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quality of this paper!***

Continuous Haulage Systems and Curve-going Conveyors

Historical overview and new innovations

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Historical Developments leading up to the introduction of Continuous Haulage (CH) systems

Several innovations have marked milestones in the mining of coal and other soft applications.

In times past, coal and ore were broken out of the face by strong-armed miners using chisel and hammer. The materials were hauled on carts, in baskets and on rail hoppers by either man or horse power.

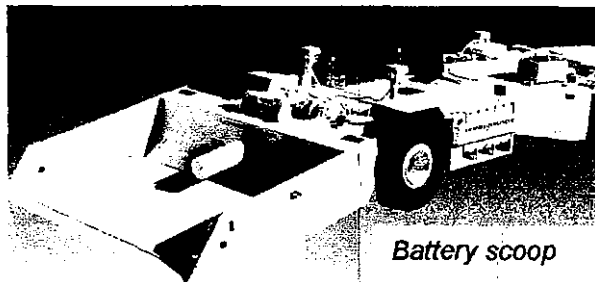
Explosives changed this manual mining process; pneumatic jackhammers replaced manual tools.

The donkey cart was replaced by locomotives and on the coalface, mechanization started in earnest.

Coal cutters, acting as giant chainsaws allowed bond and pillar bulk mining.



Coal cutter



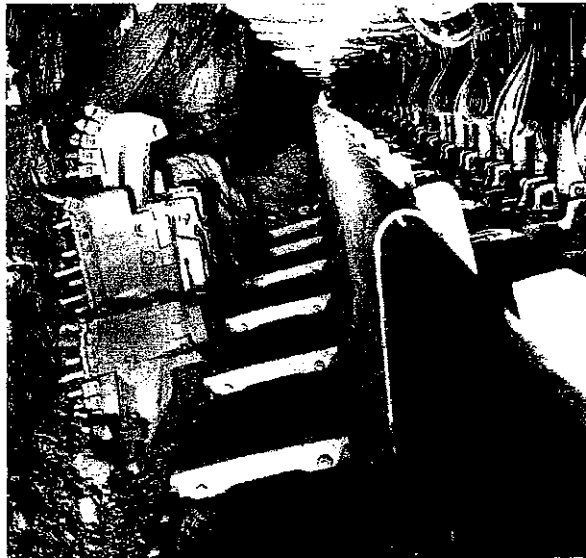
Battery scoop

Mechanized transport, LHD (Load-haul-dump) units, loaders, scoops etc. were introduced to handle the increased material flows.

Multi-head drill rigs speeded up the blasting process.

Pillar mining systems left large ore reserves un-mined; hence total extraction methods were developed.

Short and Longwall mining, using coal plough and shearer systems facilitated full extraction of these valuable reserves.



Roadheader

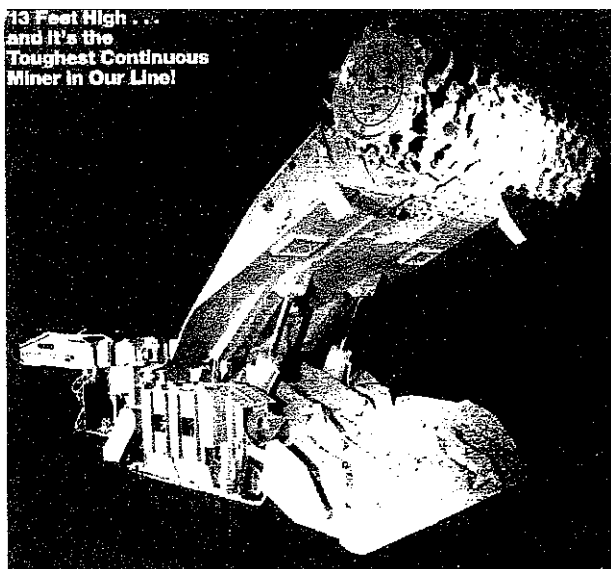


Longwall shearer

Longwall plough

These methods however could only be applied efficiently, if one had a large undisturbed ore body available and these are rare.

The Continuous Miner / Roadheader, a track mounted machine equipped with a rotary drum cutting head was developed in the early 1950,s and this unit combined mobility with high production capacities.

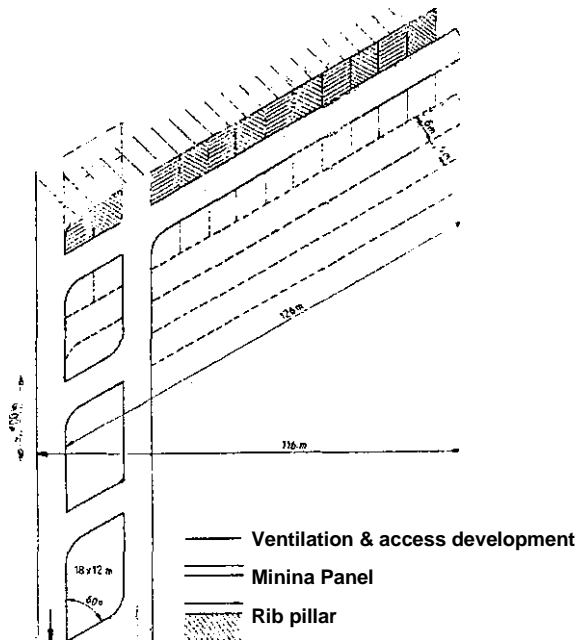


The CM is a highly mobile unit and always on the move, whereas the main conveyor system feeding the coal out of the mine is stationary and thus not able to follow the CM.

This distance between the Continuous Miner and the main panel conveyor may be up to 150 m and needs to be bridged.

