THE RESPONSE TO THE DEMAND FOR NEW TECHNOLOGY AND EQUIPMENT IN THE FIELD OF TRANSPORT BY CONVEYORS

KONVEYÖRLERLE TAŞIMACILIKTA YENl TEKNOLOJİ VE DONANIM GEREKSİNİMİNİN KARŞILANMASI

RJ.C. GILUBRAND (*)

ABSTRACT

The techniques for designing and providing a coal clearance system from highly mechanised faces are developing to meet the increasing demands of higher output, with safety and reliability.

This paper comments upon the increasing requirement for technology applied to design and planning. It comments upon some of the equipment being introduced in modern high output mines.

ÖZET

ileri düzeyde mekanize ayaklarda homur nakliyat sistemleri artan üretim, güvenlik ve güvenilirlik gereksinmelerini karşılayacak şekilde gelişmektedirler

Bu bildiride tasarım ve planlamada artan teknoloji gereksinimine değinilerek, modern, yüksek tiretimlı ocaklarda kullanılan bir kıstm donanım tanıtılmaktadır

(*) B.Sc. (Min) C. Eng. M.I. Mİn E Marke ün g Director, Fletcher Sutcliffc Wild Ltd., Universal Works, Horbury, Wakificld, West Yorkshire, ENGLAND

1. INTRODUCTION

During the last three decades mining engineers have been continuously and successfully striving to increase the production of coal from the working faces. So often it has not been possible to match improved production and productivity with the provision of a compatible coal transport system, since Managerial and financial resources have been directed mainly to the coal producing operation.

The need to provide more efficient transport systems has led to new planning and system design techniques, and an Improved and new equipment. High capacity, high efficient transport systems are required to be installed in both existing and new or reconstructed mines, although the techniques and equipment provided may differ in these two basically different situations.

In existing mines we work within the constraints provided by already driven roadways of fixed dimensions, and hence limited scope for change in width of conveyors etc. Shafts and adits may be operating at maximum capacity during part of the coal production time, with conseouent loss of output if there is no provision for smoothing out of peak demands by bunkerage. The cost of replacement of existing systems may be prohibitive or would take so much time that loss of output would be unacceptable.

The new mine presents a different picture. Many options of layout, equipment selection etc. may be available. Nevertheless there will be a need to design and install systems which enable equipment installed in the early stages to be later uprated or used elsewhere. Capital investment can be minimised by upto date design techniques using computers to aid planning of the systems used. There are also many other benefits possible by the use of such techniques.

The aim of this paper is to highlight the types of equipment, soma new developments currently in use and also required in the future in the full transportation system from coal face to surface coal preparation plant.

To put into prospective the size of the problem by reference to the United Kingdom, at the end of 1983 there were 190 collieries, 550 coal faces and 1000 development headings in operation. The total length of transport roadways was over 1000 Km, the weight of mineral transported was 70,000 tons per day and 75 % of this was handled by 5,110 conveyor systems. Extend this view to cover the worldwide coal mining operations and there is scope for new conveyor systems well planned, suitably installed.

1.1. Conveyor/Bunker Systems

The largest proportion of underground mineral production İs cleared through conveyor/bunker systems and improvements in coal clearance has, therefore, been concentrated on such systems.

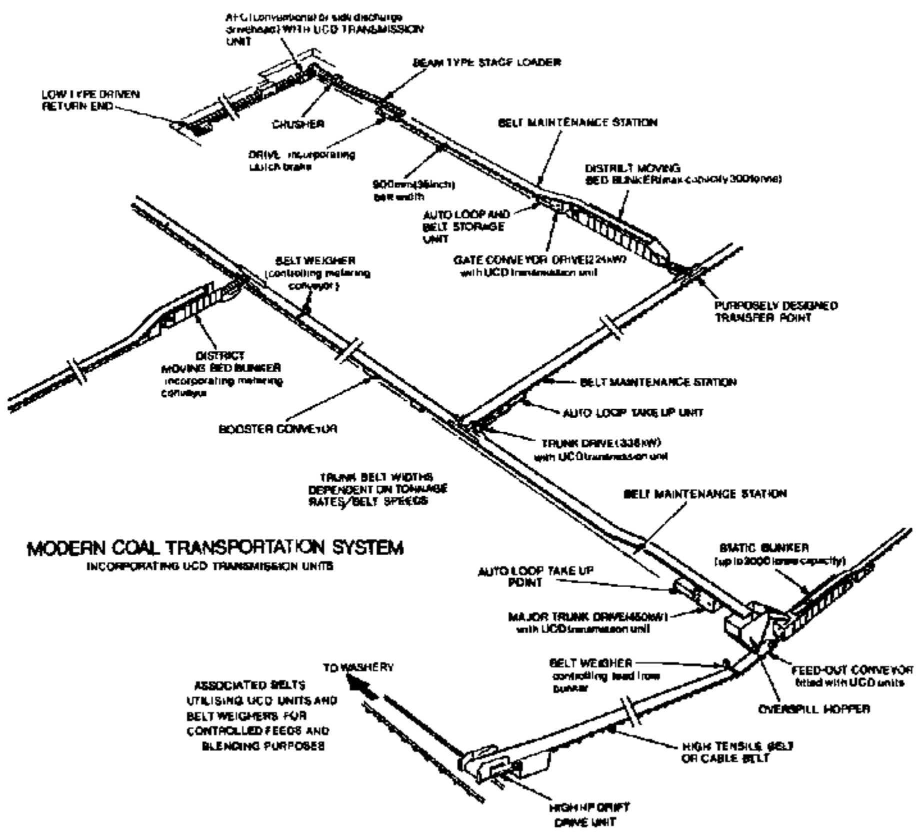


Figure 1. Modern coal transportation system incorporating UCD transmission units.

The main problem with conveyor/bunker systems is that they can be the source of major delays to face and development operations with delays totalling on average as much as 30 mins. per shift. Also they can be expensive on manpower requirements.

For these reasons, there is a need for an examination into existing systems and detailed planning for new installations.

The illustration shows a modern coal transportation system incorporating AFC's, belt conveyor (variable speed), bunkers etc.

A coal clearance system at a large mine is often much more complicated than it appears to be. It can be compared with a complex electrical network in which the elements are subjected to alternate overload and underload independently of each other and one in which the number of energised circuits varies in a random manner.

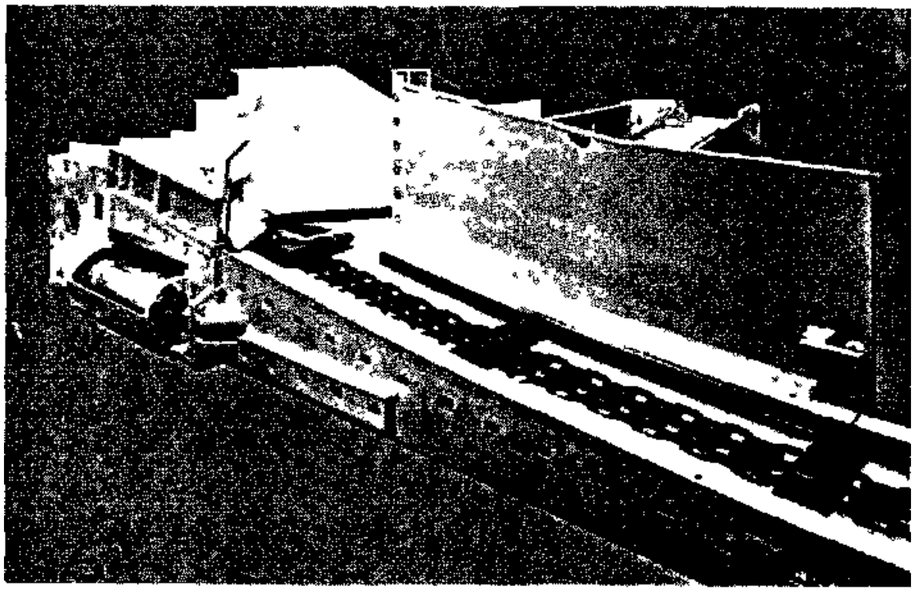


Figure 2. AFC side discharge drivehead.

