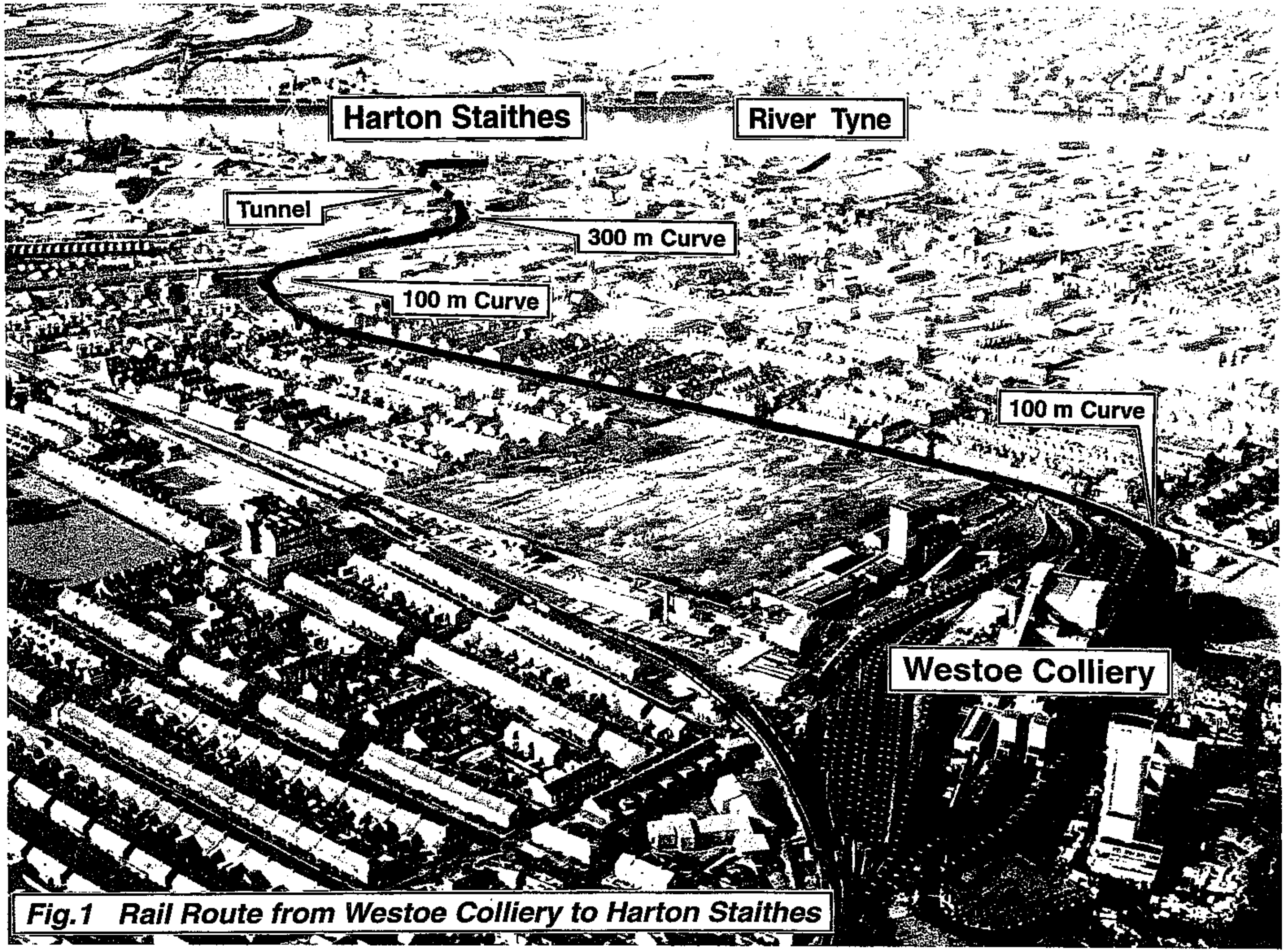

Fig.1 Rail Route from Westoe Colliery to Harton Staithes

