New Developments in Vertical Conveying with Special Emphasis on the Transshipment of Bulk Materials

Juergen W. Paelke, Germany

Summary

A new vertical conveying method based on the FLEXOWELL-technology is introduced, which lends itself to vertical and inclined bulk solids conveying in deep shafts, in open pit mining, in processing plants and blast furnace charging, in filling silos and dumps etc. and especially for unloading of ships.

1. Introduction

In all branches of the transshipment and conveying of bulk materials, careful attention to the cost/benefit ratio is now more important than ever. This applies equally to invested capital and to daily operating costs.

With the aid of FLEXOWELL*-technology and of the newly developed conveying systems which it allows, it is now possible to overcome the performance limitations of conventional conveyor belting and to break through into new dimensions in conveying technology. These new developments have already been successfully applied in practice. Innovative designs combine vertical conveying with horizontal loading discharge sections, eliminating the need for material transfer stations.

The vertical conveying system must meet the following important requirements: dust-free and noiseless, environmentally acceptable conveying; high degree of functional reliability coupled with long system service life through extensive use of resilient, corrosion resistant materials; operational flexibility, ranging from horizontal to vertical conveying ; smooth directional transition; widely varying choice of conveyor route configurations; and minimum space requirement for vertical conveying. These requirements apply to the conveying of all kinds of bulk materials, with lump sizes up to 400 mm and conveying capacities from 2,000 to approximately 40,000 t/h.

The new CEWELL* conveying system provides radial guidance of the belt to differentiate it from the vertical S-conveyor. Each system meets specific performance criteria.

* FLEXOWELL® and CEWELL® are registered trade marks

Ing. Juergen W. Paelke, Manager and Chief Engineer, Scholtz-EFS Engineering für Fördersysteme GmbH, Am Stadtrand 53—59, D-2000 Hamburg 70, Federal Republic of Germany

The S-conveyor can elevate 2,500 m³/h up a 300 m vertical lift. The CEWELL conveyor can elevate 10,000 m³/h up a 30 m lift. These alternatives permit innovative design of conveying plants for the transshipment of bulk materials.

2. FLEXOWELL Conveyor Belting

FLEXOWELL conveyor belting provides the design requirements for universal application in various conveying systems. In contrast to conventional trough belts, it is a flat belt with corrugated, flexible sidewalls. Fully loaded FLEXOWELL belts can therefore be guided through any angle including 90 degrees via straight pulleys. The FLEXOWELL-technology thus permits considerable flexibility in the choice of route configuration of the transported materials (Fig. 1).

There is no need for transfer stations between horizontal sections and steeply inclined or vertical sections with the FLEXOWELL belt. Therefore, finely granulated material can be conveyed with minimal dust formation.

FLEXOWELL belts are manufactured with corrugated sidewalls in heights of 40—400 mm. Types S and ES are additionally provided with a cross stabilizing fabric insert. The special cross cleats, preferably of curved form, fit into the corrugations and can be bolted firmly into position. The result is closed conveying segments or pockets. This type of construction guarantees the trouble-free transportation of bulk materials, both horizontally and steep inclined or vertically, without material degradation. In comparison to conventional trough belts, the design features of the FLEXOWELL belting with corrugated sidewalls and cross cleats permit steeper and therefore space saving conveying.

The advantages become apparent if the height of lift is compared with the required surface area. FLEXOWELL belting achieves high capacities in the least amount of space (Fig. 2).

3. Vertical Conveying of Bulk Material

FLEXOWELL-technology now offers an economical, operationally reliable and well tested solution to the problem of vertical conveying over widely separated levels (Fig. 3). This equipment, the FLEXOWELL S-conveyor can be installed in very little space. Elevation up to 300 m can be achieved.