The difference lies in that where the electrical system can blow a fuse or trip out on overload, In the coal transport system, we have conveyors overloaded, bunkers full and loss of coal. Alternatively we could design a system with inordinately high horse power and capacity in which for much of the time we would be moving empty conveyors. In determining the most suitable conversion for a particular section of the system, the following points should be examined:

— the maximum tonnage rate to be transported on each section of the system,
— the necessary belt speed for a selected belt width to cater for these tonnage rates,
— the power rating for each conveyor to meet the belt speed and tonnage requirements,
— bunker capacity requirements and the siting of various bunkers in order to maintain an optimum tonnage rate.

Conveyor Installation	(Tons/Hr)	Belt Speed (m/s)	Belt Width (mm)	Power Rating (kW.)
Gate	1,000	2.8	900	223
Trunk	1,500	3,9	1,050	335
		3.0	1,200	
Major Trunks & Drifts Conveyors	1,500/ 3,000	3.0 to 6.0	1,200 to 1,400	1,200 to 3,000

Now let us consider the types of equipment operating in a transport system, starting at the coal face and successively moving outbye to the surface, identifying those areas in which a development and innovation is taking place and also attempting to predict future trends.

2. COALFACE

The armoured face conveyor (AFC), is the first machine in the transport sequence and although much development due to the working environment and systems of working which usually involve continual snaking of the conveyor, is a major contributor to the losses in machine cutting time and for this reason a vast amount of research and development has taken place in the designs of these conveyors.

2.1. AFC Driveheads

There are many versions of varying sizes and horse powers, but basically they fall into three main categories:

a) The conventional where the coal is delivered at right angles to the stage loader direction of delivery. This has served the industry for half a century.

b) The side discharge which has a number of advantages compared with the conventional designs:
   - smoother and guided delivery of mineral from AFC to stage loader giving a reduced possibility of large lumps becoming staked.
   - a fixed delivery from AFC to stage loader since the AFC is firmly attached to the stage loader.
   - very much reduced carry back on the bottom chain of the AFC since the bottom chain is clear of the transported coal.
   - in some models the right angled gearbox gives opportunity to provide the maximum roof support by permitting supports on the waste side to move close to the the AFC and also from a mechanical engineering point of view the straight coupling would be generally prefered.

In the example illustrated the height of the drive is minimised by interlacing the return hcain of the AFC between the *top* and *bottom* chains *of the stage* loader. Scuh material still carried on the flights can be dumped at this point and fall through slits in the deck plate and be swept clear by the bottom return chain of the stage loader.

c) Ringt angled curve chain conveyors - the alternative to an AFC loading onto a stage loader is a continuous curved AFC with dhe delivery direct onto the gate

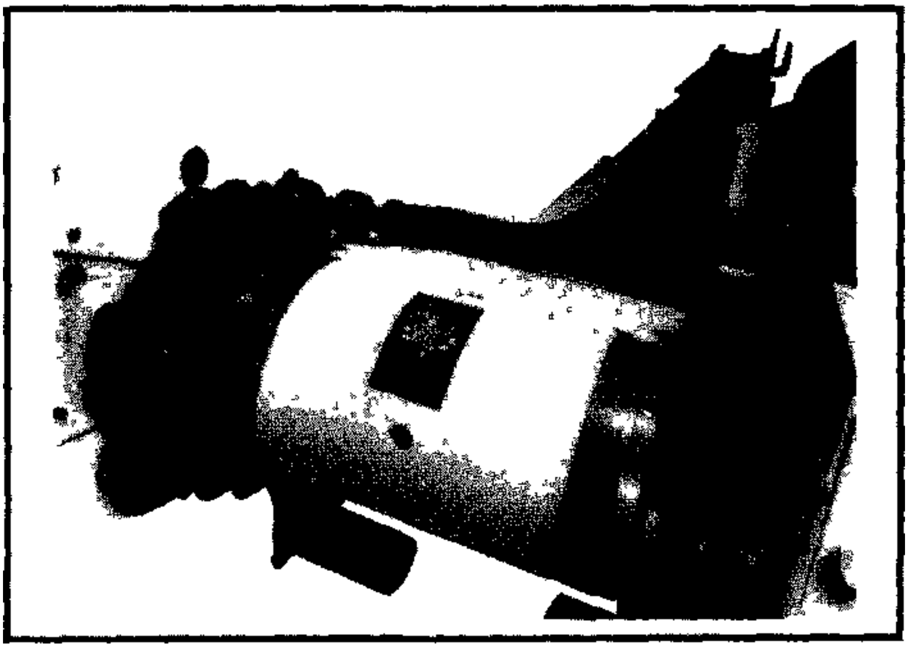


Figure 3a. FSW AFC internal bearing sprocket.

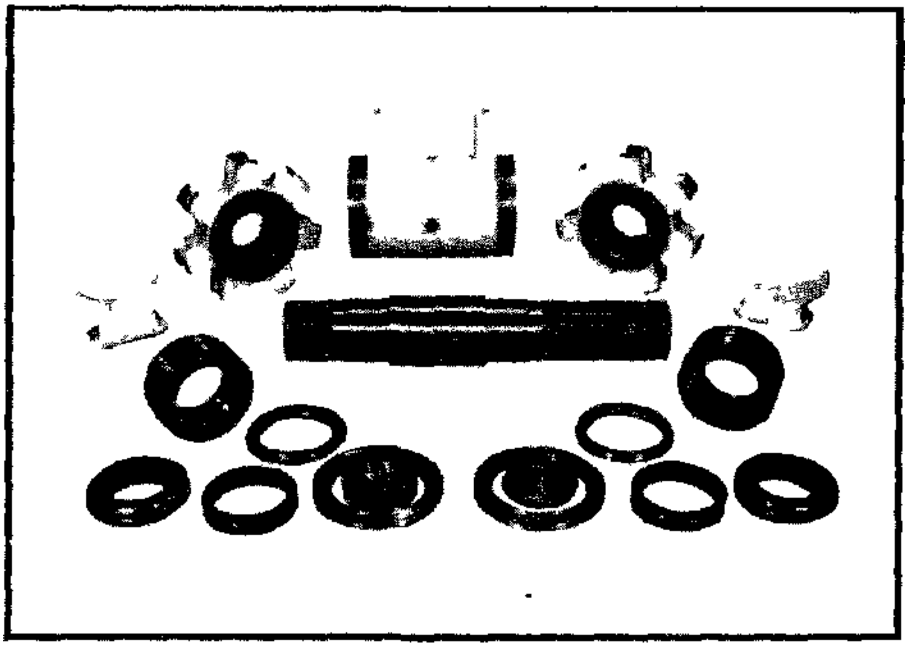


Figure 3b AFC Internal bearing sprocket assembly.

belt. These are successfully used on faces in several coal fields, particularly in Germany, but have only had a limited use in the U.K. with its stringent regulations covering roof support, mainly due to the required amount of room the conveyor takes up at the face end area, resulting in complicated support systems.

2.2. Sprocket Assemblies

Any AFC drive is only as good as the sprocket.

A robust assembly with long life is necessary if output is to be maintained.

Robust hard wearing sprocket rings are called for, bearing and mechanical seal life must be maximised and it is desirable to make it possible to change seals, rings or the whole assembly in a very short time.

The illustration shows a new modular design of sprocket assembly with several new features which lead to overall cost saving, increased reliability and reduced lost time due to mechanical failure. Note several important features:

— The placing of the bearing in the stationary oil filled tube instead of in the drivehead frame permits bearing widths of twice the normal width when the bearing is placed inside the frame, thus doubling bearing life.

— Increased shaft diameter with reduced stresses and deflection.

— Long life mechanical face seals and a dtstinc advantage that with this configuration the machining of the sprocket ring to provide space for the seal is not required.

— Rapid withdrawal and fitting of the assembly.