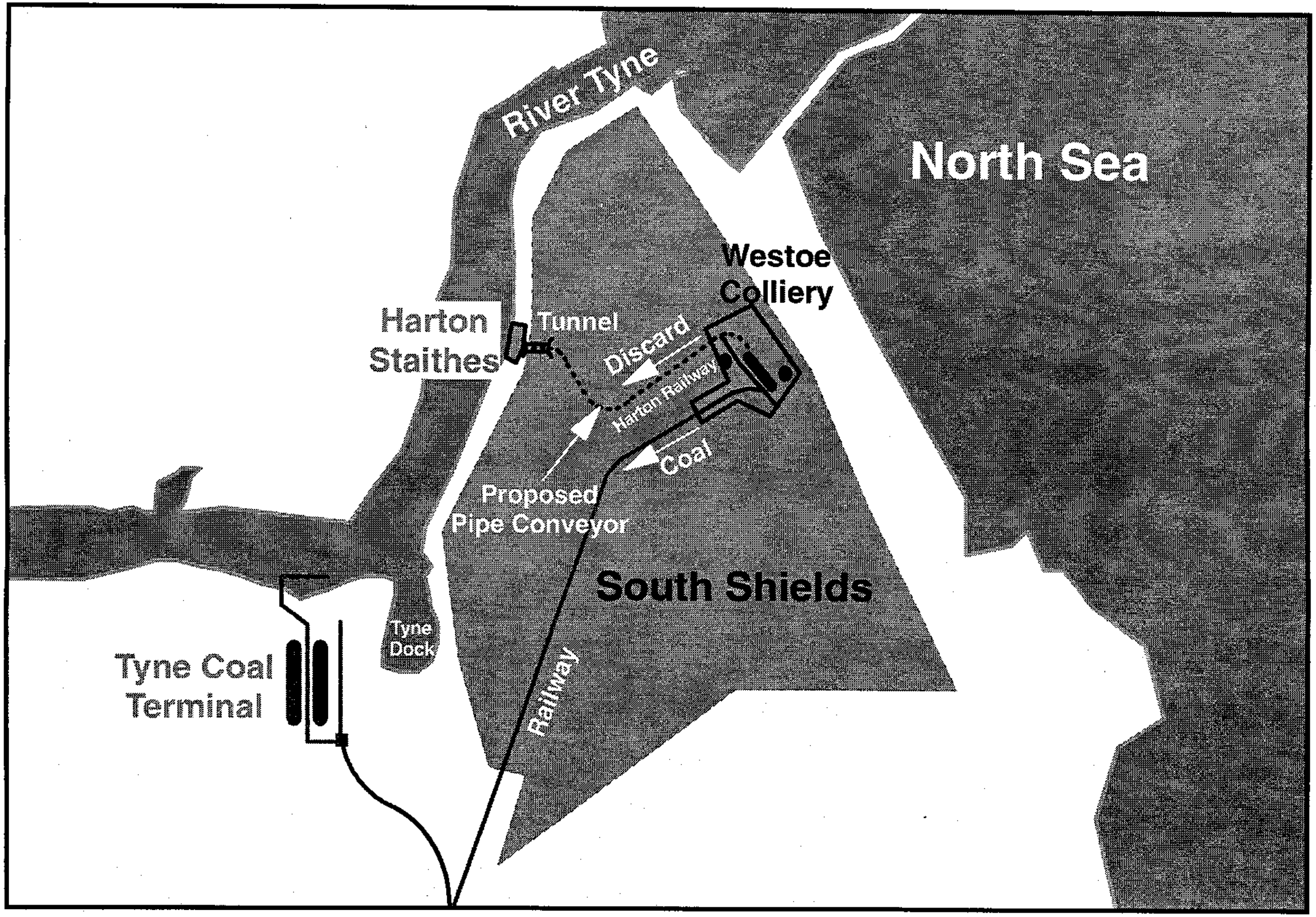

Fig. 2 Coal and Shale Transport Routes from Westoe