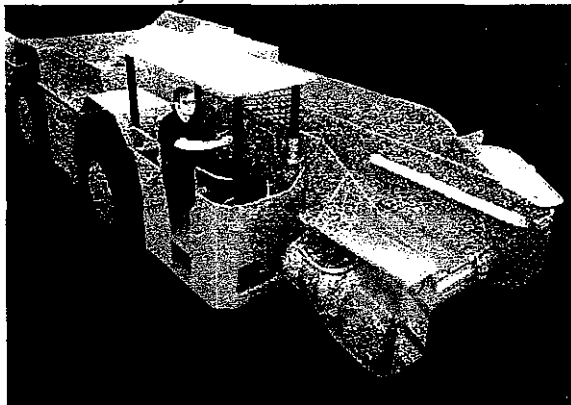
TYPICAL PANEL LAYOUTS RIB PILLAR

BORD & PILLAR



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This was and still is done by using mainly diesel; battery or electrically powered shuttle cars (underground trucks), designed to carry the coal from the CM's out-feed conveyor, to a stationary rubber belt conveyor.



Shuttle car



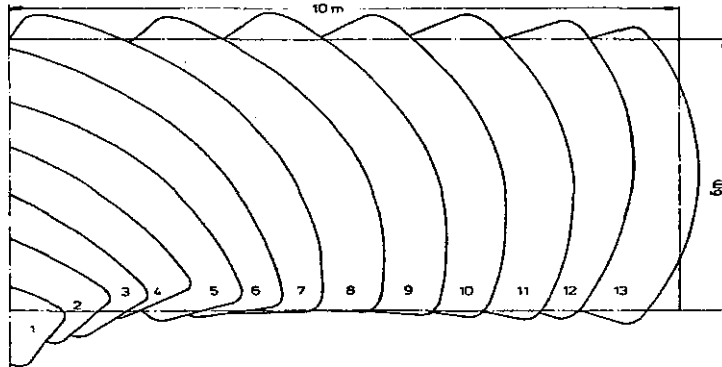
Battery hauler

The confined space underground is not conducive to the use of mobile conveyance.

This results in many delays caused by time used up during positioning the shuttle cars, tramming, bunching up at discharge points, and beneath the CM's discharge point.

Consequently the CM, although capable of cutting almost continuously, has to stop and start frequently.

The mining process becomes a severely interrupted and no longer a continuous one.



Turn off 90° and advance 10m Eindrehen 90° u. 10m Vortrieb				Cutting forward advance 11m Geradschneiden 11m Vortrieb	
Schnitt	Bumping cut Einbruch	Horizontal cut Horizontalschnitt	Vertical cut Vertikalschnitt	Cutting height 35m	Cutting height 35m
1	10 sec	5 sec	10 sec	60 sec	
2	20	9	74	118	
3	30	15	120	160	
4	40	21	166	200	
5	50	27	212	240	
6	60	33	258	280	
7	60	33	198	230	
8	60	33	138	180	
9	60	33	78	120	
10	60	33	18	20	
11	60	33	186	270	
12	60	33	186	270	
13	60	33	186	270	
Σ			2112 sec	3100 sec	
geschr. Volumen mining volume	m³	214	306	231	330

SCI-ME1DVORGASEN BEI W GERADSCHNHOEN - CUTTING DEPTH AT CUTTING FORWARD
Einbruchtschnitt: T50-T70 mm Vorgabe = & Schnitftte Sumpiog cut : 150-T70mm depttn « 6 cuts
Horizontaltschnitt: 350-370 mm Vorgobe (vsrtikal) = 5 Schnitte tohoe

Horizontalcut: 350-370mm depth = 6 (without suroping)
EinbruchscPirtt: 150-170 Vorgobo = 6 Scnr.il Sumping cut: "SO + 170mm tfepth - 6 cuts
Horizontaltschnitt: J50*370mm Vorgabe t vertikal = 10 Schnitte (ohns Einbruchschnilli)
Horizontalcut: 350-370 mm depthf vert ic<3]= TO cuts (wit hout sumping cut J S CH NEID Z. ET ERMITTLU N G DETERMINATION OP CUTTING TIME

ALPINE MINER AM 100-AOO KW — 12:52

Cut and load	Waiting for shuttle car	Change over	Other times	
1 cut 27 = 270 sec 45cuts = 203 min 3.4h = 42%	1.0h = 13%	1.2h = 15%	2,4 h = 30%	Actual study Shows between 28% and 34% production time lost during shuttle car operation
1 cut = 270 sec 49 cuts = 221 min 3.7 h = 46%	1.2 h = 15%	1,5 H = 19%	1,6h = 20%	

It is estimated that 40% of production capacity are lost due to inefficiencies.

The result of these interruptions becomes evident in the following example.

A large Colliery group operates 70 continuous mining systems each 490 shifts per year, a shift lasting 9 hours.

Their yearly coal production is ± 43 million tons, resulting in an average hourly production rate of 140 tons.

Since Continuous Miners can comfortably cut 600 to 1 000 tons/hour and in peak periods up to 1 500 t/hr, this means that the total efficiency of their mining process system is at best 20%.

The shortcomings of the shuttle car system are not the only cause of this inefficiency.

There is support work, roof bolting, shunting, maintenance, conveyor installation, etc. to be considered but in essence the overall efficiency relative to the financial input is reality and the mines have been searching for new solutions.

CONTINUOUS HAULAGE SYSTEMS - THE QUEST TO TAME THE CURVE

The trick is to achieve fast, continuous, uninterrupted material feed, bridging the distance from the continuous miner to the panel conveyor by means of a **self propelled, mobile haulage system**.

Conditions encountered underground can be quite severe; muddy soft undulating underfloor conditions are prevalent.

Space is at a premium whilst the equipment has to be strong, mineworthy as well as maneuverable.

The materials mined are partially abrasive and occasionally break of in large chunks.

The major obstructions are however the roof supporting pillars and any haulage system has to be able to convey around them, negotiating these tight **CURVES**.