Experience has shown that in emergency this type of assembly can be withdrawn if required and replaced in under 2 hours. This should be compared with times varying between 5 and 20 hours. The saving in output can be quite enormous.

The armoured face conveyor is the first in a transport sequence moving coal from the coal winning machine to the surface of the mine. Over nearly half a century the main development in its design has been mainly to increase its strength and capacity without much change in design. Its short comings make it a very major contributor to loss of output.

23. Return Ends

On the highly productive and longer faces the return end usually incorporates a drive unit. Designs of return headframes, whether driven or not, are designed to a minimum overall height enabling the cutting machines to traverse on them to cut over into the end of the face, this being more advantageous in longwall advancing installations than for retreat faces. Here again an improved sprocked assembly is called for.

2.4. AFC Transmissions

On the armoured face conveyor power from the electric motor is transmitted through a fluid coupling and gearbos to drive the conveyors. Much productive time is lost by dealing with overloading of the conveyor. One solution has been to provide motors of excessively high power rating in order to provide a high starting torque. Two speed gearboxes have been designed. One common and successful aproach has been the application of 2 speed electric motors.

If we consider present needs and future desirable features of transmissions, we will probably identify them as follows:

— Soft start and high starting torque.

— Elimination of the need for precise setting up of the fluid coupling and problems well known when overload is consistent.

— Variable speed for clearing volumetric overload, clearing falls, materials transportation.

— Ramp start - programmed length of time to run up to full speed, i.e. controlled acceleration rate.

— Full power/speed reverse.

— Low power/speed for chain maintenance, examination tensioning.

— In the future it is quite possible that shearer speeds and conveyor speeds should be mutually variable and compatible, and be programmed from an external source.

An exciting development is taken in the United Kingdom with the introduction of a Universal Control Drive (UCD). This device İs also applicable to belt conveyors, in the design of underground bunkers and metering conveyors. For this reason a description of the UCD is to be included later in this paper.

2.5. Pan Line & Chains

There has been for some time a move towards heavier duty pans from which the user can anticipate a minimum of duty representing the carrying of 2 million tons of coal. The Sigma section is being replaced. Since this design was arrived at in order to provide facility for the attachment of AFC furnishing it is not surprising. For cheapness it makes sense to include face side ramp plates, racks for chain less haulage, spill plates *etc.* in the fabrication.

A typical pan to meet modern requirements would have the following specifications:

— Square profile for added strength compared with sigma section.

— Thick bottom plate ensuring maximum floor contact area.

— Thick top flanges and overlapped deck plate. All these of high grade wear resistant steel.

— Integral ramp plates on the face side with two row ten bolt fixing on the waste side for furnishing.

— Three hundred ton dogbone connectors allowing 2 degrees articulation horizontally, 6 degrees vertically.
Such a pan is of course manufactured in varying widths and deckplate thickness increases with pan height.

— The scraper bars for use with square profile pans have a square profile at the ends (compared with sigma shaped pan) for increased contact area between bar and pan with resultant reduction in wear.

The bars are constructed in two parts horizontally divided. Precise location of the two *parts is achieved* through a state in the *upper part and* Hatching groove in the lower part. For maximum durability bars are manufactured from a chrome molybdinium steel of tensile strength 900-1100 N/mm. These bars can be repaired re-usage rate of approximately 90 % is common. Many bars are repaired several times before scrapping.

3. TRANSFER OF COAL FROM THE FACE TO THE BELT CONVEYOR SYSTEM

The stage loader is the final stage in the conveying of coal from the face. There is no necessity in this paper to dwell upon stage loader design. However, when the coal İs delivered from this stage loader it is desirable to size it by crusher or mineral sizes so that it can travel on the belt conveyor without spillage or blocked chutes at transfer points.

3.1. Crushers/Coal Sizes

In order to convey a consistent size of mineral onto the transportation system at an early stage, crushers, if not fitted onto the shearer, should be housed in the stage loader. The following paragraphs describe two types currently introduced and working successfully in the UK.

— A conventional design of crusher is an in-line unit with a drum rotating on a horizontal axis over a specially designed heavy duty stage loader pan.

  It is driven by a 112 Kw (150 HP) electric motor and will crush material with a compressive strength of upto 1400 kg/cm squared down to 75mm size, and cater for tonnage rates upto 1480 tons/hr.

— A second type is of screw design incorporating twin drums fitted with scrolls and picks rotating in opposite directions, driven by a 150 Kw motor. Mineral is fed into the top of the crusher and passed through the twin screws ensuring all the product is sized down to 12 mm, at a maximum capacity of 2000 tons/hr.

3.2. Dutch/Brake

The stage loader is powered in exactly the same way as the armoured face conveyor, i.e. by motor driving through a fluid coupling to a gearbox. A development is being pursued in the UK to provide an improved transmission unit. In addition sad events have shown that the overrun characteristic of this short conveyor, especially when a crusher is installed on it, presents a serious hazzard to safety.

A clutch brake unit has now completed its underground triais and received approval from the National Coal Board.

When chain conveyors are switched off there is a considerable amount of overrun before the chain actually stops. This is most relevant on the shorter chain conveyors and downhill conveyors. This overrunning can be dangerous on such installations as stage loaders, particularly when housing coal crushers. A clutch brake device has been developed to eliminate this danger, stopping the chain almost immediately ît is switched off.

When running, the electric motor driving the stage loader is responsible for over 90 % of the inertia in the stage loader. If the motor inertia can be separated from the gearbox drive before the brake is applied, the braking effort to arrest tha chain is greatly reduced. The clutch brake is designed to achieve this end. The clutch/brake is a 112 Kw (150 HP) totally enclosed unit inserted in place of the fluid coupling between the motor and gearbow on a stage loader. It is approximately 50 mm larger than a standard fluid coupling and readily accepts an NCB spec. 48 Kw or 112 Kw electric motor.

It consists of two identical multi-disc assemblies each of 15 discs, 7 of which are of steel and 8 sintered bronze - one being the clutch, the other the brake. The clutch is engaged hydraulically and spring disengaged; the brake is spring engaged and hydraulically disengaged.

The hydraulic pressure is proivded by a pressure compensated, constant pressure, variable delivery swash plate piston pump, rigidly mounted on the inside of the clutch brake housing and driven from the input shaft. The hydraulic working pressure is 28 bar (400 psi). An electric solenoid valve is used to control fluid to the clutch.

A pressure switch is incorporated in the circuit, controlled on initial start by a timer to ensure the correct pressure before starting. If a low oil pressure is sensed the pressure switch shuts down the motor.

The sequence of operation is as follows:

— When the motor is energised it will run only after the operation of a 5 second audible pre-start warning.

— The motor turns the input half in the clutch/brake unit, this drives the pump, generates the pressure to the pressure switch and the solenoid valve.

— v "Sen a pressure of 13.8 bar (200 psi) is rendered, the pressure switch and solenoid valve is energised and fluid flows to apply the clutch and disengage the brake. At this point tue coupling between the motor and the gearbox will be solid.

In terms of drive efficiency the clutch is now acting as a solid coupling between motor and gearbox. It İs capable of stalling a 112 Kw (150 HP) motor which means that it is capable of withstanding 3.4 tonnes the full load torque of the motor without being damaged. Compare this with the best maximum of twice full load torque from a fluid coupling at which slip will occur, heat will be generated and the fusible plug will melt to release fluid from the coupling. This device of course is of use in providing rapid stop in crushers and of great use in preventing overrun and spillage on steeply inclined downhill conveyors.

4. GATE CONVEYORS

With increasing output from individual faces the demand will increasingly be upon high capacity and also provision for quick installation and withdrawal of driveheads, loops tensions etc. As faces now advance or retreat so rapidly there must be a generous belt storage and facility for installing or removing belt in lengths of 50 metres very quickly.

An example of this is the unit designed for the Selby Mine in the UK. The unit had to meet the following criteria:

— Jib section, fines conveyor to be permanently assembled in one piece and able to be transported to and from site without disassembling.