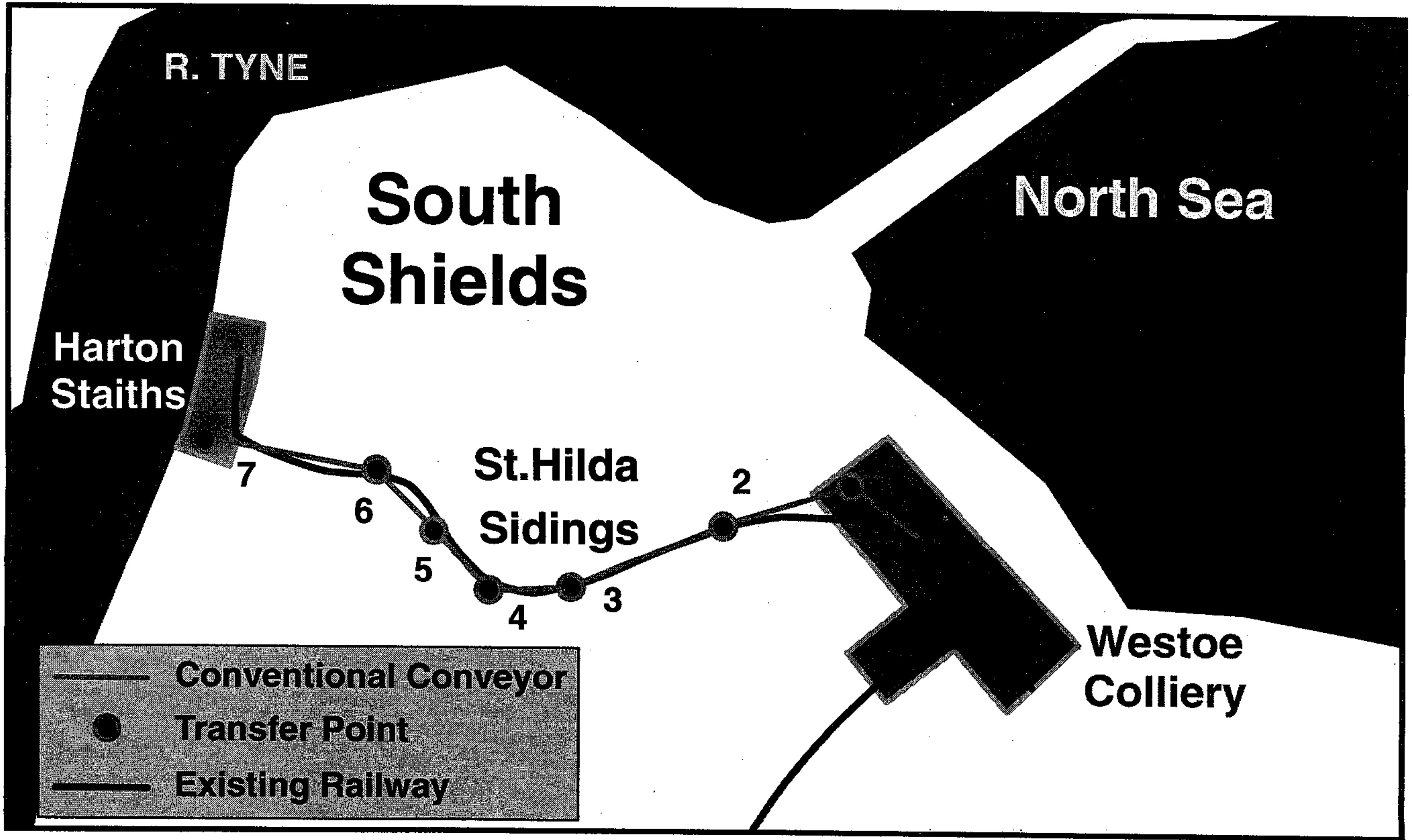

Fig. 3 Conventional Conveyor Solution

