Environmentally Friendly Enclosed Conveyor Systems

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SYNOPSIS

Enclosed Conveyor Systems

Belt conveyors remain the most widely used means for the transportation of bulk materials in industry. The greater *economic efficiency* of belt conveyors and the *high degree of automation* available are some of the main reasons for their success as transport systems.

When it comes to conveying in enclosed systems, the inherent advantages have long been recognised when handling dry powdery materials or materials with high moisture content.

Before the advent of these conveyor types, their conveying involved positive pressure, vacuum type pneumatic systems or pumping systems, with the associated problems of limited capacities and high power consumption.

Today however there are several enclosed conveyor technologies in varying stages of development and this paper will attempt to enumerate them by comparing them with the already proven Pipe Conveyor.

These systems are broadly:-

- Pipe conveyors
- Sandwich belts
- Bag conveyors
- Folded belts

ADVANTAGES OF ENCLOSED CONVEYORS

The material being transported by enclosed conveyors is completely enclosed by the conveyor belt for the major portion of its travel. This has several benefits:

■ The environmental pollution is minimised as dust generation and en route spillage is practically eliminated.

Material is effectively protected from the elements and from contamination.

■ Valuable product is also effectively protected from theft.

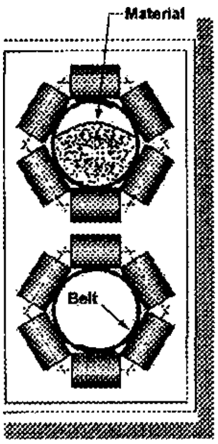


Fig 1. Enclosed Conveying

GENERAL DESCRIPTION OF PIPE CONVEYORS

Since the Japan Pipe Conveyor® is probably the most widely used of all enclosed conveyor systems we will describe this in some detail in order that the principles of enclosed conveyors be more clearly understood and therefore serve as a comparison for the other systems described herein.

It is a derivative of a conventional belt conveyor system, and comprises a head and tail pulley, one of which is driven, over which an endless conveyor belt is spanned. The belt is tensioned in a similar manner to conventional belt conveyors. Beyond the loading point, the belt passes through a series of pipe forming idlers which effect the transition from conventional to rolled form. This transition takes place over a distance calculated to minimise belt stresses. Once formed the pipe shape is maintained by six idlers set in a hexagonal pattern at each idler frame. Idler frame spacing depends on pipe diameter and ranges from 1 to 3.5 m.

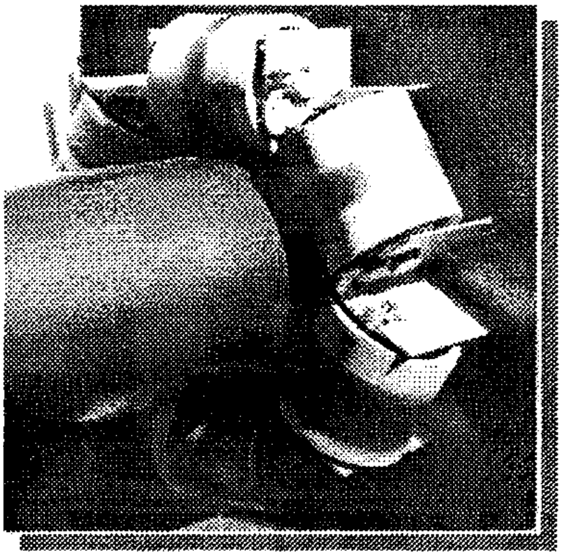


Fig 2. Japan Pipe Conveyor®

The return belt is formed into a pipe shape in a similar manner with 'dirty' side still on the inside.

