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Longwall shearer haulage systems - a historical review. Part 2 – First cordless haulage systems solutions

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Abstract:

Searching for cordless haulage systems started in early 50-ties of XX century. In semi-mechanized longwall faces in Germany and Hungary tracked narrow face cutter-loaders (first continuous miners) were used. Real trials began ten years later in Great Britain. First solutions described in this article were simply an adaptation of the existing Anderson's or BJD's single or double drum shearers. The main idea was to interfere to as less as possible extent with the shearer structure. After the first positive trials and experiences in British and French mines the first cordless solutions such as Rackatrak, Peratrak or ram propulsions were either developed or gone to the past. This article is a review of the first cordless shearer haulage systems.

Keywords: longwall mining, longwall system, coal cutter-loader, coal shearer, shearer haulage system, cordless haulage systems, chainless haulage systems



1. Introduction

Longwall coal cutters, moving along the face floor, using first a traction rope and then a traction chain revealed their drawbacks and limitations quite soon. The appearance of drum shearers in the early 1950s and the increase in the haulage force caused the rope to be replaced by a more durable chain. Drum longwall shearers were moving along the AFC route more and more often with its forced guidance along the conveyor. This made it possible to attach the chain ends to the drives of the face conveyor. The length of the walls and therefore the chain length has also increased. Increasing the efficiency of the longwall shearers caused in an increase in the haulage force (already in the 1960s it exceeded 250 kN) and unfavourable phenomena related to the presence of a tight chain [1,2,3,4] appeared, such as:

- the risk of being hit by the ends of a broken chain,
- the risk of impacts due to transverse chain vibrations,

In fully mechanized longwall systems with the use of powered roof supports and the face (flexible) conveyor following the shearer [5,6], this induced the probability of:

- the shearer power cable or even the powered roof support to be damaged by the chain as a result of horizontal, transverse impacts of the shearer chain.

At the same time, the scope of application of longwall shearers for inclined and pleated–longwalls began to be extended, which resulted in the possibility of further undesirable phenomena, such as:

- an excessive wear of the traction chain in contact with the flight bars, face conveyor chain and raw coal.
- a serious risk of chain breaking off in longwalls with a significant inclination causing the shearer to slide down.

Problems related to the operation of chains in the longwall shearer haulage systems had also occurred earlier, causing the search for more convenient solutions from the beginning of the 1950s. This paper provides an overview of such solutions and it describes how they were achieved.

2. Tracked mining machines in the longwall faces

A rapid development of mining machines intended for narrow-face hard coal mining systems at the turn of the 1940s and 1950s caused that in the German Ruhr region an attempt was made to use the American Colmol (Fig. 1) tracked shearer (crawler undercarriage) in semi-mechanized coal longwalls equipped with a belt conveyor and an individual steel roof support [3]. In the American coal mining industry, machines of this type were used as cutting and loading machines in early varieties of the room&pillar system, cooperating with cars collecting the raw coal at the rear of the machine. The cutting machine worked in parallel to the face. The output material (raw coal) from the internal conveyor was collected by a short belt conveyor installed transversely behind the machine, which loaded the coal onto a longwall belt conveyor installed along the entire length of the longwall. In this solution, the cutting machine pulled a cart equipped with a manual hydraulic pump enabling the setting and expansion of individual hydraulic props following-up the cutting machine.