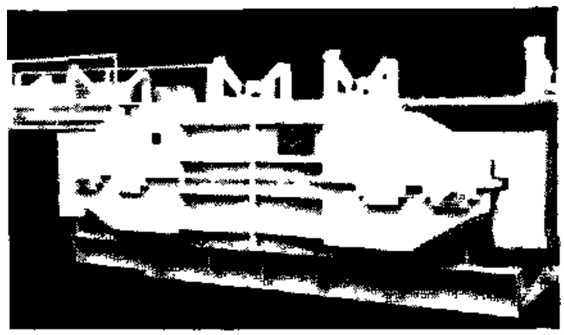
— The drive unit must meet the same requirement.

— AH electrical equipment to be fitted into a complete transportable module.

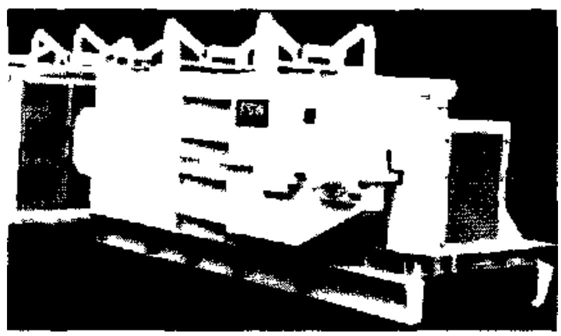
— The loop and winch, including drums and carriage to be assembled from pre-fabricated modules dowel led for ease of assembly.

— A modular belt reeling/maintenance station for quick installation or withdrawal of belting (in one piece) must also be prepared.

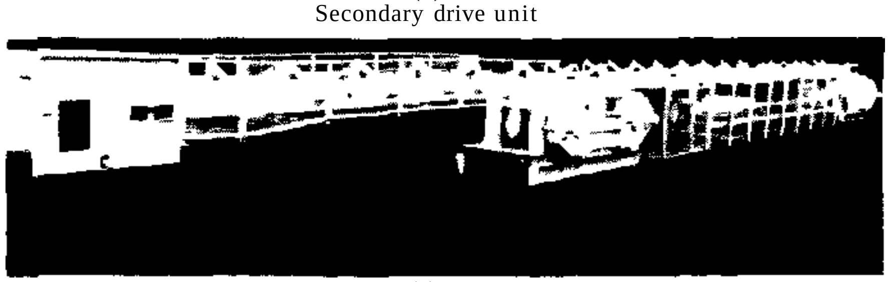
The diagrams show the modules section. All the modules are transportable in either free steered vehicles on coolie cars. The whole installation including an FSW



(a)
Primary drive unit



(b)
Secondary drive unit



(c)
Full unit with jib

Figure 4. Multi motor unit with loop & jib.

300 HP In-seam drive unit, loop take-up and belt maintenance/reeling station can be installed in a few hours. The belt is reeled onto a belt cassette on the surface of the mine. The down time required for taking out or putting in of 50 metres of belt is 10 minutes. Larger capacity units are to be installed. In this one approach labour, time and risk of damage to belting has been drastically reduced.

5. TRUNK CONVEYORS

5.1. Driveheads

As in the case of gate conveyors there is an increasing demand for compact, conveyors of larger capacity and power. One important approach is that in which a conveyor drive can start its duty at a comparatively small duty and at a later time increase its power. This is achieved by the use of multi-motor drive units. The illustration (Fig. 4) shows a unit consisting of a primary drive twin motor drivehead, and a secondry single motor drivehead separated by an automatic belt tension storage unit, the combined and ultimate power rating being either 3 x 112 Kw (450 HP) or 3 x 150 Kw (600 HP).

The second example is of an even more versatile drive unit suitable for a 150 Kw (200 HP) and 224 Kw (300 HP) motors in single and double drive unit configuration to a maximum of 675 Kw (900 HP). This conveyor meets the increased demand for versatile standard, off the shelf drives which can meet high capacity requirements without the cost of custom design and long lead delivery.

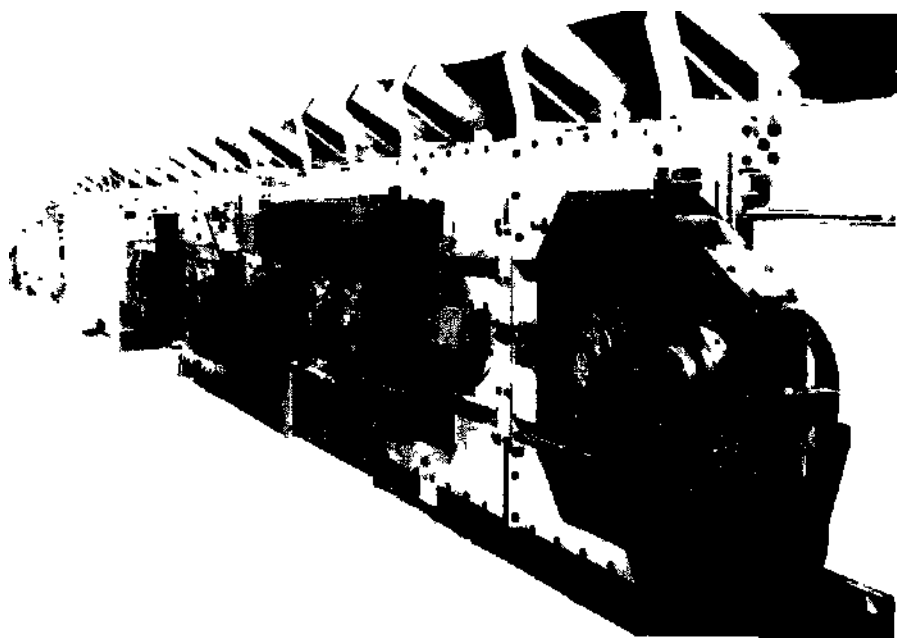


Figure 5. High powered belt conveyor drive unit.

Belt speeds for trunk conveyors are increasing with increasing tonnage capacity and speeds of 6 *w/sec*, becoming common. It is of interest to note that in the UK the current average trunk belt speed is 2.9 m/sec.

5.2. Extension Of A Conveyor Line

A conveyor line can be extended by the use of tandem conveyors in line or by the use of a multi-motor *conveyor* drive. A *further* alternative is by the use of Booster Drives (See Figure 6).

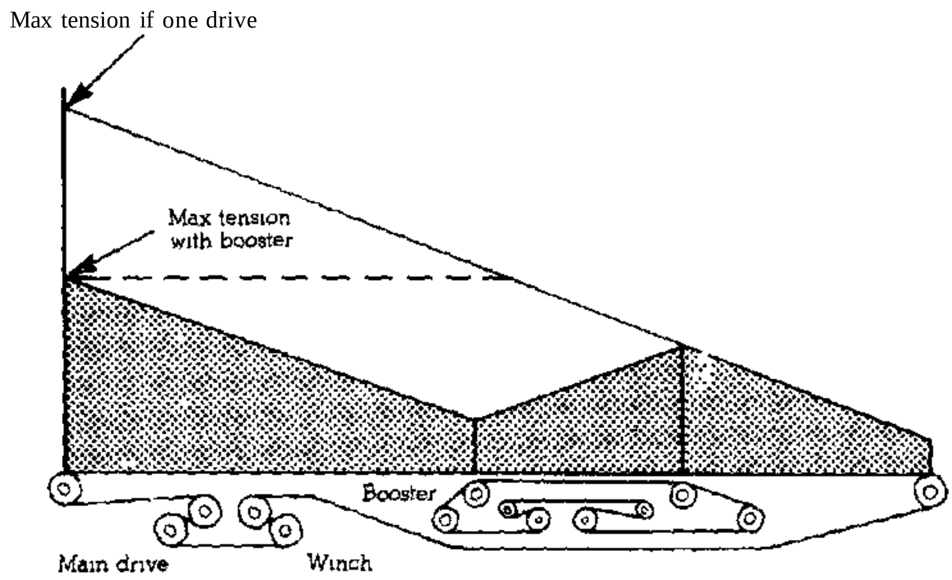


Figure 6a. Tension giaph.