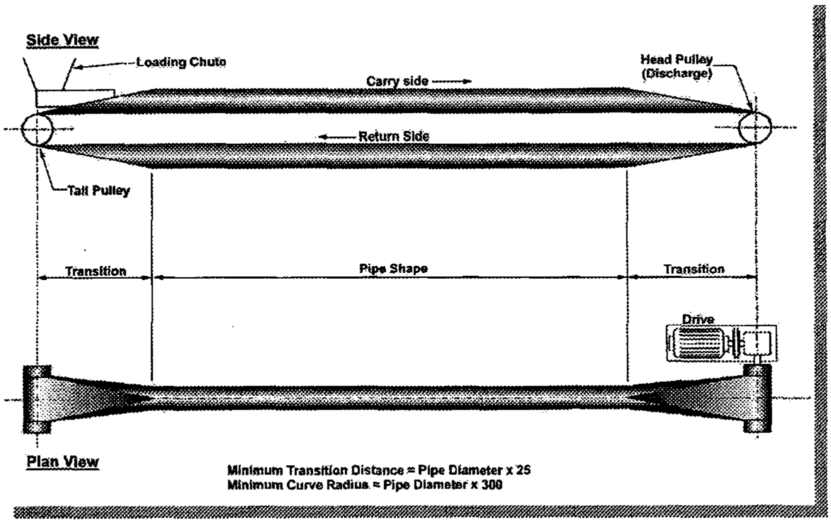


Fig 3. Schematic of the JPC layout

Because of the load distribution within the pipe conveyor and the resulting contact area between the material and the belt, it is possible to convey material at inclinations of up to 50% more i.e. 27° to 30' compared with 17° to 20° of a conventional belt conveyor and hence:-

- As a result, the overall length of the conveyor system can be reduced and plant footprints can be smaller.
- The structure of the pipe conveyor is narrower than a standard troughed conveyor of the same capacity and therefore requires less floor space.

Curved Transport

Because of the pipe form of both the feed and return side of the conveyor, it is possible to curve the conveyor in both the horizontal and vertical planes. Curves of up to 45 ° with a radius of 300 x pipe diameter are easily achieved, making in-plant curves feasible and reducing the number of transfer points required. Recent on-going development at J PC now permits curves through 90 ° with a radius of 600 x pipe diameter. This reduces:

- The need for multiple transfer points and drives which normally require more space and

cost.

- The power required lifting the material at repeated transfer points.
- Degradation of the product and dust generation at transfer points
- Costly chute liner

replacement.

PipeBeltConveyor Drives

Belt tensions and installed powers are calculated, as for conventional conveyors and power consumption for pipe conveyors and conventional belts performing the same functions are similar. Additional installed power due to curves and pipe forming resistance is minimal.

Brakes and holdbacks are installed when necessary. The conveyor drive is, wherever possible, located at the discharge terminal. Because of the special characteristics of the conveyor belting, pulley diameters are typically slightly larger than in the case of conventional conveyors.

Idler Sets

Idler sets are made up of six roils each for both top and bottom strand. The idler rolls are fitted in brackets and welded in hexagonal pattern to the idler support steelwork. The idlers are aligned via special adjustable locating clips. (See Fig 2)

Idler sets are spaced at intervals of from 1 to 3.5 metres depending on pipe diameter, loading, number of curves etc. The ability of the rolled belt to contribute towards its own support does allow a larger interval between idler sets than in the case of conventional belts, in the case of larger diameter / width conveyors.

Roll construction is similar to conventional conveyor idler rolls and incorporates deep grooved ball bearings, lifetime lubricated and sealed and labyrinth seal and dust protection.

BELTING

The most important part of the pipe conveyor, as with any conveyor, is the belt, and a special belt had to be developed to suit the particular needs of the pipe conveyors.

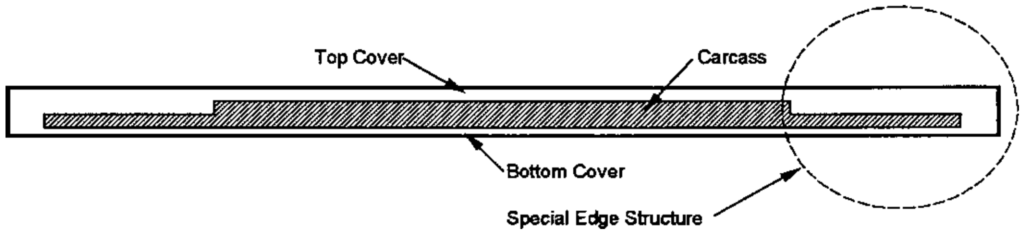


Fig 4. Basic JPC Belt Structure

The most important of these is that the belt closing force (i.e. the effort required to continuously form the belt into a tube as it passes through the transition section) must be kept as low as possible. However, the belt has to be sufficiently stiff to form a tube and not be pressed by the load into a hexagonal shape as it passes through the idlers. These are set with six idlers in the shape of a hexagon.