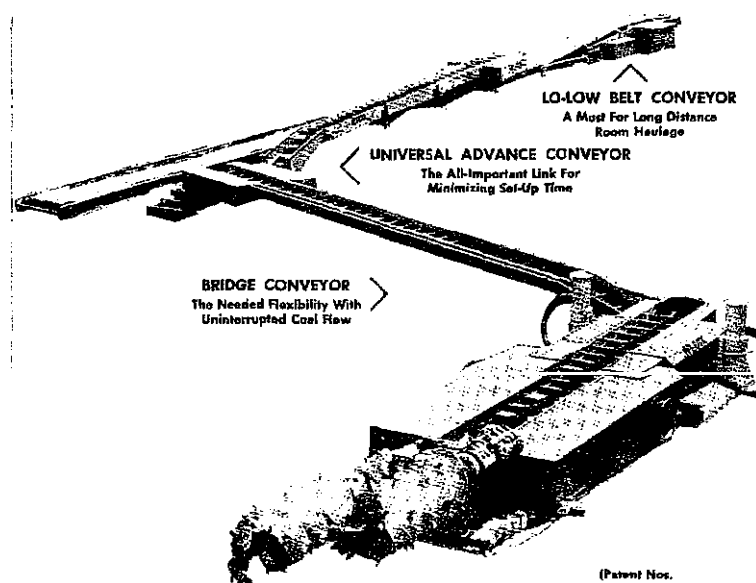
Most major equipment suppliers have attempted to design and implement a CH-system. Some of these are operational today, some had partial successes and some have failed entirely.

SYSTEM CATEGORIES: A. BRIDGE-TYPE CONVEYORS

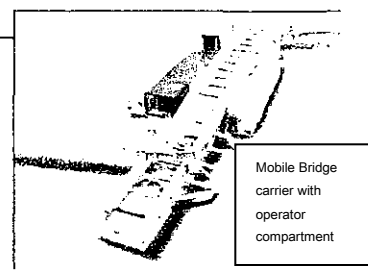
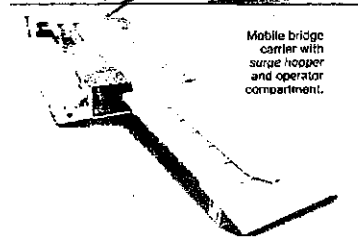
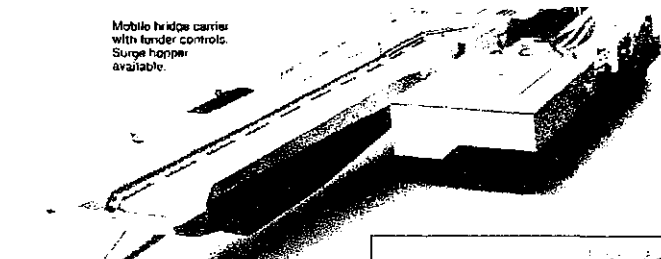
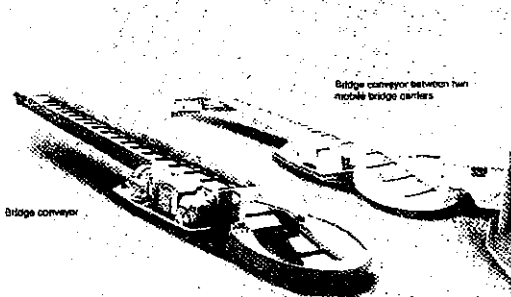
Most of these consist of mobile bridge sections; track or wheel mounted and carry chain-or rubber belt conveying decks.

1. Fairchild

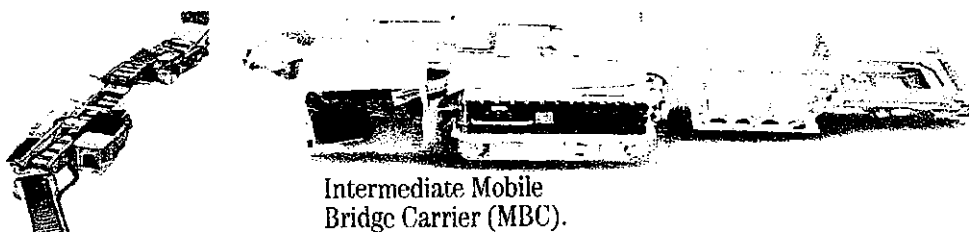
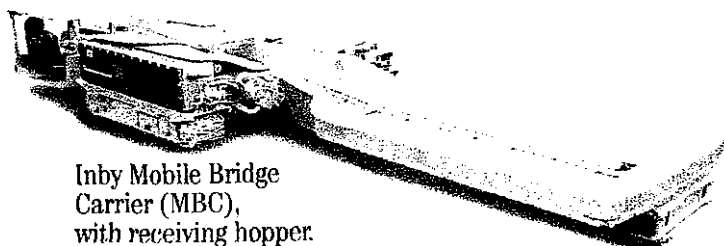
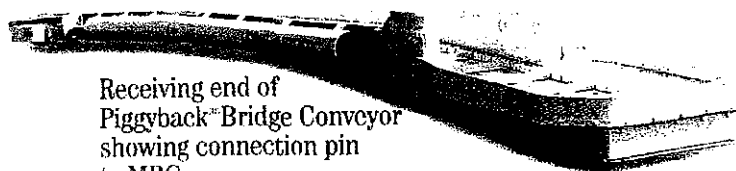
First with Continuous Haulage For Continuous Mining