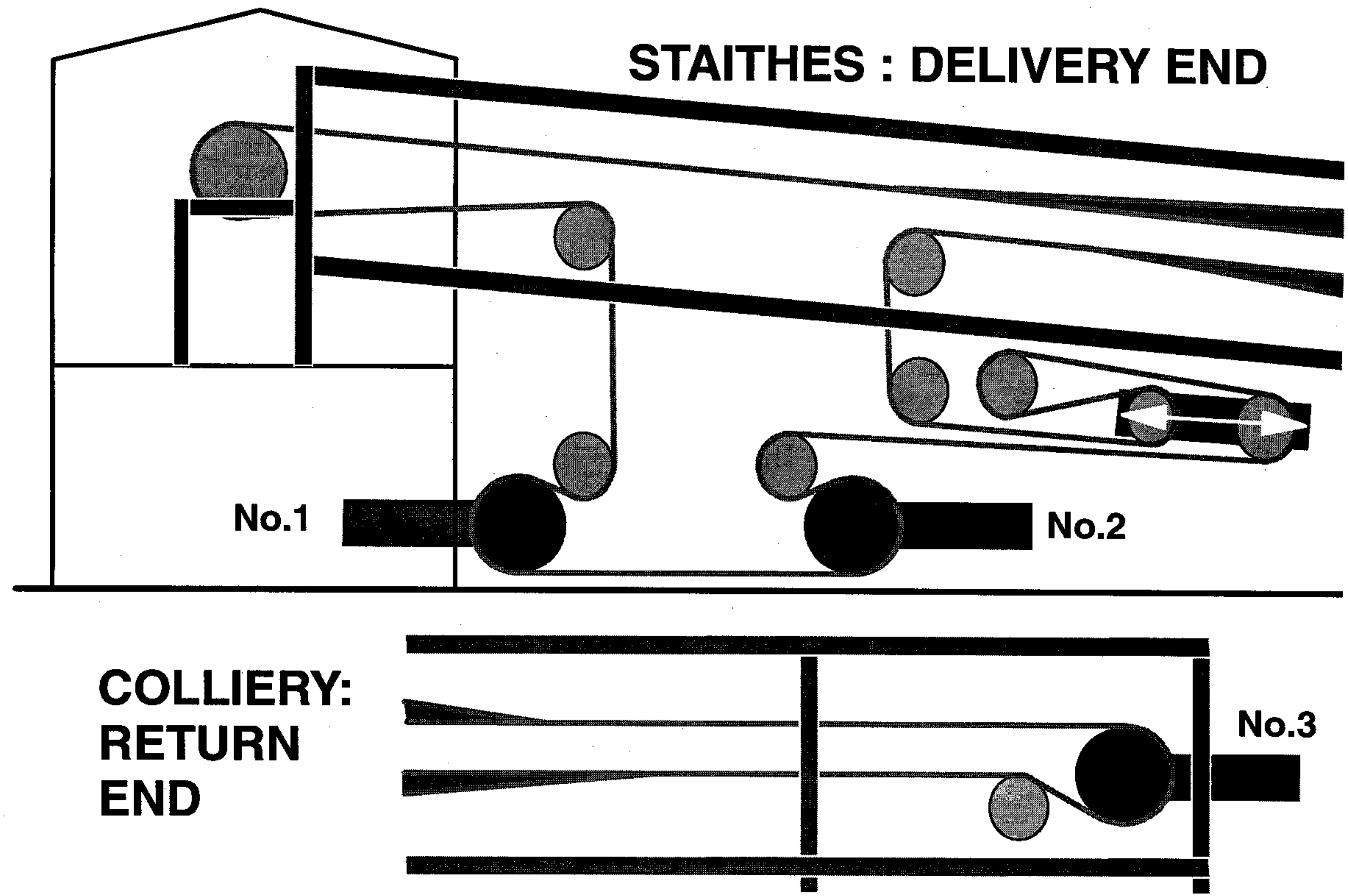

Fig. 4   Pipe Conveyor Drive Arrangements

WESTOE COLLIERY