For steel cord belts, a similar type of construction is used with a layer of transverse fabric being placed above and below the steel cables, again with a carefully controlled layer of rubber separating the fabric layers from the steel cords.

Although it appears to be a conventional belt to the casual observer, the pipe conveyor belt has taken a considerable amount of design and experimental work to develop to the state where the pipe conveyor may be considered a positive and problem free method of conveying material.

However since there is now a large world population of Japan Pipe Conveyors®, belting is manufactured by several well known companies thereby preventing a monopoly situation from arising.

Take Up Assembly

Pipe conveyor belts are tensioned in a similar way to conventional belts by gravity, hydraulic or mechanical methods.

ENCLOSED CONVEYOR SYSTEMS - GENERAL OVERVIEW

Enclosed conveyor systems can be divided into two main systems namely those which can be curved horizontally and those which cannot be curved horizontally. It follows therefore that each type will have been used in the situation that utilises its features and benefits to the maximum.

1. Horizontally Curvable Systems

Pipe Conveyors

Pipe conveyors are by far the most widely used with more than 700 installations The Japan Pipe Conveyor® boast over 600 installations worldwide, the longest being 5.5 km in length and the largest tonnage operation being 7000 tph.

There are now several alternative makes such as the Rollgurt® Conveyor coming onto the world market, ail having variations on the JPC idler layout, in attempts at circumventing the Bridgestone Engineering patents.

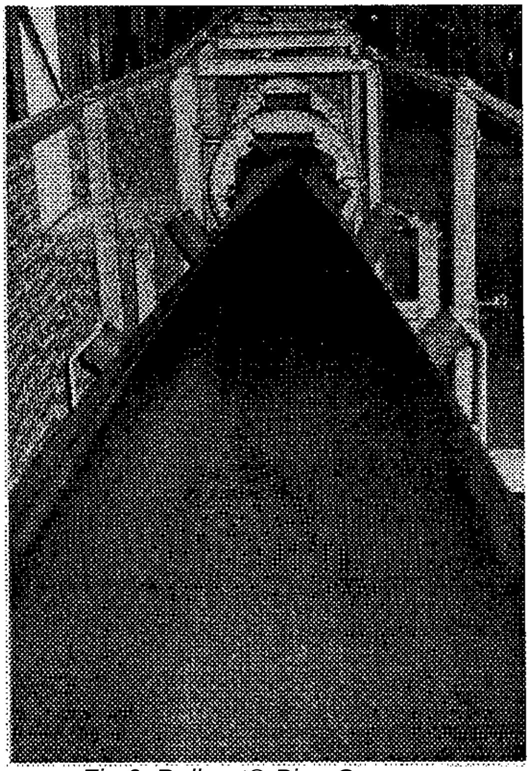


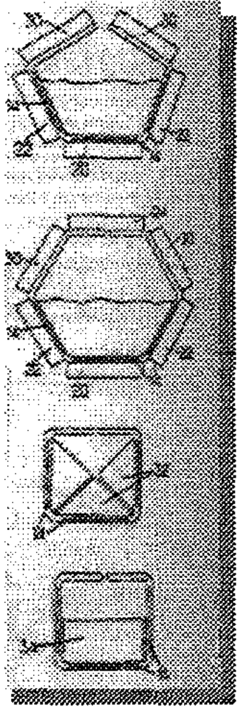
Fig 6. Rollgurt® Pipe Conveyor

U or Square Shaped Conveyors

These are available in a wide range of designs from several manufacturers and they lie between the conventional troughed conveyor and the true pipe conveyor. They tend to use fewer idlers than the pipe conveyor. To date few installations are listed world wide. While they should be simple to operate, it is reported that some problems have occurred with belting due to differential tensions when negotiating curves.

The key part of a U.Con® system is patented closed belt which has variable cross stiffness over its width. In one version it is fitted with a locking system which keeps the belt folded without using rollers. This system results in good sealing which allows for vertical transportation. It is claimed that the U.Con® uses sharp curves but no figures are given in the literature.