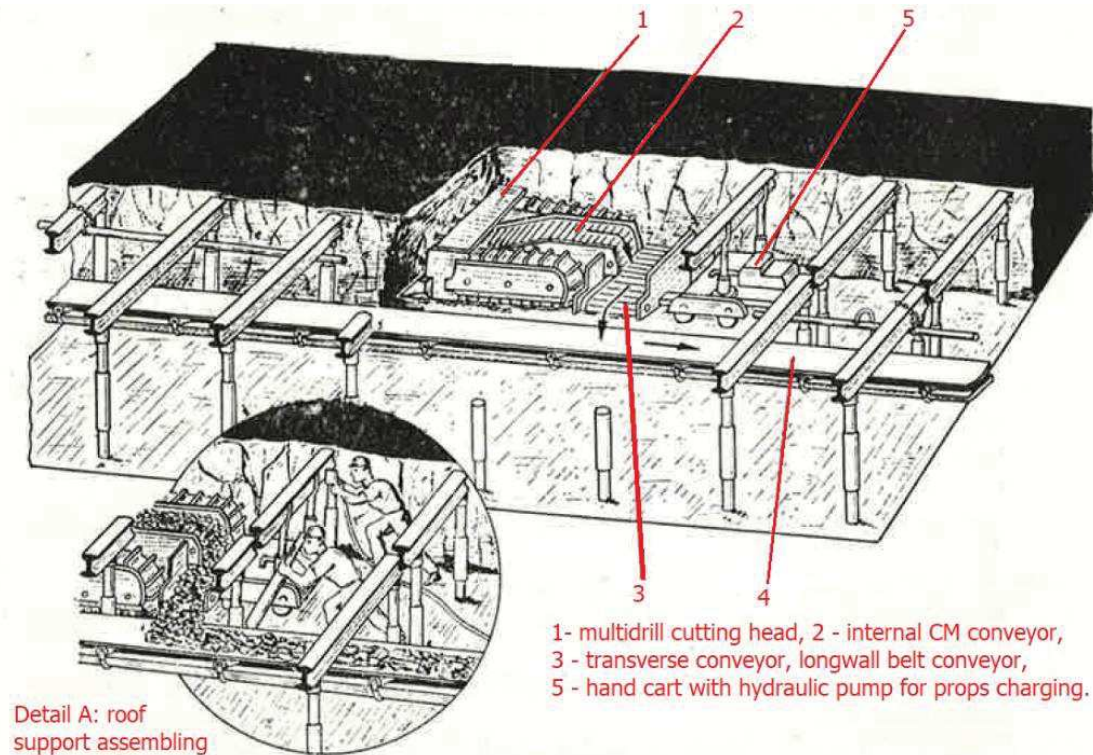


Fig. 1. Colmol continuous miner as a cutting-loading machine in semi-mechanized longwall face [7]

Similar solutions adapted to coal longwalls in the form of narrow-face cutter loaders were developed in 1951 in Hungary (Petofi I) [8] and in Great Britain (Dosco Miner). Both machines were already equipped with an integral transverse belt conveyor intended for working with the face belt conveyor (Fig. 2). The use of belt conveyors in coal longwalls in Great Britain has been widespread against the coal mining with impact hammers and manual loading of raw coal.

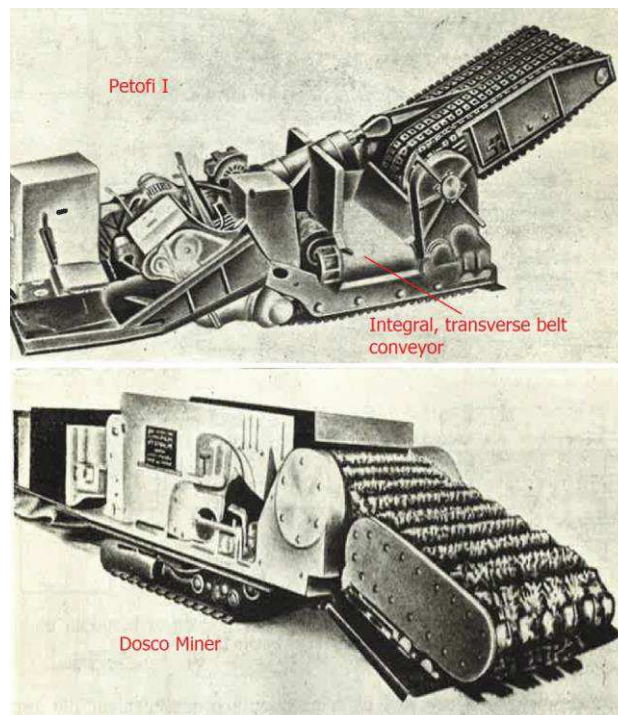


Fig. 2. Tracked narrow-face cutter loaders adapted for longwall mining [3]

Similar but different solutions were later used in Australia in a so-called Shortwall Mining system, but no longer a face conveyor and a powered roof support were used [9]. The applied solution did not become popular due to its disadvantages, such as low speed of movement and problems with the preparation of the next operation cycle of the machine. The problem was also to lay and run the machine power cables.