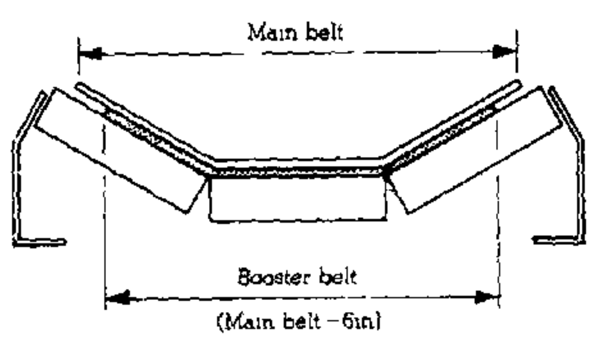


Figure 6b. Lay of belts through booster length.

5.3. Booster Conveyors

The tension distribution on a long trunk conveyor is at a maximum at the delivery end and progressively decreases towards the return end. In order to increase the tension without introducing high-powered drives and stronger belting, booster conveyors Can be installed at intermediate point(s), at predetermined position(s) between the head and return pulleys. Power İs transmitted by an endless driving belt, the top belt of which runs between the conveyor İdler rollers and the underside of the top main conveyor belt, thus transmitting power by friction.

Engineers are often faced with the necessity of enlarging existing trunk belts either in length and/or carrying capacity.

In some such cases it may be impossible to add more driving power to the existing conveyors because the existing belt would not be of sufficient strength to do so. To change to high power drives would involve major capital expenditure and the booster belt system is a means of avoiding this. Patents of the system were introduced as early as 1919 by Krupp, and first installed in open pit mines and subsequently in underground mines in Germany. The first UK installation was at Royston Colliery, in the Barnsley Area, NCB, in 1978 and numerous others have since been successfully installed.

5.4. Transmissions For Belt Conveyors

Smaller drives are usually powered by electric motor with a fluid coupling fitted between motor and gearbox. In the case of the larger units scoop coupling are widely used to give a soft start facility.

The Universal Control Drive (UCD) is designed to provide many of the other characteristics desirable in conveyor drive units wish:

— Soft start - the motors start up under no load condition.

— Ramp start - controlled acceleration and deceleration over a pre-determined time. This results less stress in belts and drive gears, and makes it possible when riding men to move the belt to a very high speed without the risk of caterpulting men from the conveyor.

— By virtue of variable speed facility, two speeds can be selected - one for mineral transport the other for manriding.

— Regulated torque multiplication when starting conveyors - automatically applying the required torque but not exceeding the breaking load of the belt.

— Load sharing - multi - motors equal load.

5.5. Monitoring

The capital investment İn conveyors is increasing the need for continuous running and demands a continuous monitoring of the conveyor. There are a number of monitoring systems which seek to establish:

— Where a malfunction will cause damage unless the conveyor is stopped immediately.

— Where if a warning is given at an early stage, the conveyor can continue to operate but remedial action is required.

Ideally, all these areas should be monitored to a consol display panel which is usually installed in the surface control room. There are many electronic systems available to monitor the following:

— Shutdown alarm - conveyor belt slip, belt speed, conveyor stopped, monitoring unit fault, belt alignment, torn belt, blocked chute.

— Warning alarm signals - temperatures, brake wear, smoke detection, monitoring fault detection.

Sequencing stop/start of a full conveyor system is also a function of the system.

6. NEW DESIGN OF TRANSMISSIONS - UNIVERSAL CONTROL DRIVE

A Universal Control Drive is a transmission unit fitted between the motor and gearbox of any drive unit to provide a soft start facility and variable speed. The variable speed being automatically controlled by an electro-hydraulic valve activated from an external *source* strategically placed according *to* the needs of the system Fig. (7).

All machines driven by electric motors have three basic modes of operation, i.e. start, run and stop. The relationship between torque and rotational speed varies considerably for differing duties and it is the matching of these variations which is the most important *function* of a transmission *system.*

The design, based on the wet clutch principle, is a type of hydro-viscous drive which offers certain advantages over other slip type clutch transmissions. It can best be described as a modulating clutch, which used İn conjunction with a torque convertor, can give tremendous advantages in the control of power transmitted by a prime mover. Variable speed, torque control and torque regulation, wihch can limit the tension in chains or belts being the main advantages of the system.

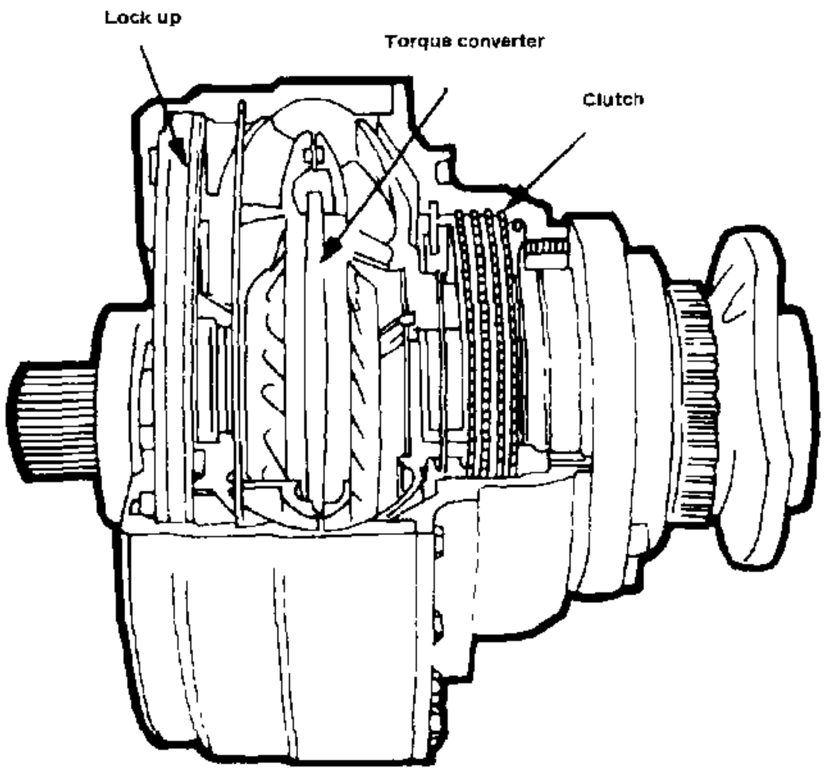


Figure 7a. Assembly of UCD complete unit.

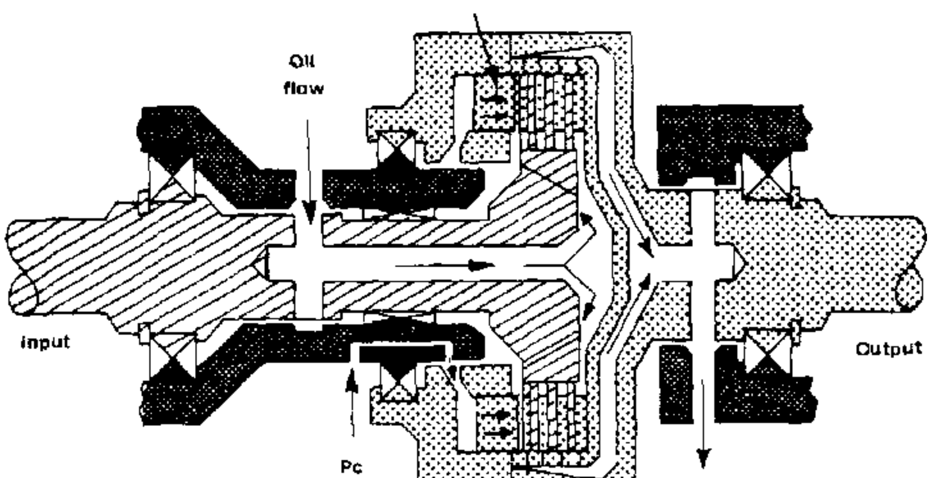


Figure 7b. Oil flow through UCD unit.