Square Belt® utilises a belt design derived form the Michelin radial tyre technology. Where the longitudinal strength is separate from the flex characteristics and has resulted in the Autostable® belt. Claims for this system include perfect belt training since the shape does not allow for rotation, tight horizontal and vertical curves (no data given) and wide spacing of idlers



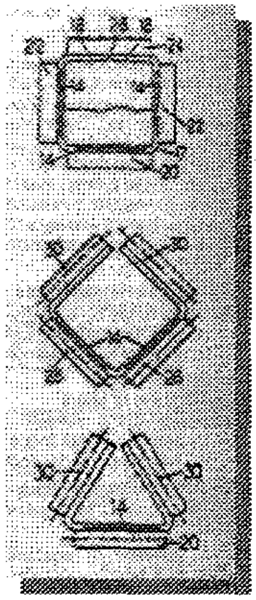


Fig 7(b). Variations of the Square Beit® Square Conveyor®

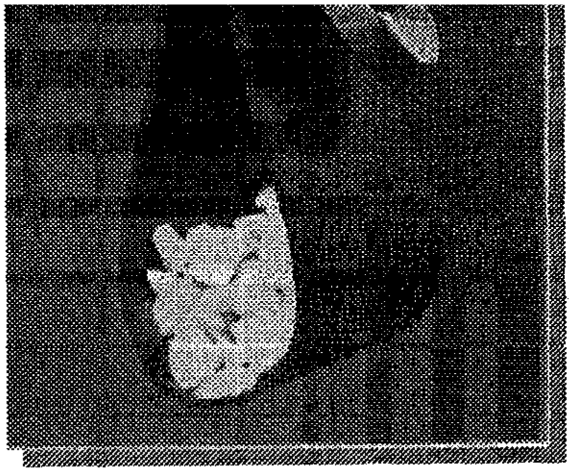
Bag Conveyors

The name derives form the tear drop shape. The simplest way of describing them is to imagine folding and nipping the two edges of a conveyor belt together at the top and allowing it to hang below.

There are several commercially available systems of which the SICON® is perhaps the most widely used and known. The method of nipping them together varies from types of spigot and cup, zip pinch rollers and in built wire rope. It follows that the belting manufacture is specialised and that until they are widely used the belting manufacture can tend to be monopolistic. To date systems in use have tended to be of small tonnage, but they have the advantage of being able to negotiate curves of radii even less than pipe conveyors. This feature allows them to be laid out in a spiral and thus convey material vertically.

On interesting feature of the Sicon® conveyor is its ability to run as a closed loop. This is because the return section of the belt does not have to follow the carry section one can imagine the variety of load carry that this system allows for flexible plant design. Multiple drive units can be installed usually fitted to any curve where belt wrap is a minimum of 90 In this context a 500 m Sicon® conveyor carrying alumina over a distance of 500 m has 29 ninety degree bends within its length.

Fig 8(a) Cross Section of the Sicon® Conveyor Showing



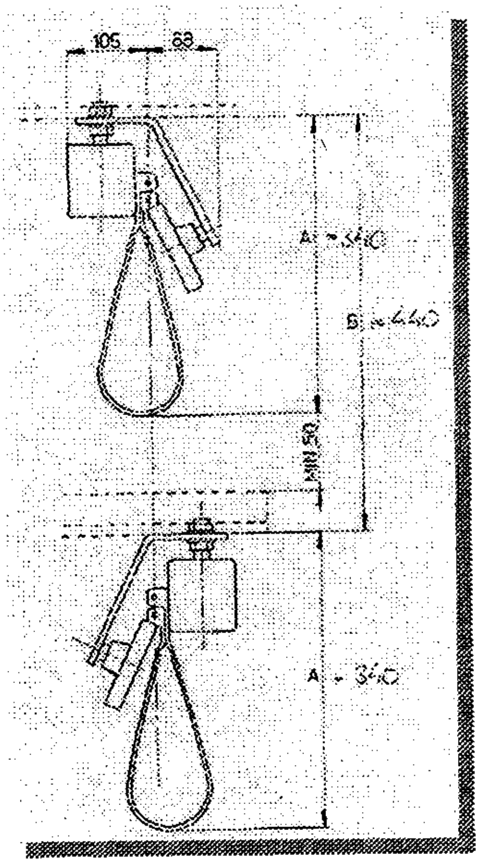


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Fig 8(b). Sicon® Conveyor Showing Drive Arrangement

Non Horizontally Curvable Conveyors

Sandwich Belts

Probably as well known and more widely used than the Pipe Conveyor, the sandwich belt, as the name suggests, consists of a conventional troughed conveyor with a second conveyor belt placed on top of it. The conveyed material being the "meat" in the sandwich.