3. Classic longwall shearers with chainless haulage systems

In the countries with an extensive hard coal mining industry with developed industrial facilities for the production of mining equipment, such as Great Britain and Germany (FRG), solutions were intensively sought for the chainless haulage system of the longwall shearer. By the end of the 1960s, it was estimated that at least 40% of accidents in the longwalls were caused by vibrations or break of the shearer chain. In 1972, the British Ledston Luck coal mine probably used the first chainless shearer haulage system of Rackatrack type, developed by Pitcraft Ltd. [5].

In a short time, several basic groups of solutions emerged (Fig. 3)

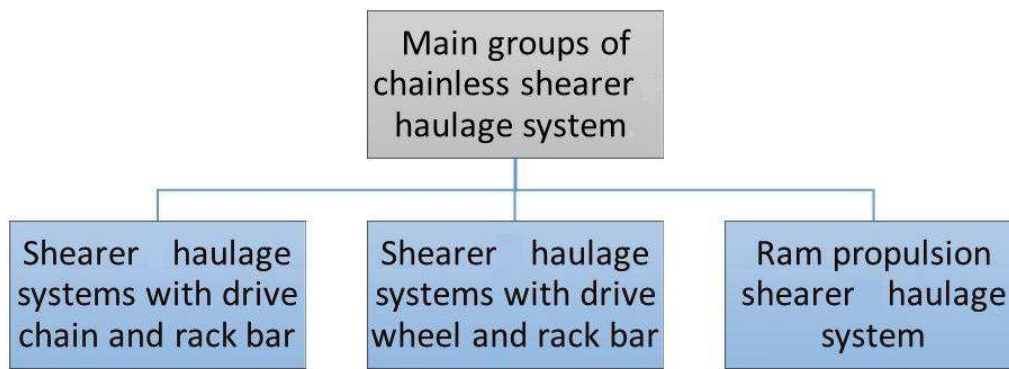


Fig. 3. Main groups of chainless haulage systems of longwall shearers [author]

Haulage systems with a drive chain and ram-propulsion systems have been discontinued quite quickly and nowadays the systems with a drive wheel and a rack bar have been applied in the longwall shearer haulage systems.

3.1. Longwall shearer haulage systems with drive chain and rack bar

When attempting to eliminate the chains from the longwall shearers haulage systems, solutions were originally sought that did not introduce any fundamental changes to the internal structure of the haulage systems. In the longwall shearers haulage systems used at that time, there were two solutions for driving wheels pulling the chain: horizontal and vertical ones.

The first chainless shearer haulage system was a solution in which the shearer movement was produced by a flat endless chain with pins embedded in it, driven by a vertical, slightly modified drive wheel [10]. The toothed flat chain was to transfer the traction force to the horizontal flat bar with holes (a structural element of the face conveyor), causing the roadheader to move (Fig. 4). This haulage system was originally called the Rack-a-Track with the subsequent commercial brand simplification into the Rackatrack. According to the available data, at the end of 1977, 691 mechanized longwalls were working in British hard coal mines, including 71 equipped with chainless haulage systems. The Rackatrack system was used in 59 longwalls. These haulage systems were used on British one-drum and two-drum shearers by Anderson Strathclyde and BJD; at the same time, this haulage system was tested in German coal mining and three longwall shearers with a Rackatrack haulage system were delivered to the USA.