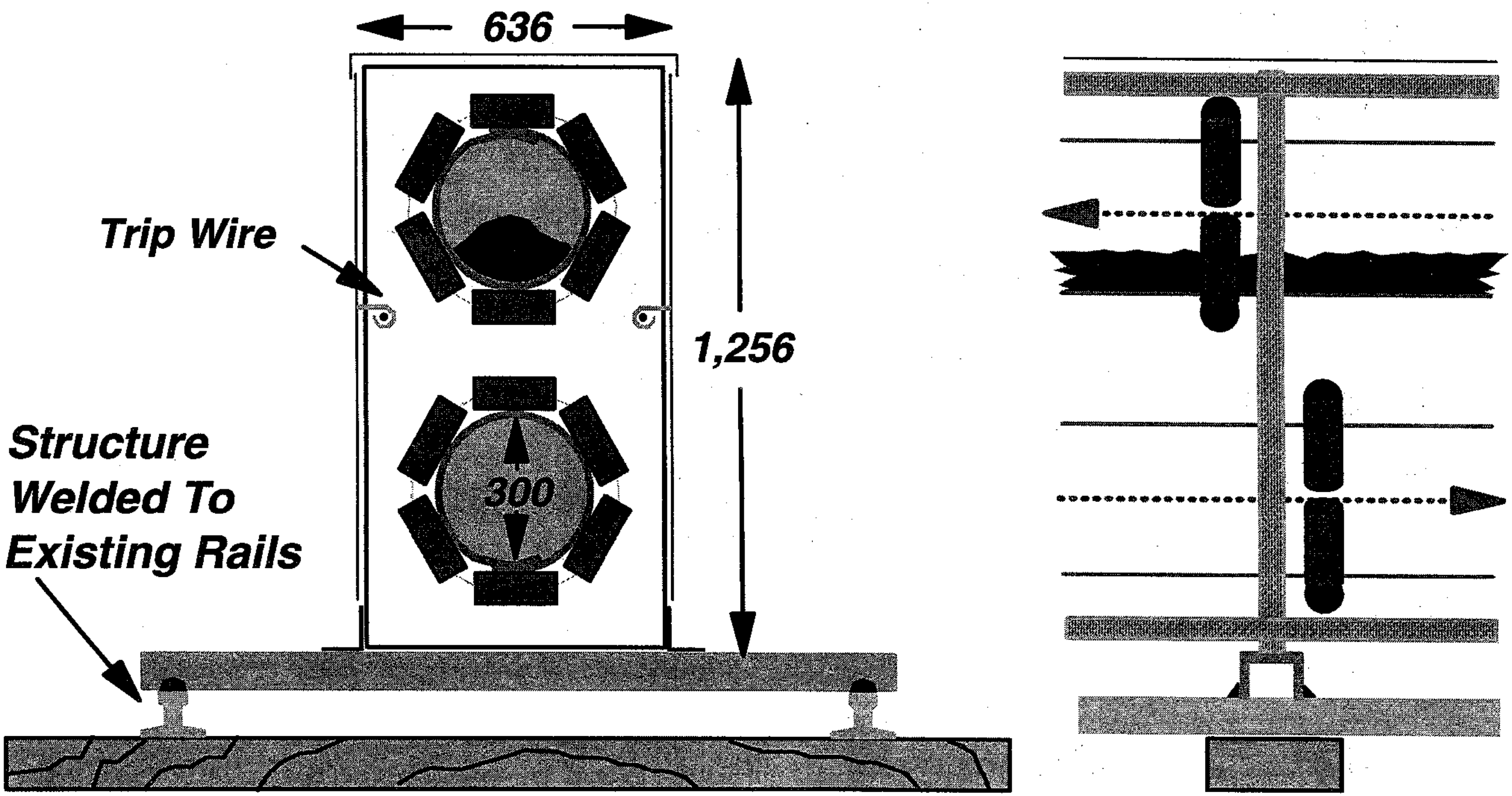

Fig. 5 Sections through Pipe Conveyor