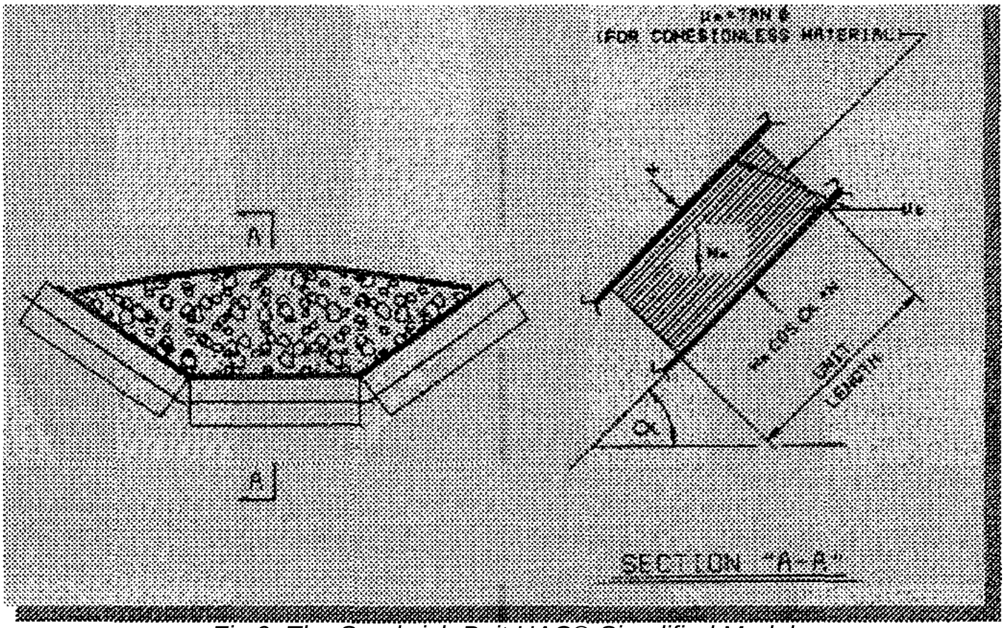

Fig 9. The Sandwich Beit HAC® Simplified Model

This top conveyor is not driven but is propelled by the friction between the top and bottom belts due to their edge to edge contact. It follows that while the belting is not of special constructions (As are all the other enclosed conveyor systems discussed here) in order to provide the contact zone between belts they must both be wider than would normally be used. Additional downforce is provided by placing idler sets, on top of the belt, at suitable intervals.

Belts of this type are able to convey material up inclines of up to approximately 45 º.

When the top belt is also driven and tension is applied to pull the top and bottom belts together as distinct from relying on gravity to keep the top belt in contact with the bottom belt, then such belts are capable of conveying material vertically.

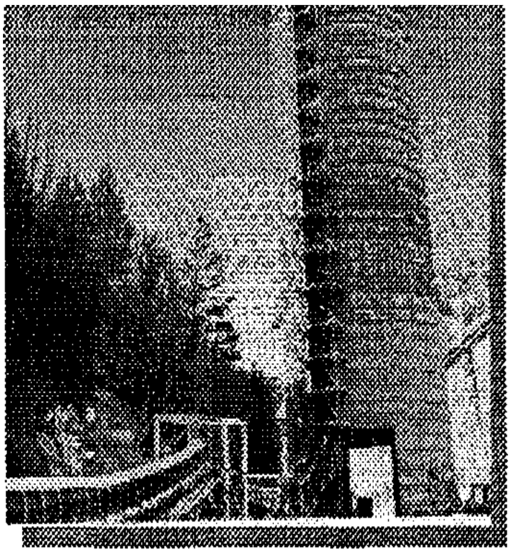

Fig 10. HAC® for Bethenergy, USA

The best known is perhaps the HAC® usually shown going up the side of a silo, as and in Z configuration it is widely used in the Great Lakes region of USA/ Canada on self unloading ships.