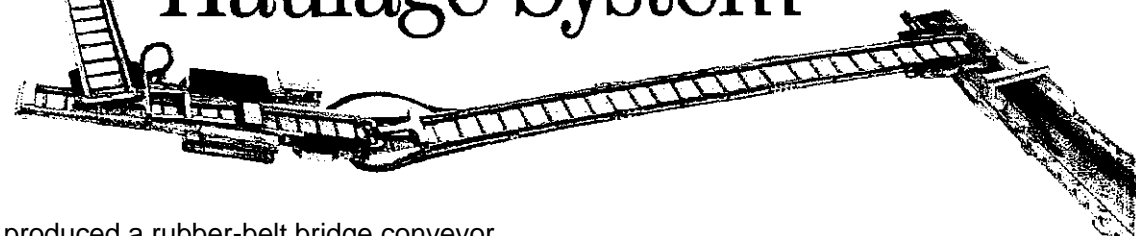
2. Jeffrey



3. Long-Airdox



Haulage System

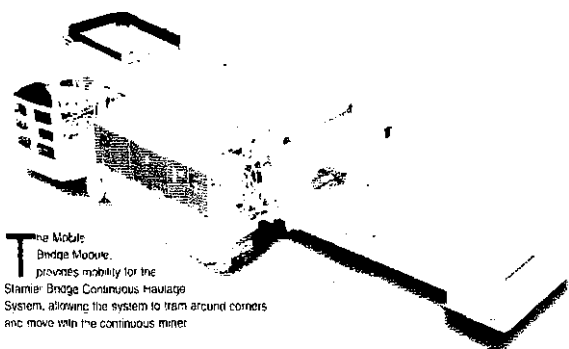


Initially LA produced a rubber-belt bridge conveyor

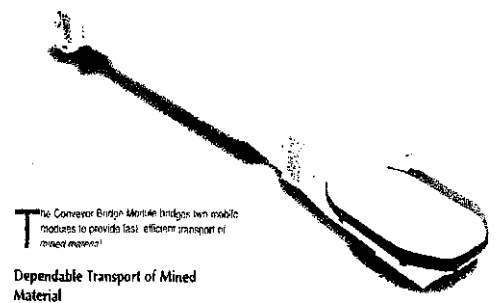
Because of major spillage and belt cleaning problems it was later discarded in favour of a chain-conveyor bridge.

4. Oldenburg Stamier

Mobile Bridge Module Stamier Bridge Continuous Haulage System Conveyor Bridge Module



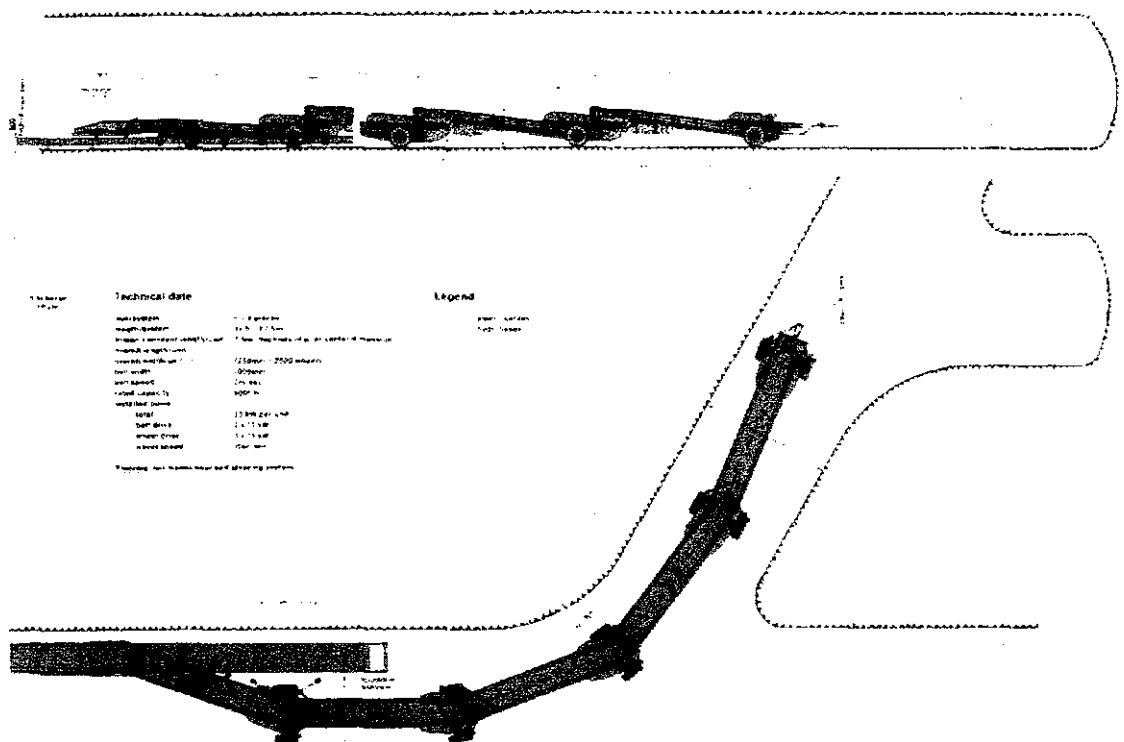
Stamier Bridge Continuous Haulage System



5. JOY Bridge Type CH

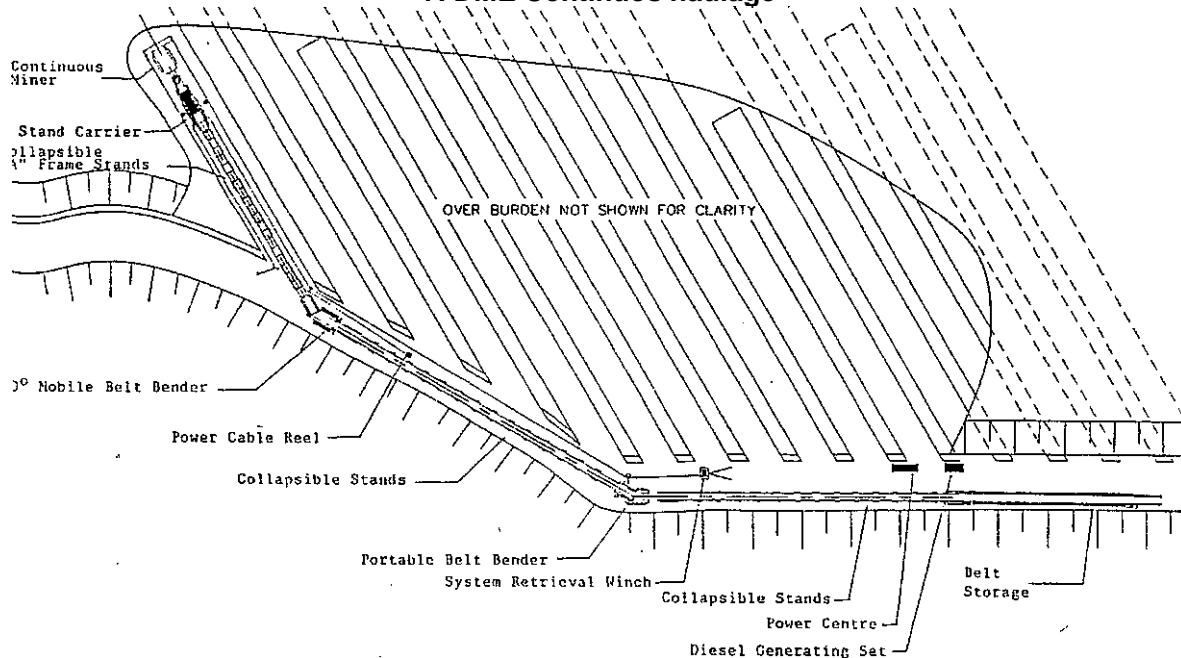
6. Voest CH

The Voest Alpine bridge-conveyor system was equipped with a rubber belt conveyor and propelled on rubber wheels. Spillage was uncontrollable, and thus tramming became a problem.