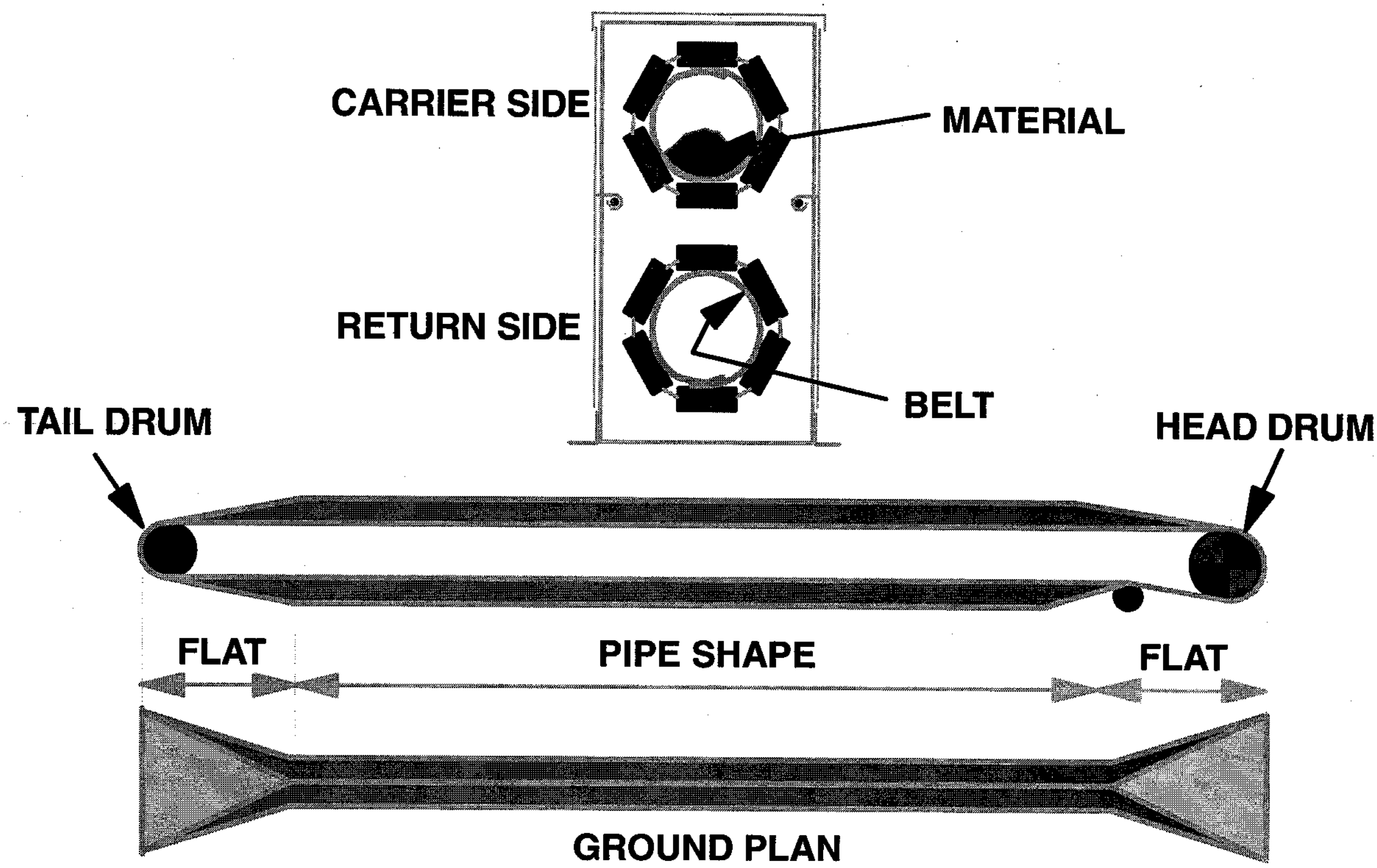

Fig. 6 Schematic of Pipe Conveyor Concept

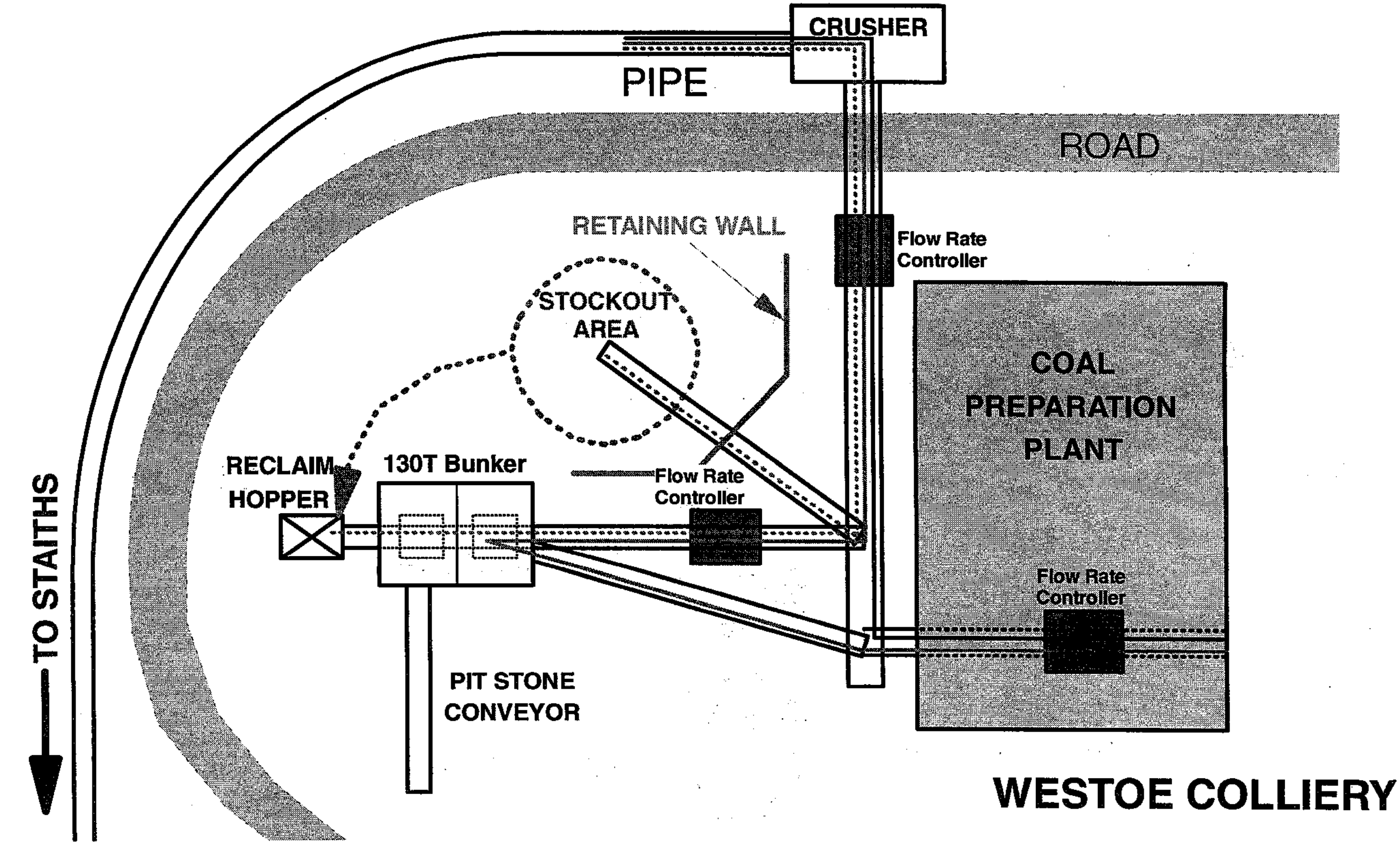