Here in South Africa in a C configuration there are several examples to be found at Sasol 2 and Sasol 3 carrying coal.

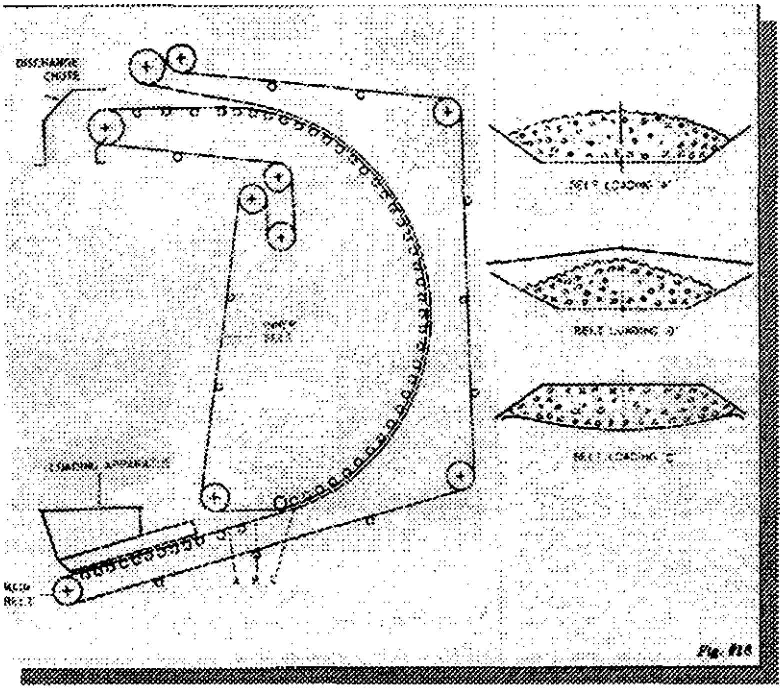

Fig 11. Full Gravity Type Self-Unloaders

The Sandwich and HAC® conveyors offer several advantages perhaps the most important relate to their use of conventional conveyor equipment such as belting, pulleys drives etc. What is perhaps not appreciated is that conveying rates in the order of 6000 tph have been achieved with HAC® for out of pit operations true vertical lifts of up to 175 m have been achieved.

Folded Belt®

This is a new technology which utilises a single belt which has 2 notches running along its length roughly 1/3 in from each edge. Material is loaded as for a conventional conveyor and the conveyor then runs through a set of transition rollers which fold the two edges over on top of the material. At first glance one is tempted to say that this is another form of pipe conveyor, however in contrast to the pipe conveyor, where material only fills 50 - 60 % of the pipe cross section, the belt "hugs" the material tightly, in a manner more analogous with the sandwich conveyor. Such belts are able to carry material at inclinations of up to 45