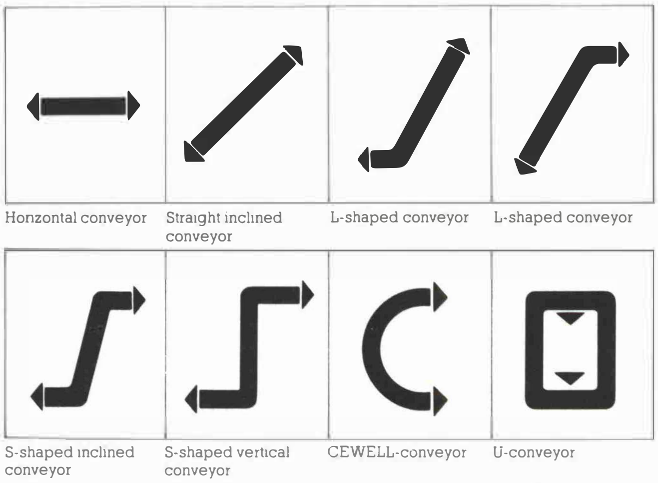

Fig. 1: Belt configuration

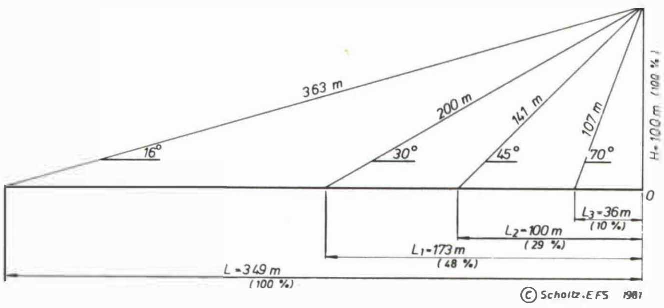

Fig. 2: Relationship between surface area and height of lift and conveying angle

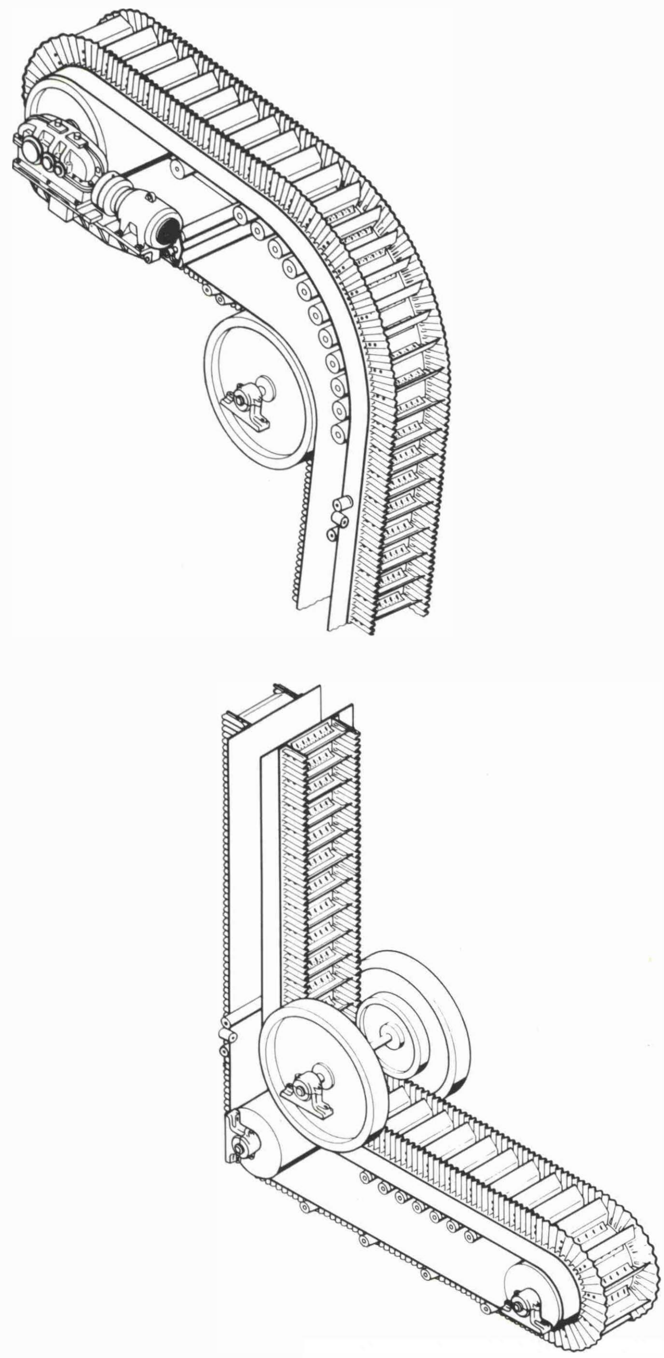

Fig. 3: Isometric view of vertical S-conveyor

Since the horizontal loading and discharge sections are continuously joined to the vertical conveying section, the loading, elevation and discharge of the material takes place in a continuous, smooth sequence without any material degradation. No scooping is required. In addition to economy and reliability (the system is driven by a single motor) particular attention was paid to the following considerations during development: Universal application for all kinds of bulk materials (up to 400 mm lump size). Integration of the conveying system into existing installations, ensuring a continuous flow of conveyed material. Achievement of large elevating heights. Low power consumption, approximately equal to the work done only in lifting. Design features qualify the vertical conveyor for several applications. Among them are deep shaft and open pit mining, tunnel construction, charging blast furnaces, and filling silos and dumps. The vertical conveying systems are of proven efficiency and versatility and universally suitable for different capacities and types of materials. The efficiency of conventional elevators is limited according to the type of material to be conveyed.