7. COMPLETING THE TRANSPORT SYSTEM - STORAGE BUNKERS

As commented earlier in the paper a conveyor system is not only capable of transporting mineral but also provides a bunkering facility.

The methods of working at the coal face results in peaks and troughs in production an these need to be regulated to give a consistent tonnage rate onto the out-bye conveying system. Also, at any point İn the transportation system. For these reasons bunkers should be installed at strategical points throughout the system, Fig. (8) shows a typical transport system with possible location of bunkers in both in-bye and out-bye locations.

7.1. In-Bye Bunkers

Either the moving bed or horizontal strata type. The former having a maximum capacity of approximately 300 tonnes and the latter 700 tonnes.

The moving bed type can be installed under an extended jib length of the gate conveyor. It is basically a double scraper conveyor, each independently driven at speeds up to 100 mm/sec. by hydraulic or electric motor. The bunker is filled at

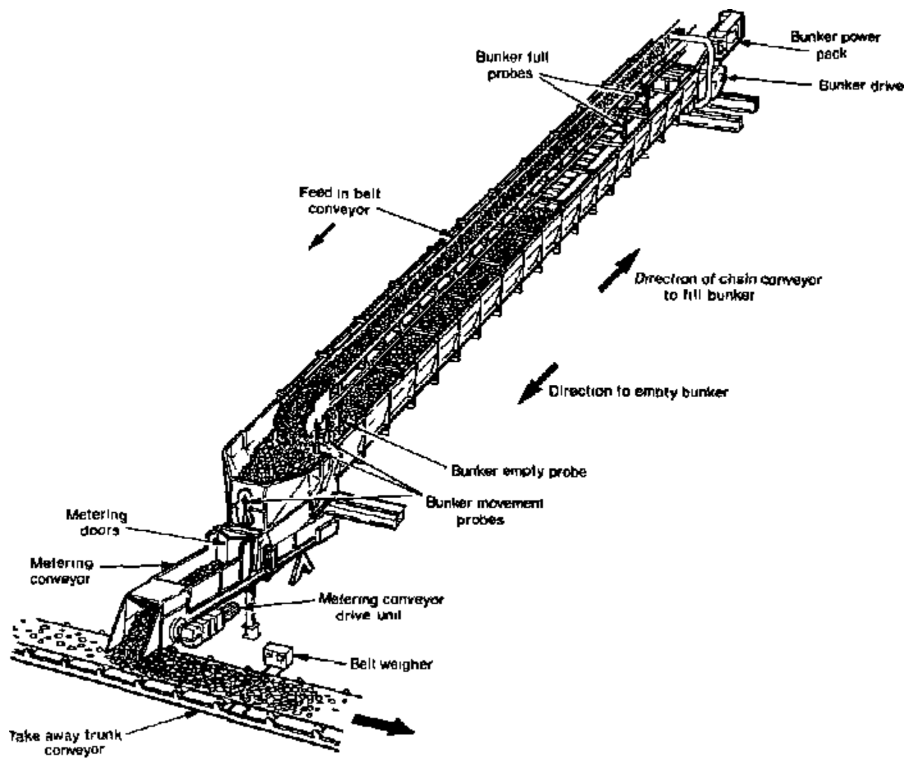


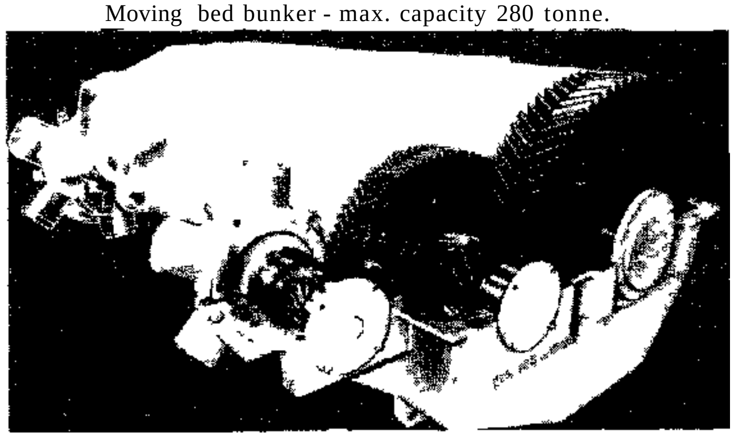
Figure 8. Moving bed bunker.

the discharge end of the gate belt with the chains running in reverse and is emptied by running forward. To ensure even output from the bunker, discharge from the bunker is normally onto a metering conveyor and rates upto 1400 tons/hr. can be automatically controlled. Alternatively, for this application of district bunker the metering conveyor can be eliminated by introducing a UCD on the bunker drive, which when controlled from a belt weighter sited out-bye of the gate belt transfer point, can automatically ensure constant tonnage rates from gate to trunk conveyor. This type of bunker can be automated (See Figure 8,9,10).

(a)

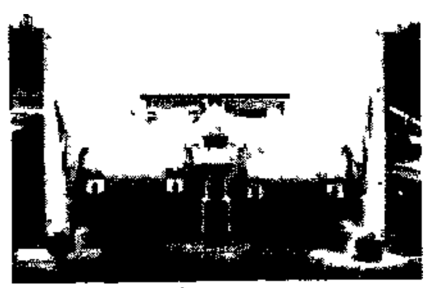
Moving bed bunker - max. capacity 280 tonne.

(b)



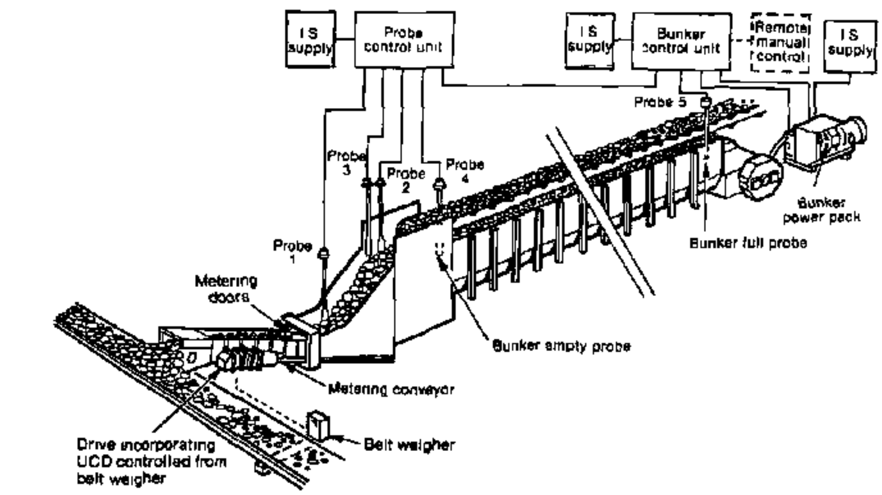
Gearbox for FSW moving bed bunker

(c)



Front view of moving bed bunker

Figure 9. Views of moving bed bunker.



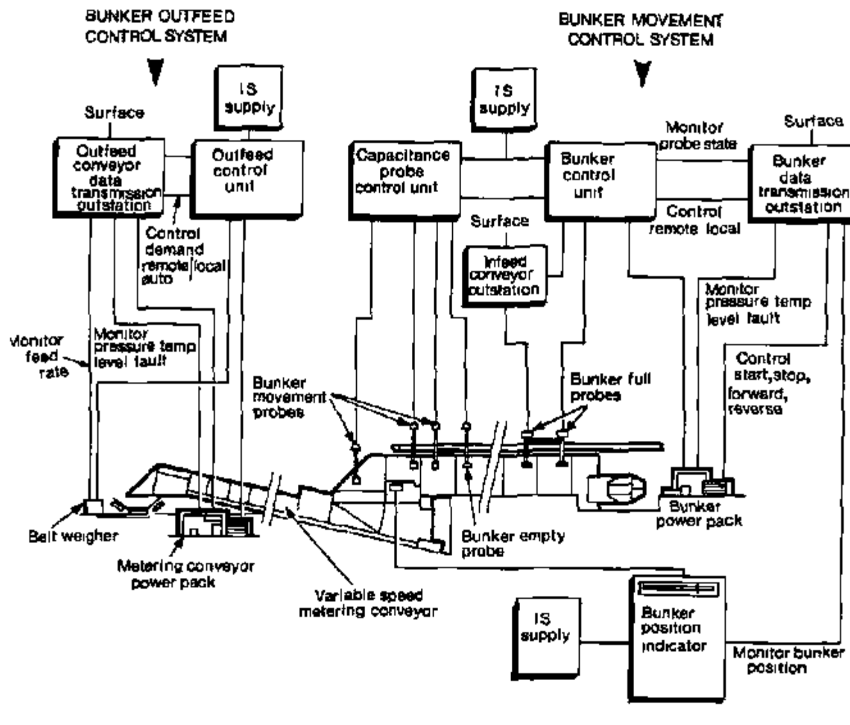


Figure 10. Bunker automation system.