Fig. 7 C.P.P. SHALE CLEARANCE SCHEMATIC LAYOUT

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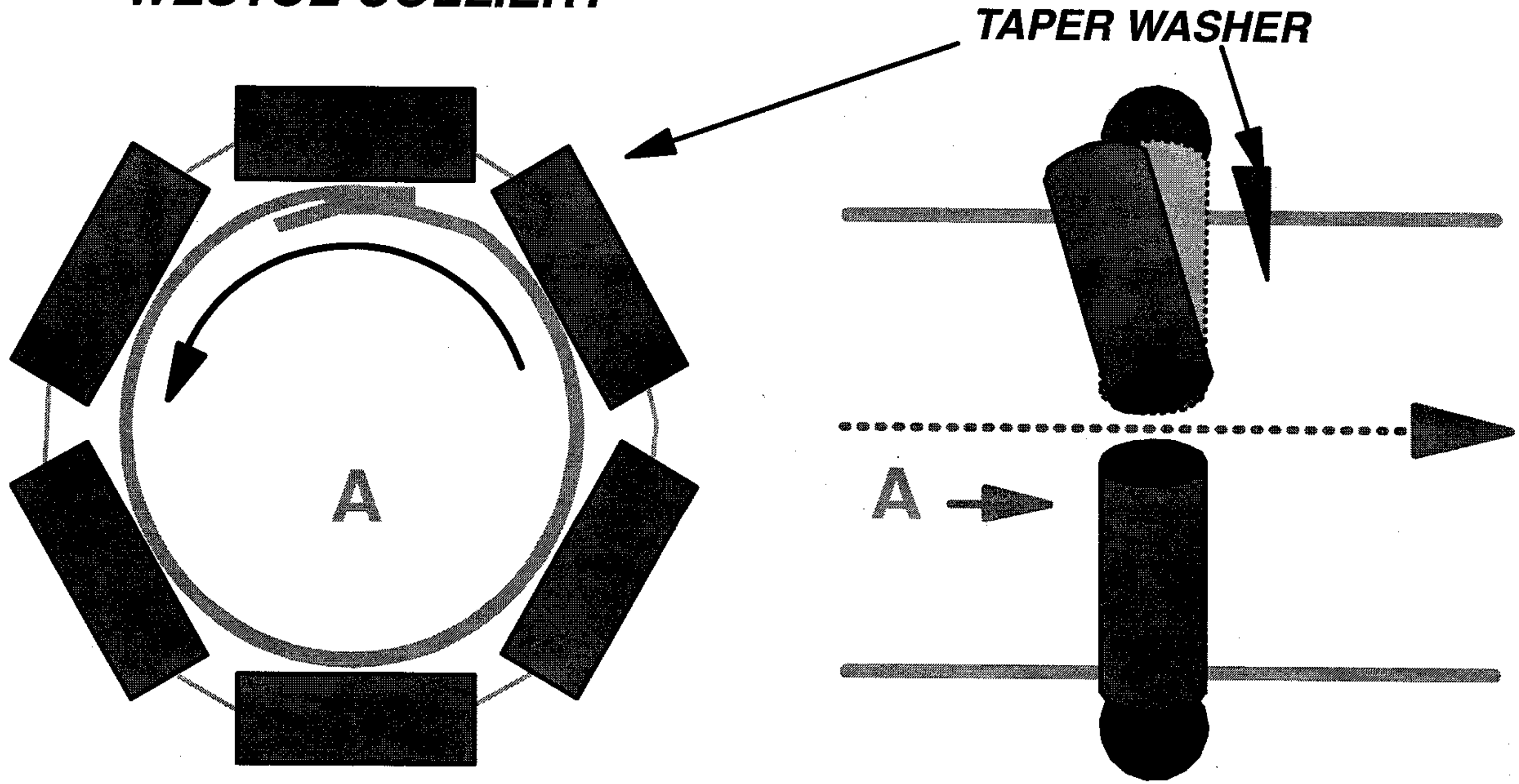

Fig. 8 TRACKING OF CONVEYOR BELT