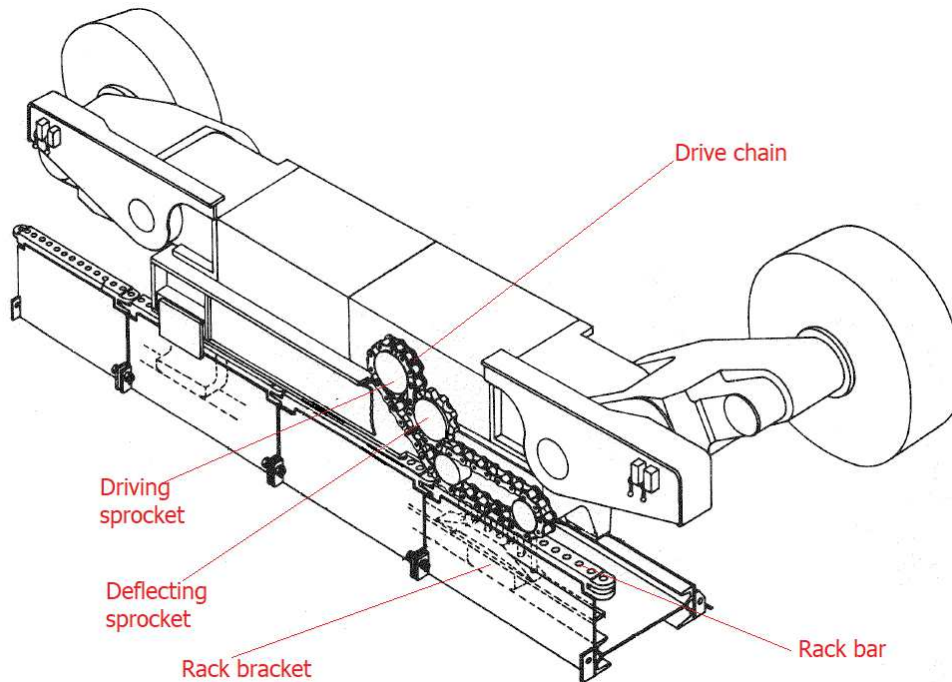


Fig. 4. Chain-less shearer haulage system of the Rackatrack type with a drive chain [author]

In the mid-1970s in the coal mining industry of Great Britain, it was subject to testing in the German coal mining. When using this haulage system, a significant disadvantage of this solution was revealed consisting in rapid wear of the drive chain. Cases of damage to the shearer cable were a great problem. Users indicated the low position of the toothed bar as an advantage, which allowed for a good operation of the haulage system in pleated seams. There was also an attempt to use this haulage system in a steeply inclined longwall (Seafield Colliery). In the end, the Rackatrack system gave way to more reliable and durable solutions.

At the same time, a similar solution for the shearers with a horizontal drive wheel was developed by the British company Perard Engineering Limited. The haulage system called Peratrak [11] used classic mining chains of various diameters (18, 22, 24, 26 and 30mm) as a closed working chain/cord (Fig. 5).

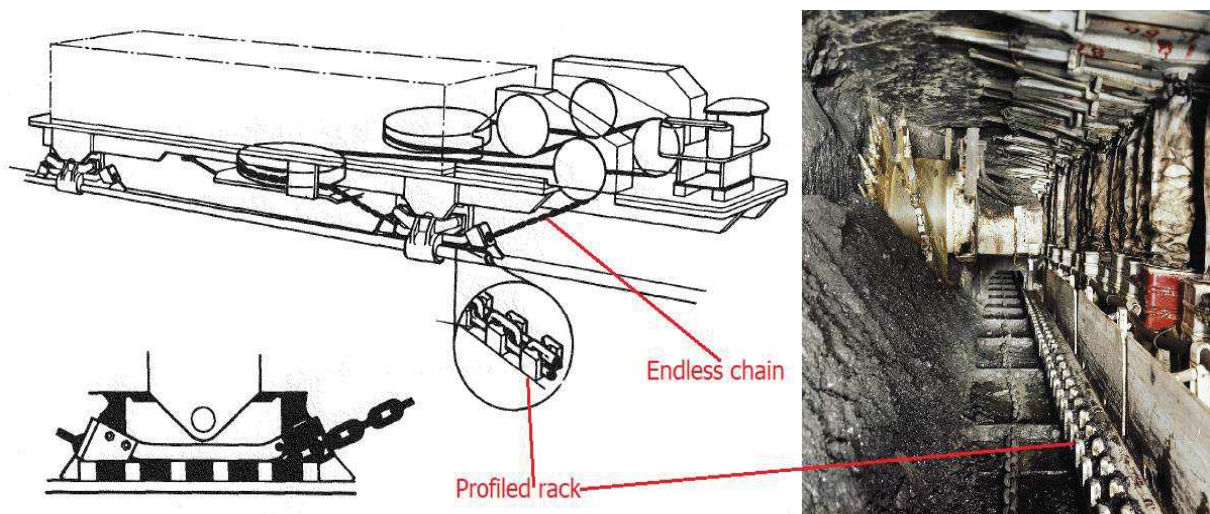


Fig. 5. Peratrak cordless haulage system – main idea and AFC adapted for Peratrak [author]

The Peratrak system was used in low versions of one-drum Anderson Strathclyde shearers with a cutting drum embedded in the harvester's body (mainframe). It was also used in the Trepanner drilling machines. At the end of 1977, nine longwall shearers with this haulage system, were working in the British mining industry. There was also a similar type of haulage system developed by Mining Supplies Ltd. A flat endless (closed) chain with inserted cast teeth was applied in this system called the Reactive Haulage system. These teeth entered the holes of the bar installed in the gob-side part of the face conveyor (Fig. 6).