Proposal for pillar extraction CM-Joy 12 HM 9 with VOEST-ALPINE cont haulage system

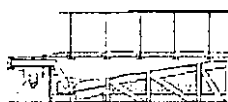
7. DME Continuos haulage



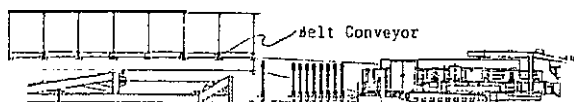
All these above Systems have their roots in existing chain and rubber belt technologies.

A telescopic conveyor utilising a belt bending section and collapsible A-frame belt supports mounted on skids.

T



Belt Storage Magazine



Telescopic Stands

/ Mobile Feeder
 Telescopic / Breaker Stands
 -Trailing Tail Unit

Summary

None of the above bridge type systems is able to negotiate tight curves without interrupting and re-directing material flow.

Hence, they all rely on the use of a multiple bridge sections, moving ore/coal in a series of waterfall-like transfer stations from one to the next section.

The pitfalls are:

Spillage:

Every transfer station is a potential source for spillage

One has to imagine that whilst conveying up to 10 000 M³ per shift, even as little as 0.1% of spilled material (10M³) necessitates an expensive cleaning exercise. In confined spaces, manual labour is many times the only option.

Rubber-belts especially, are prone to retain sticky materials and the application of multiple cleaning stations is in many cases not technically feasible.

Hence, mostly wear and tear prone chain conveyor systems are in use.

Deterioration of minerals:

The creation of fine particles causes major loss of revenue, especially to the coal industry. The more transfer waterfalls, the more fines.

Chain conveyors cause an additional milling action, especially in the bottom layers of the conveyed heap.

Increased manpower requirements

Every bridge-conveyor module needs a driver/operator, thus increasing the labour contingent, when compared with shuttle car operations.

A variety of systems are operational throughout the globe.

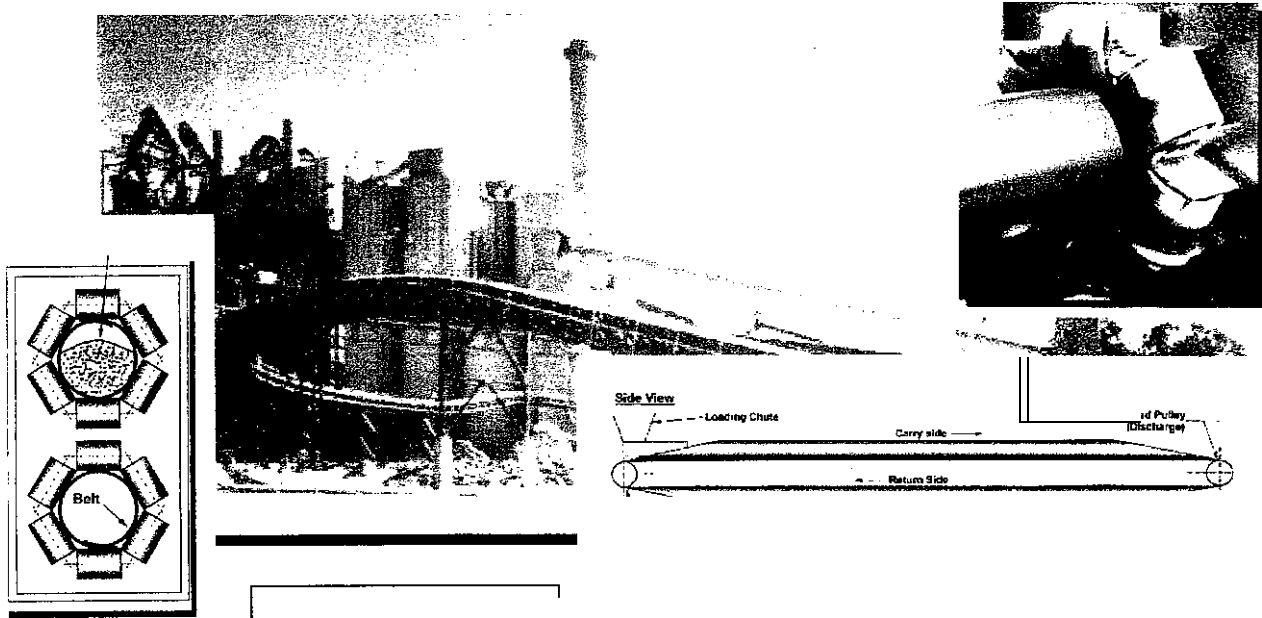
These systems produce **± 20% more tonnage than shuttle car systems**, but being mostly chain conveyor-based, are expensive to run and to maintain. Running steel on steel and transporting sandstone-laden ores cause high wear. Correspondingly short TBO's (one million tons on average) are the costly result.

B. CURVE CONVEYORS

Only continuous curve-going systems are able to alleviate the shortcomings of bridge conveyors.
This revelation has progressively led to various design concepts.