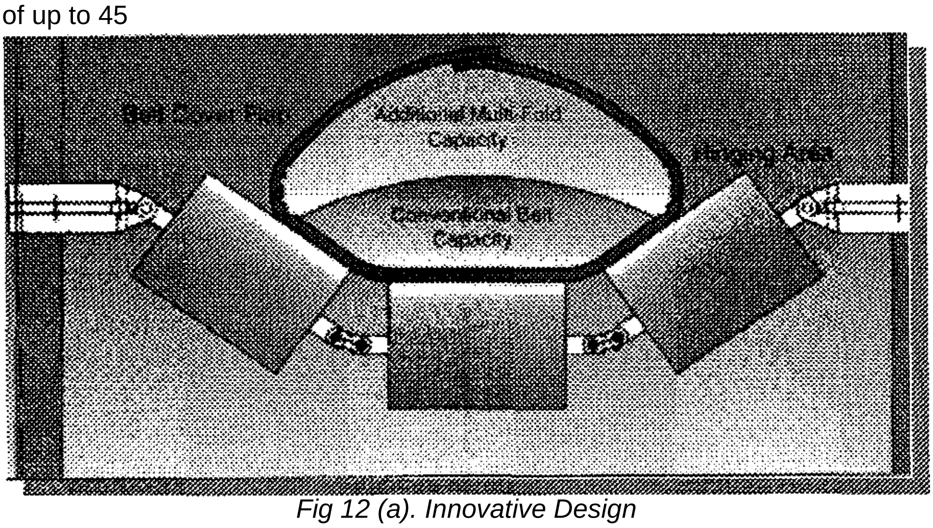

Fig 12 (a). Innovative Design

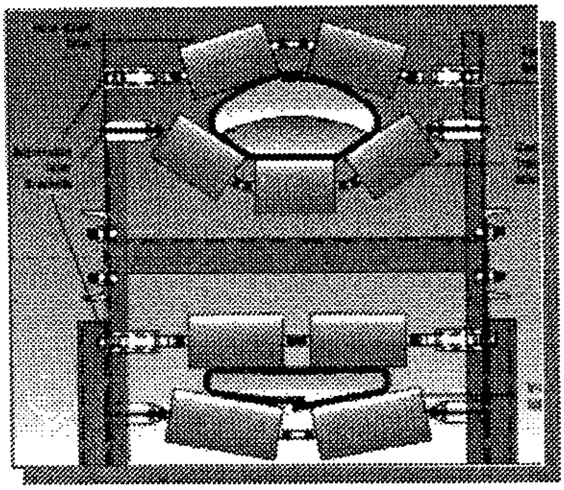

Fig 12(b). Contained Conveying

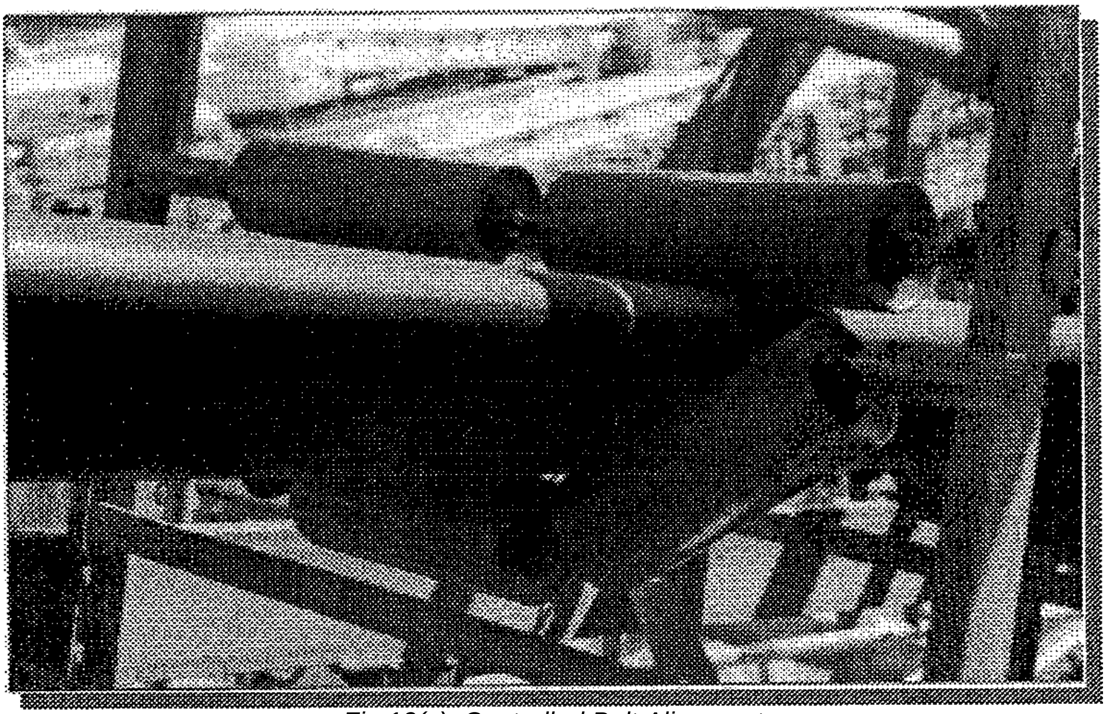

Fig 12(c). Controlled Belt Alignment

CONCLUSION

As engineers we are going to be more and more faced with environmental issues in our work. Enclosed conveyors with their ability to protect the carried material from the environment and conversely the environment from the material will play an even larger role than in previous times. The technology of enclosed conveyors can therefore be expected to develop more rapidly in the future than it has done to date.

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