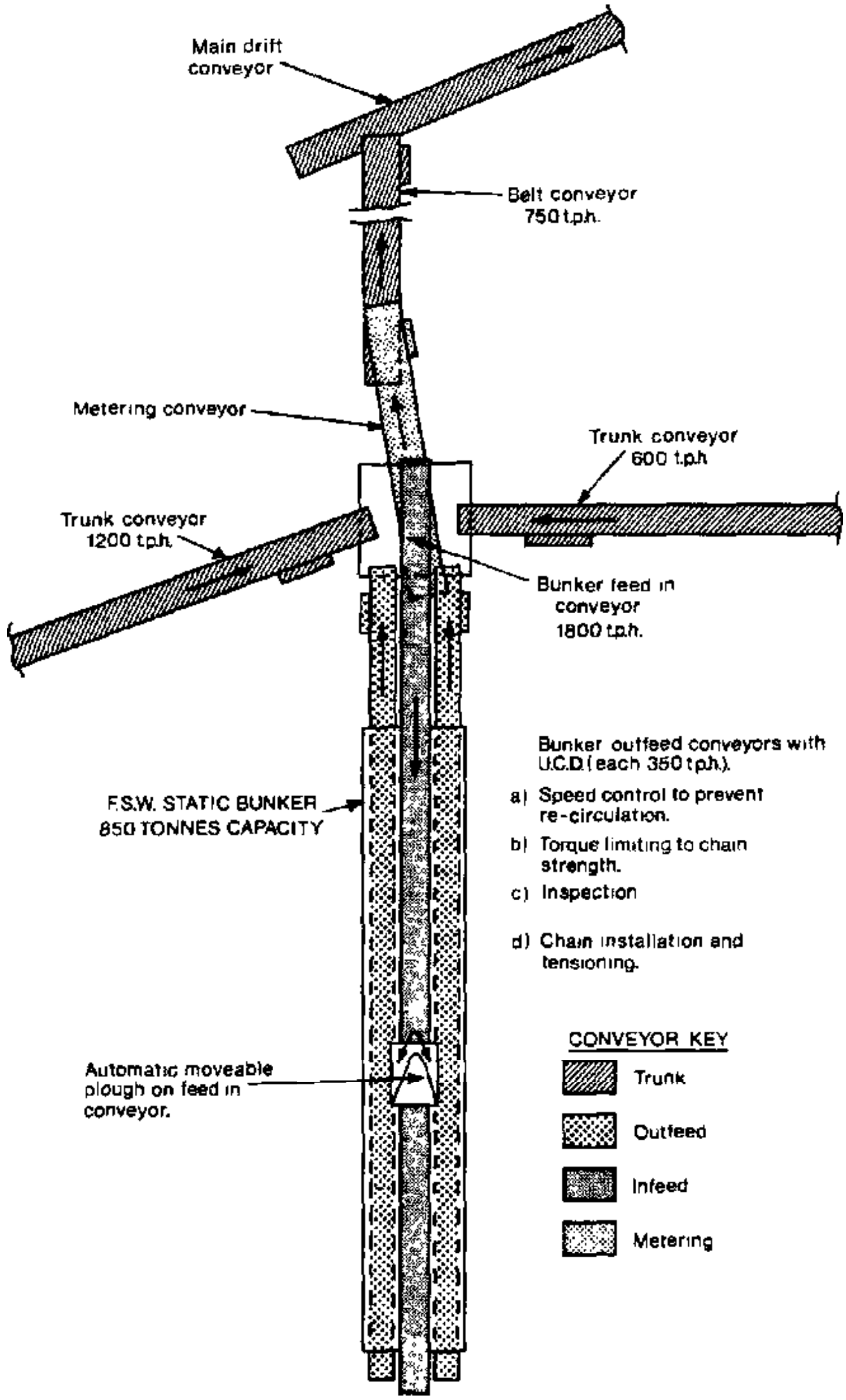


Figure 11. Static bunker with UCD units on feed out conveyors.

The horizontal strata type is an arrangement whereby run of mine coal from an infeed conveyor is stored on the floor of an underground roadway to be subsequently load out, as required, onto a chain conveyor for delivery onto the outbye conveyor system. Different arrangements for loading out the coal have been employed but the favoured method is by a shearer fitted with loading devices. This system is relatively cheap in capital costs but can be expensive to operate and maintain Automation is difficult and usually there is a relatively high manpower requirement for its operation.

7.2. Out-bye Bunkers

High capacity bunkers strategically sited in the out-bye conveyor section are an essential piece of equipment in modern transportation systems. They serve the

Figure 12a. Underground installation of 900 tonne static bunker (Kellingley Colliery).

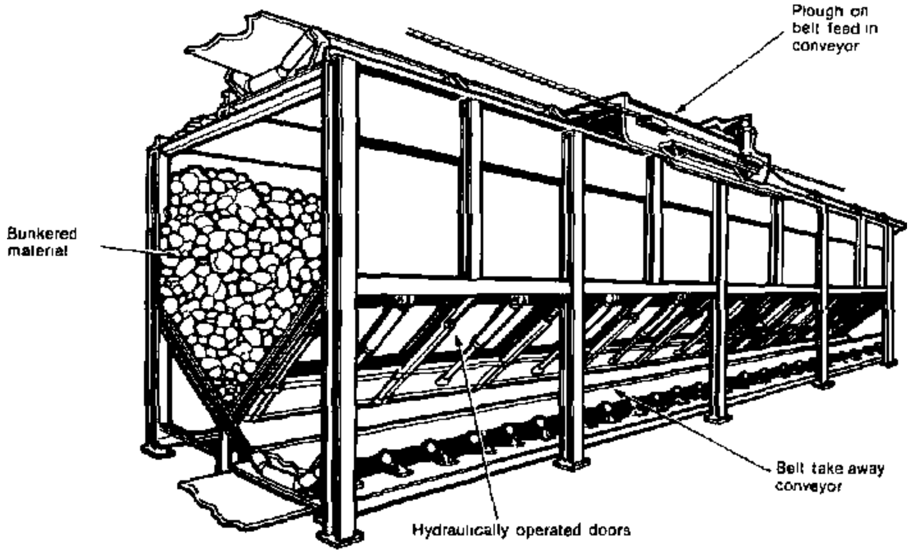


Figure 12b. Layout of static bunker (with belt feed m and out conveyors).

same purpose as the in-bye bunkers but with capacities up to approximately 2000 tons. Currently design work is taking place to exceed this figure.

Out-bye bunkers fall into three main categories, static, moving car and staple and inclined. All types can be fully automated.

7.2.1. Static Bunker

This type of bunker hasa capacity range of 300-1500 tonne. See Fig. (12).

Basically it consists of a storage by V shaped bins with a single feed-in conveyor running centrally over the bins.

Discharge is either through hydraulically operated doors feeding onto a single take-away conveyor, or by through openings at the bottom of each side plate of the V bins which allow mineral to be discharged onto two take-away conveyors - one each side of the bunker roadway.