1. JPC Pipe conveyor

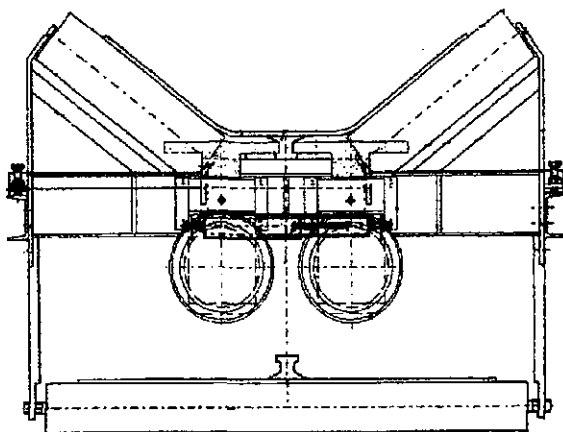
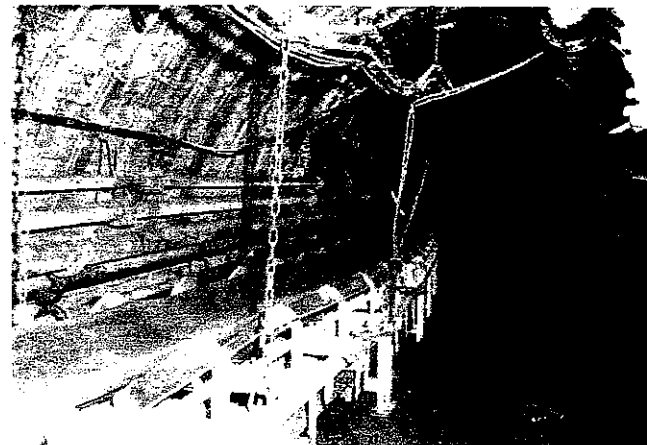
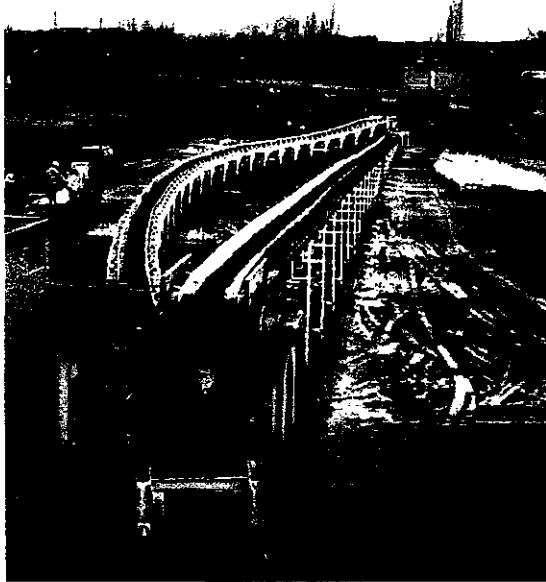
Idlers are arranged in such a way that the conveyor belt forms a tube containing the material



2. BINDER System

3. CONFLEX system

The design relies on a stretchable rubber belt driven by multiple friction rollers acting on a vertically vulcanised drive strip



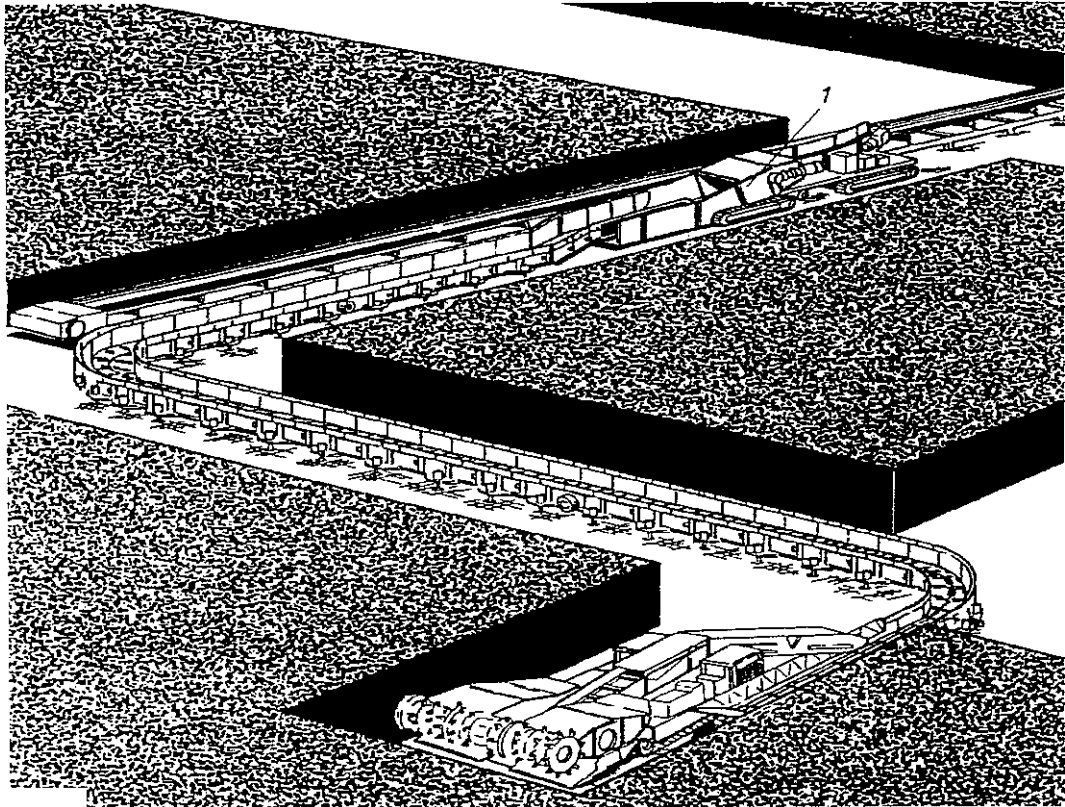
Minimum Radii Achieved: 40 m

Summary:

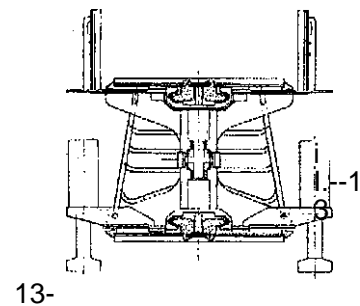
None of the above designs are able to handle the tight radii prevalent in underground pillar mining situations.