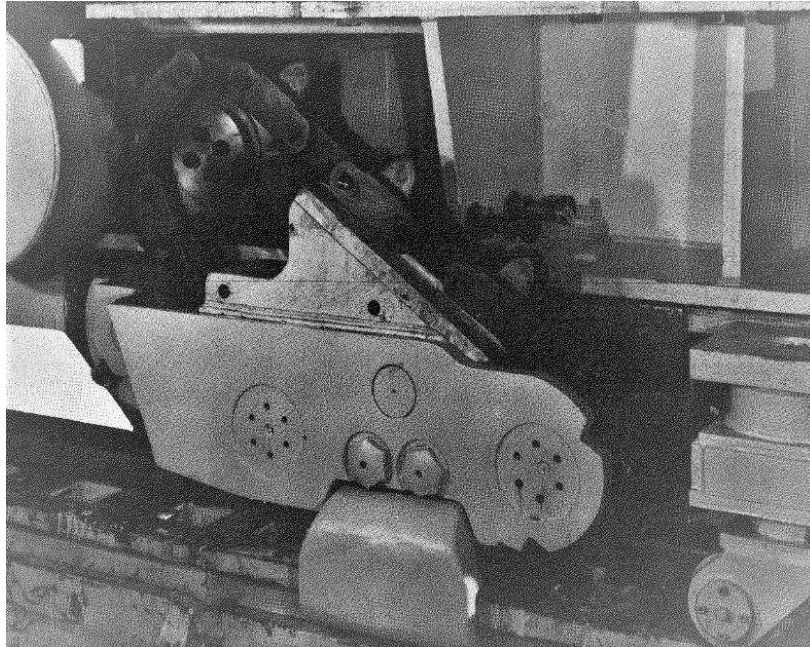


Fig. 6. Reactive Haulage system [10]

The Reactive Haulage system was recognized by the British National Coal Board in the mid-1970s as one of the standard and recommended haulage systems. It was available in two versions:

- For the Trepanner machines and two-drum shearers, the chain was driven directly by the vertical drive wheel of the haulage body.
- For one-drum shearers with a horizontal drive wheel, a solution was applied with the use of a haulage body hydraulic pump for low-speed drive, a hydraulic engine installed in the shearer sleigh (slide base) intended to drive the chain [12,13].

3.2. Ram propulsion haulage systems

At the end of the 1960s, attempts were made in France and Great Britain to develop systems with the traction force to be produced by hydraulic cylinders cooperating with ratchet systems enabling cyclical, alternate moving of the shearer or the ratchet system. The first such haulage system was applied in 1974 in the French Cevennes coal mine (Mains Pincantes – Cerchar) [10] (Fig. 7).

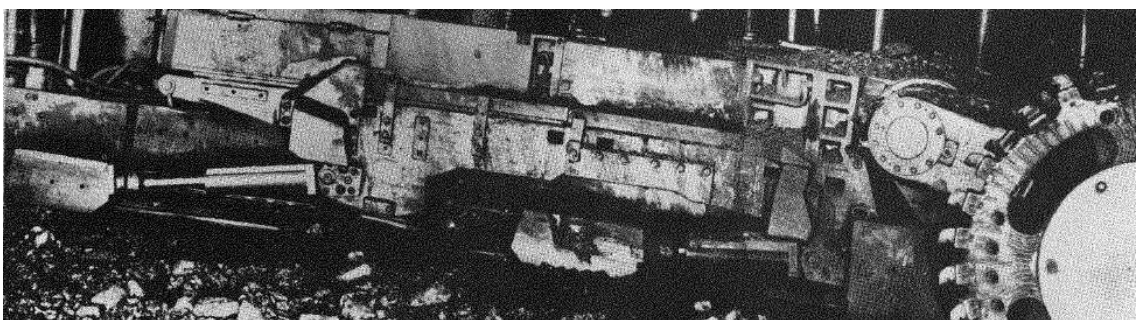


Fig. 7. Ram propulsion haulage system installed in longwall shearer [10]

In the opinion of users, the ram propulsion system eliminated chain-related accidents of the haulage systems, but it was also suitable for higher longwalls. The costs of its maintenance were also low. In the French mining industry, there were at least 8 shearers with such a haulage system.