These bunkers can be installed in-line under a trunk conveyor or, more usually, in a separate roadway adjacent to the trunk road. They are sited at the discharge end of a trunk belt which usually incorporates an overspill hopper that ensures (if coal İs available) that a constant tonnage rate is fed onto the next out-bye belt. This is achieved as follows.

— If the required tonnage rate is being conveyed by the trunk this will be loaded though the hopper directly onto the out-bye belt.

— If the required tonnage rate is not being supplied by the trunk, then automatically the bunker will discharge the amount necessary to load the receiving conveyor to maximum capacity.

— If the required tonnage rate is more than required on the out-bye belt, the surplus to requirement is automatically loaded into the bunker through the overspill hopper.

— If the out-bye belt should stop then all the coals are loaded into the bunker.

7.22. Traversing Cars

The capacity range of this bunker is between 200-1000 tonne. The bunker consists essentially of a train of wheel-mounted bottomless hopper cars, coupled together so that they form a continuous storage bin which can be hauled forward and backward by an endless rope haulage. A non-driven flat belt is arranged under the train of cars, the top strand being supported on closely spaced idlers fitted in such a position that the upper surface of the belt forms the base of the bunker. The belt is carried around fixed delivery and return pulleys, and is clamped to the terminal car of the bunker so that it can move under the action of the bunker cars and the container load.

7.23. Staple Bunkers

The vertical type staple bunker can be costly on excavation since a shaft must be formed between two levels of roadway. Basically it is simply a shaft with steel linings incorporating spiral guides for controlling the loading of material and is discharged at the bottom of the shaft onto the conveyor system. Inclined bunkers are of similar design except that instead of vertical shaft a steeply inclined roadway is utilised. Discharge at the bottom is usually by vibrator feeder or can be by a variable speed metering conveyor.

8. DRIFT CONVEYORS

Multi motor drive units with two or more driven drums, depending upon power requirements, are available to cater for high tonnage rates being conveyed up steeply graded drifts. Belt speeds of 10 m/sec. and power in excess of 10,000 Kw are not unknown.

There are basically three types of conveyor belts used in drifts:

— conventional woven or multi-ply belt
— steel cord belt
— cable belt.

However, for single unit drives conveying long distances at loads in excess of 1500 tons/hr. and belt speed of 6 m/sec, the steel cord or cable belts are employed.

The advantages of steel cord belt are:

— specification can be tailor made by choice of diameter, number and material of the steel cords

— stretch is limited (0.2 to 0.3 %) and is virtually non-permanent

— vulcanised joints are immensely strong.

Cable belt is widely used on steep even graded drifts and the obvious advantage is that the ropes and not the belt are under tension. Maintenance of rope and rope pulleys have been costly on many installations but latest designs using plastic lined pulleys have reduced these costs.

It is worthwhile commenting briefly on the large conveyors which are normally the final ones out-bye of the conveyor system, often in the drift to the surface of a mine.

Power requirements and capacities continue to rise. Belt speeds of 10 m/sec. and power in excess of 10,000 Kw are not unknown. The type of belt used in these circumstances must have a very high tensile strength. Generally selection is from the three types listed below:

1 - Solid woven belt
2- Steel cord belt
3- Cable belt.

9. CONVEYOR BELTING

Conveyor belting is undergoing development. The introduction of this solid woven carcase, with its superior physical characteristics, has led to the demise of the conventional rubber ply belt in the more sophisticated markets, where initial capital cost is not the only criteria considered. Together with its improved operating performance the PVC impregnated solid woven belt has made far higher safety standards and the capability of operating satisfactorily at higher tensile strengths, strengths that at one time were only possible with steel cord or cable belting.

Whilst at one time 1400 Kw/m width was about the maximum strength for rubber ply belting to operate adequately, solid woven belting is now in regular use urp to 2700 kN/m width. Generally it is now unusual to find, particularly underground, steel cord belting operating below about 1400 kN/m and in the main, they are now restricted to higher tensile conveyors, unsuitable at present for textile belting. The development in steel cord belting has consequently been concentrated on the higher end of the range, with belts now available up to 7100 kN/m. The high cost of these belts, particularly when fire resistant qualities are required, necessitates great emphasis on jointing capability and enhanced resistance of the belt to mechanical damage.

In continuing progression up the tensile "ladder", textile belting manufacturers are developing new fibres to produce belting with higher strengths whilst at the same time retaining the flexibility of current designs. One such fibre is aramide, with an extremely high strength/weight ratio- There are aramide beltings operating today İn solid woven, steel cord and straight-laid cord configurations.

However, there are serious questions yet to be answered and proven with regard to its ability to be readily joined, its peformance at normal factors of safety and its cost-effectiveness when compared with current belting available.

Whilst the physical characteristics of beltings are continually being improved, they are at the same time having to comply with higher and higher safety requirements worldwide as more and more national authorities are continually increasing the severity of their standards. The highest standards currently in force are undoubtedly those in operation within the UK and West Germany, both countries having extensive nationalised underground operations and a close supplier/consumer liaison to provide the basis for development, with tests now undertaken to simulate underground conditions as much as possible. In addition, in the UK there is great emphasis today on Quality Assurance schemes, designed to ensure continuous production of acceptable belting.

The cable belt with its well known feature of by which the belt is carried on two cables has over the years continued to be a major option over the conveyor system designs.

10. COMPUTER AIDED DESIGN OF A TRANSPORT SYSTEM

For nearly twenty years it has been the practice to design complex systems by use of such processes. It is appropriate to comment upon the desirability of using this approach.

Coal faces and developments are situated some distance from shafts or adits to the surface. The capacity of these shafts often constitute a restriction to output due to limited capacity plus the necessity for time given to inspection, maintenance etc.

Coal is actually produced for a relatively short time during the day, much of the time being taken by maintenance, turning round of machines at face ends, advancing conveyors, dealing with geological conditions and travelling time for face workers.

The rate of coal produced at each face and development varies, and hence the total capacity requirement of the whole system continuously varies.

The simplest coal clearance system would be of sufficient capacity to allow unrestricted flow of mineral from all coal producing points to the surface without resorting to bunkers. This would require enormous conveying capacities with enormous conveyor drives which could not sensibly be accommodated underground and would be prohibitively expensive.

The problem can be resolved economically by the use of computerised coal clearance desing available UK manufacturers for agencies like British Mining Consultants and the National Coal Board. Two software systems are in use - SIMBELT andSIMBUNK.

Information required:

— Operational details from each face, i.e. rate of production, production rates and delays. Also included are random delays.

— Shaft details, i.e. time available, number of shifts per week, capacities etc.

— Mine layout, i.e. number and location of coal producing places. (Producers); conveyor belts, bunkers - from this information a model is built up.

— Conveyors - location, speed, capacity, length.

— Bunkers - location and capacity, infeed and outfeed rates.

The computer then provides the information required. Experience shows that with this approach the size and power of conveyors can be reduced and delays eliminated.

The computer print out derived from this information shows the state of the conveyor system during a prolonged operation meeting requirements taking account of all expected and unexpected and abnormal RANDOM occurrences.

11. CONCLUSIONS

From the information given in this paper it can be seen that if a transportation system is:

— planned in detail
— installed with the latest type of equipment
— controlled and monitored

Such an installation should adequately cater for the tonnage rates from highly productive faces and do so with a reduction in manpower and maintenance costs.

Most of the requirements are probably obvious yet are so often not achieved, but it is evident that if we require a coal clearance system capable of keeping abreast with the output from fully mechanised highly productive faces, then modern technology and its associated equipment must be applied.

The objective of this paper has been to highlight some of the types of equipment required for an efficient transportation system and what is considered to be the most important inclusions can be identified as follows:

— drives with the correct power rating incorporating appropriate transmissions systems to give a wide range of operational functions

— automatic take-up units with adequate belt storage and the associated equipment to ensure maintenance, lengthening and shortening of the belts is carried out easily

— type of belt, width and speed carefully selected to meet the required tonnage rates

— bunkers strategically sited to maintain continuous and consistent tonnage rates