The systems below are able to negotiate >6m radii

4.KLOECKNER SHONGOLOLO



The Klockner Becorit Shongololo was designed as a chain plate conveyor snake, resting on a series of pneumatic cylinders.



By retracting the cylinders the conveyor would lower itself on its bottom conveyor strand. It would so become an endless track, able to move back and forth. The front and rear were steerable whilst the main conveyor retained its position by resting on the bottom track plates. It could negotiate curves well, but had to stop conveying whenever repositioning.

Spillage was no longer a problem, but in essence the unit was a chain conveyor and wear and tear in the chain-guides contributed to its self-destruction.

Service access and downtime was problematic and reasonable amortisation periods could not be achieved. The project was in due course discarded.

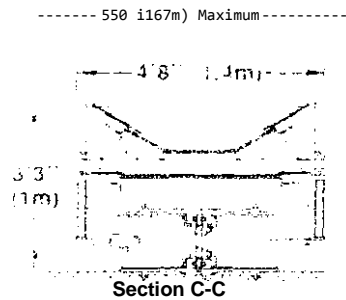
5. Joy FCT Flexible conveyor train

Joy, by building their own chain haulage, analysed the above problem areas correctly.

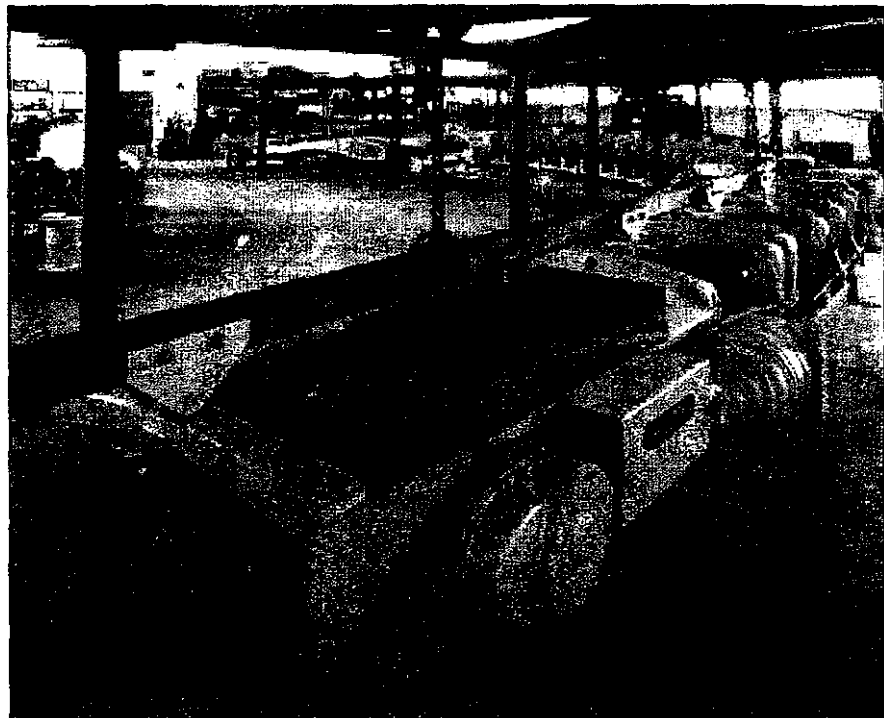
Jointly with BF GOODRICH they developed a centrally reinforced flat rubber belt, able to stretch, whilst going around corners.

A horizontal guide roller arrangement stops the outer perimeter of the belt from dislodging in curves.

The curve going undercarriage operates much like the KLOCKNER system, running on flexible multi-tracks.



A monorail-mounted FCT was introduced in South Africa, the mine found the unit somewhat cumbersome and difficult to move, anchor stability in the hanging also proving problematic.



The monorail system was relocated to OZ and presently there are four FCT systems operating in the USA.

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C. NEW MOBIFLEX CONTINUOUS HAULAGE

Evaluating the pros and cons of all the above it became clear that one needs to engineer a **robust rubber-belt conveyor system** that can carry material **abrasion- free** around **tight corners**.

This was achieved as follows

The design concept of the MOBIFLEX® system takes cognizance of the advantages of rubber conveyance, whilst applying the following parameters:

Belt system

- Application of a curve-going, folding belt strand
- Vertical support rollers take over the load carrying function of the belt. Precise horizontal guide roller system, allows smooth curved belt movement. Chain drive to carry all tensional forces (Alternative forms of propulsion, linear motor technology, rope etc. are available)
- Self-cleaning effect due to stretch and mini-vibration technology

The folds in the belt allow for stress-free stretching of the belt on the outer curve radius and contraction on the inner radius (Pic 1).



The centre-mounted chain (or rope) has a traction, as well as a load-carrying function, whilst allowing the required curved conveyor geometry.

The folding belt segments are firmly mounted to the chain and have a pure carrying function, as all other forces are taken up by the chain and its guide roller

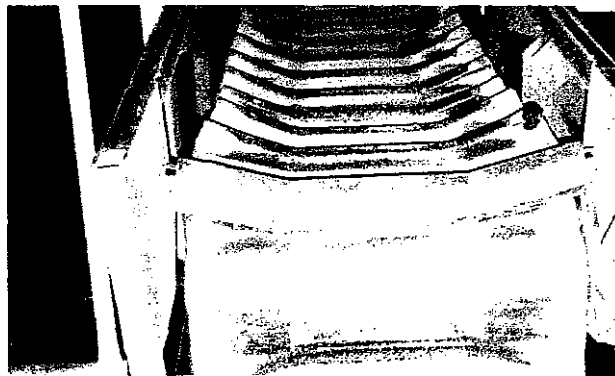
A chain-propelled folding belt has the advantage that tensional forces act solely upon the chain.

The rubber belt is not subjected to any stress or tension and does not require reinforcing or pre-stressing.

Belt longevity is thus ensured.

Horizontal and vertical guide rollers running inside pre-formed guide rails, achieve exact guidance.