Similar solutions were also applied in Great Britain. One of them was a system developed at the Mining Research and Development Establishment of the National Coal Board, which consisted of two hydraulic rams mounted at the bottom of the shearer and a hydraulically controlled clamping device along with a clamp cooperating with a special bar attached to the gob-side part of the armoured face conveyor. This solution was tested on a two-drum arm shearer by Anderson Stratclyde, but it was not introduced for industrial use, as the Tandem RamTrack solution by RB Bolton Ltd, in which the ratchet mechanism moved over a horizontal profiled bar being part of the scraper conveyor. The latter solution was tested only in surface conditions.

The ram propulsion haulage systems did not allow for high cutting speeds with the shearer, so they were quickly abandoned.

3.3. Captivated chain haulage systems

In the 1960s, longwall systems with plows as mining machines dominated in German coal mining. The first plows were pulled by drives installed in the gates at the ends of the longwall using first ropes and then link chains. Initially, these chains were run freely. With the increase in the power of plow drives and thus the forces in the chain and with the longwalls becoming increasingly longer, risks similar to those in shearer-operated longwalls occurred, related to the transverse vibrations of the chain and the possibility of its breaking due to the large longitudinal forces. Therefore, solutions were implemented consisting in forced running/guidance of both lines of the plow chain in a way to prevent transverse vibrations, and after the chain break off, to prevent its ends from moving sideways. One of the leaders of the plow technique in Germany was the Halbach-Braun company, which proposed the use of an immobilized chain held in special guides on which the sprocket wheel of the shearer was moving. The first such system was called Dynatrac [14,15,16,17]. Due to the fact that Halbach-Braun has been one of the leading manufacturers of the armoured face conveyors and the key changes were related to the design of the face conveyor, the solution with the captivated chain gained great popularity (Fig. 8).

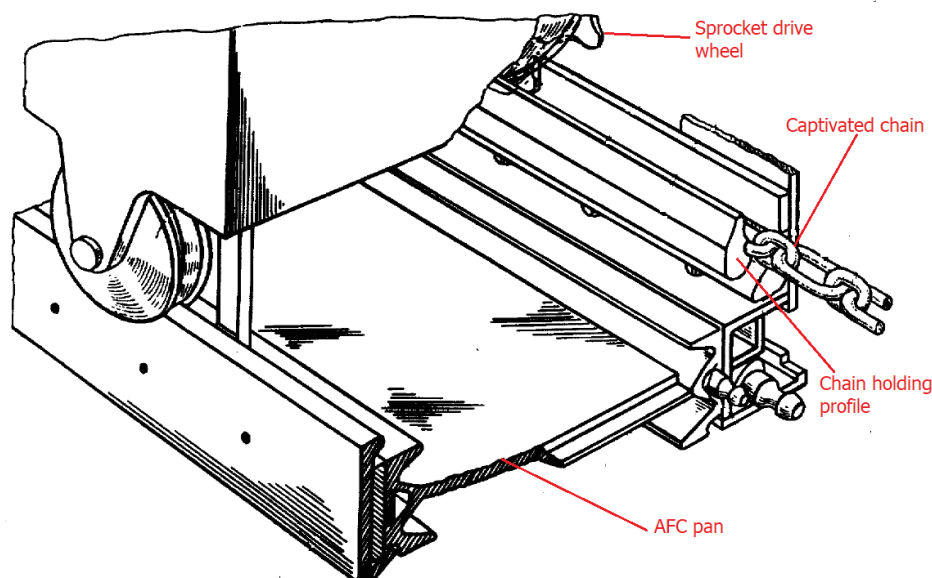


Fig. 8. Shearer captivated chain haulage system [18]

The Dynatrac system was later developed into the Rhinoride system with a chain of larger diameter, and then the Dynarhide system. High strength of the chain and its safe guidance made it possible to introduce high-power drives, allowing for high-speed cutting. The Dynatrac system was most popular in the 1990s. Fig. 9 shows a French longwall shearer with a captivated chain haulage system by Sagem Panda.

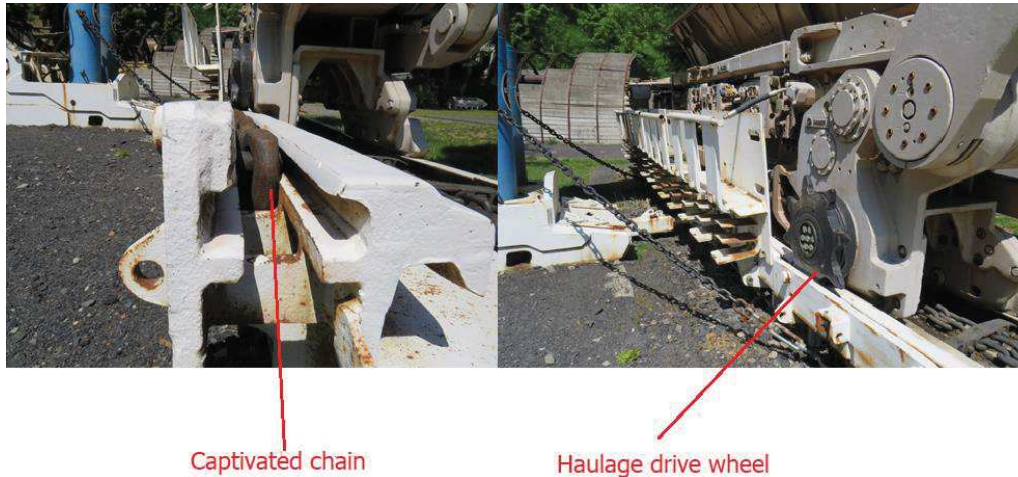


Fig. 9. Sagem Panda shearer with captivated chain haulage system [author]

In this haulage system mostly a fully electric haulage drive with frequency converters has been applied. This allowed to reduce the volume of hydraulic oil and greatly increase the haulage system power. The principle was to use double drive systems with two drive wheels at the ends of the shearer, which improved the cooperation between the drive wheels and the shearer. This system enabled efficient mining in longwalls with a height of more than 3.5 m.

In 1985 in USA was patented solution which eliminated some vices of Dynatrac as uneven chain wear – all chain had to be replaced even if only several links in the chain were broken [19] (Fig. 10).

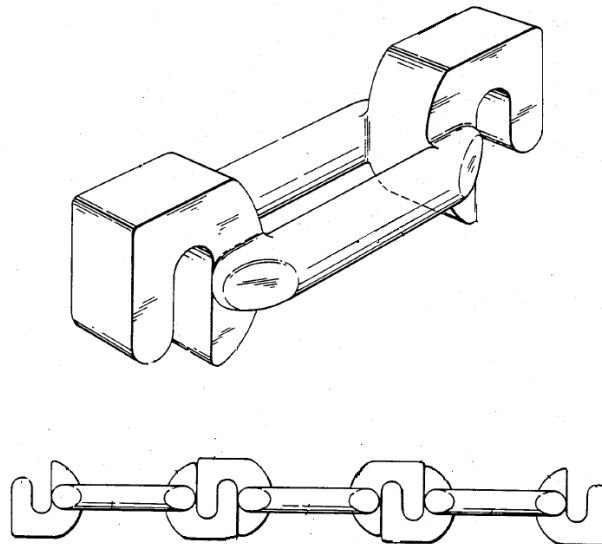


Fig. 10. Improvement of captivated chain haulage system with independent chain links patented by Anderson Strathclyde PLC [19]

4. Summary

The first solutions, eliminating the free chain in the longwall haulage systems of coal shearers were undertaken assuming the smallest possible changes in the technical system of the mechanized longwall, especially in the shearer's design and structure. These attempts were made at the time when single-drum longwall shearers with a cutting drum embedded in the shearer body (mainframe) were still commonly used. Due to the fact that the beginning of improvement of chainless haulage systems was also related to other designs of the mechanized roof supports (chocks), the introduction of powered roof supports (shields) to the longwall systems resulted in changes in the approach to the chainless haulage system of the longwall shearers. The priority was the safety of miners' work and durability and reliability of the mechanized longwall devices. The above described solutions, although satisfying these needs, complicated the design of shearers and face conveyors, in fact not bringing benefits in the form of increased longwall productivity. Therefore, solutions were still sought to be more universal in application and at the same time to enable a large increase in the coal longwalls productivity. However, before the spread of longwall shearer haulage systems based on the Eickhoff solution, many other solutions with a sprocket wheel and a rack bar were developed and implemented, which requires a separate elaboration.

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