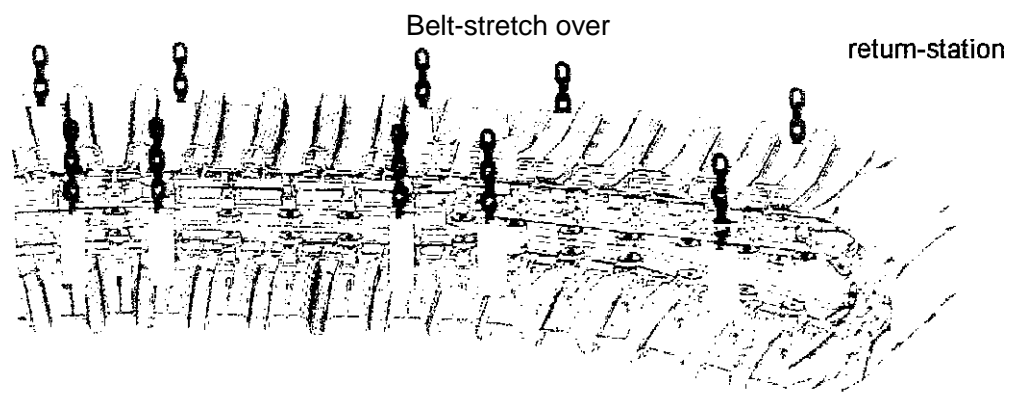
Pic 3



Pic 2 shows the cross section of the system depicting the belt as well as the guide mechanism.

Pic 3 shows the belt stretching geometry of the pulley

This simple, but robust design is suitable for even large- quantity bulk handling applications ($1500\text{m}^3/\text{hr}$).



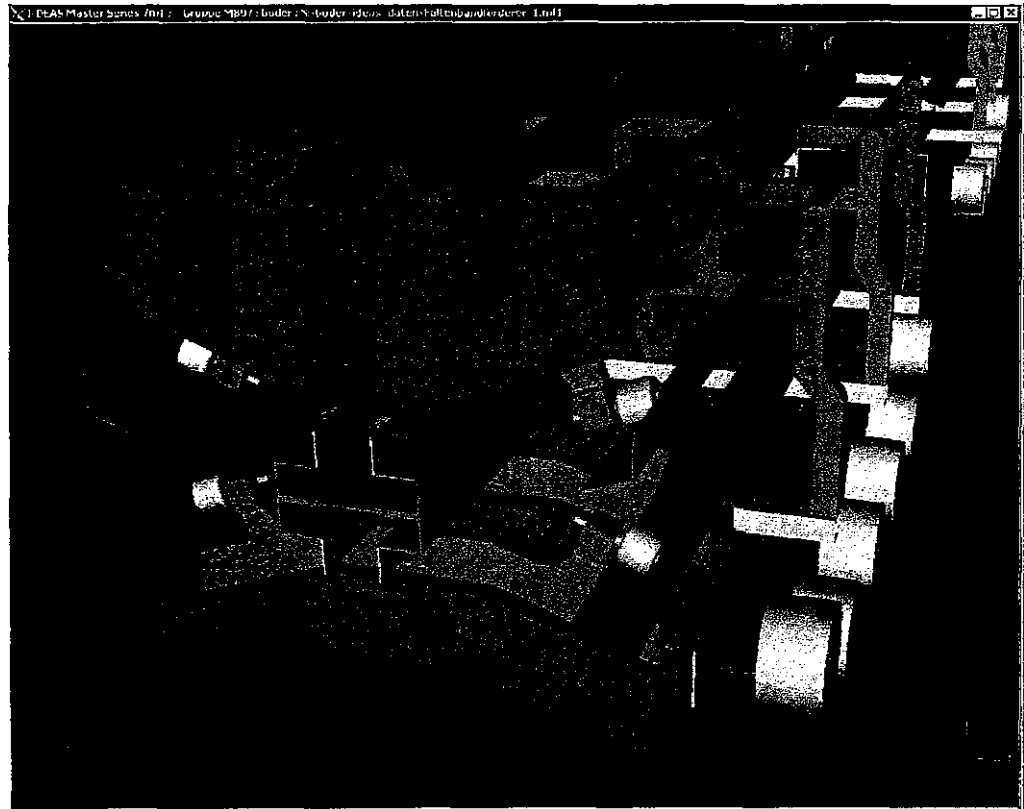
Monorail application alternative

Tramming systems

The conveyor deck rests on a chain tracks.

Variable speed drive ensures a large degree of maneuverability.

Latest hi-tech control and positioning systems make the unit fast, easy and safe to move, whilst taking cognizance of the necessity for robustness and mine-worthiness.



The advantages of the MOBIFLEX® System

- a) Space saving, light, economical construction
- b) Low energy requirements
- c) Ability to convey in a 3D environment, curves, inclines, declines, spirals etc.
- d) Precise guidance, no jumping, no misalignment, no spillage.
- e) High availability due to wear-resistant rubber belt.
- f) No transfer stations -no deterioration of product
- g) Modular design allows easy maintenance and parts replacement in situ.
- h) Improved lifecycle due to wear-free design.
- i) One operator per system

Conclusion

A well functioning continuous haulage system will increase production rates of the CM-CH process by 20-30%.

Example:

Continuous miner- Continuous haulage combination

Coal mining production section

20 % Production increase: +-200T/Hr (from 600 to 800 T/H)

@300 Hr/ mth = 60 000T Coal/ Mth

@ 30 US\$/ton=>235R/ton Harbour price (2001)

= 14 Mio Rand/ Mth Increase in T/O

= 170mio R/year Improvement in revenue

These are powerful sums and make the amortisation of a 14 MIO Rand system rather easy. The fact that the **quality** of the coal does **not deteriorate** is an added advantage, directly transferable into money, due to higher prices achieved.

At any given time, there are ± 1000-CM sections operational worldwide and growing. 140 new units are put into operation yearly.

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KF is a Mechanical Engineer by profession.

His specialised field are innovative designs related to mechanisation and productivity enhancement of mining processes and methods.

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