High speed elevators are suitable only for lump sizes up to 30 mm. Medium and low speed elevators apply only for 30—100 mm. Even then, the conveying capacities they are able to achieve are well below those of the vertical conveyor, which can achieve up to 2,500 m^3/h for all lump sizes up to 400 mm (Fig. 4). The conveying capacities result from high conveying speeds. A speed of 5 m/sec can be maintained throughout for all kinds of conveyed material having lump sizes up to 150 mm. On the other hand, due to its wear intensive belt and bucket construction, a high speed elevator reaches a maximum speed of 4 m/sec and even this can only be achieved when handling grain. In the case of the vertical conveyor it can be seen from the diagram that the speed reduction curve for lump sizes of 150 mm and above remains very flat. For lump sizes of 400 mm, a speed of 3 m/sec is still possible (Fig. 5).

Such performance was previously unattainable. The homogeneous belt construction, in conjunction with the uncomplicated directional changes which can be made without any interruption of the conveyor flow, now make such performance possible. This results in the following advantages as compared with bucket elevators: Increased rate of flow conveyed material, optimum loading and discharge on the horizontal sections, gentle handling of the conveyed material (no

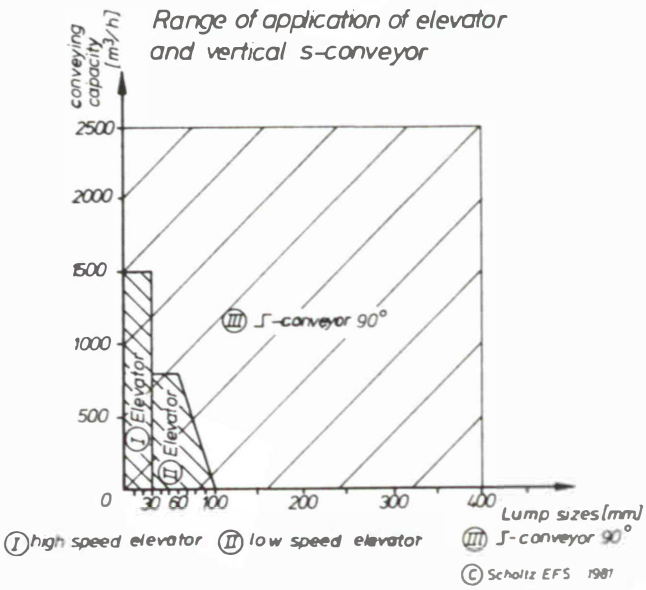

Fig. 4: Range of application of elevator and vertical S-conveyor

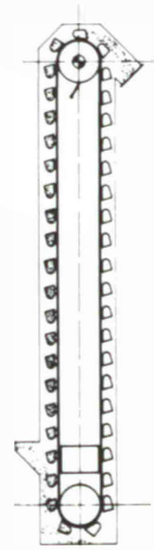

Fig. 6: Diagrammatic representation of an elevator

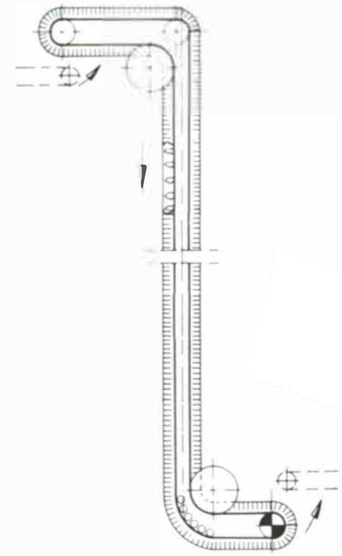

Fig. 7: Diagrammatic representation of an S-conveyor

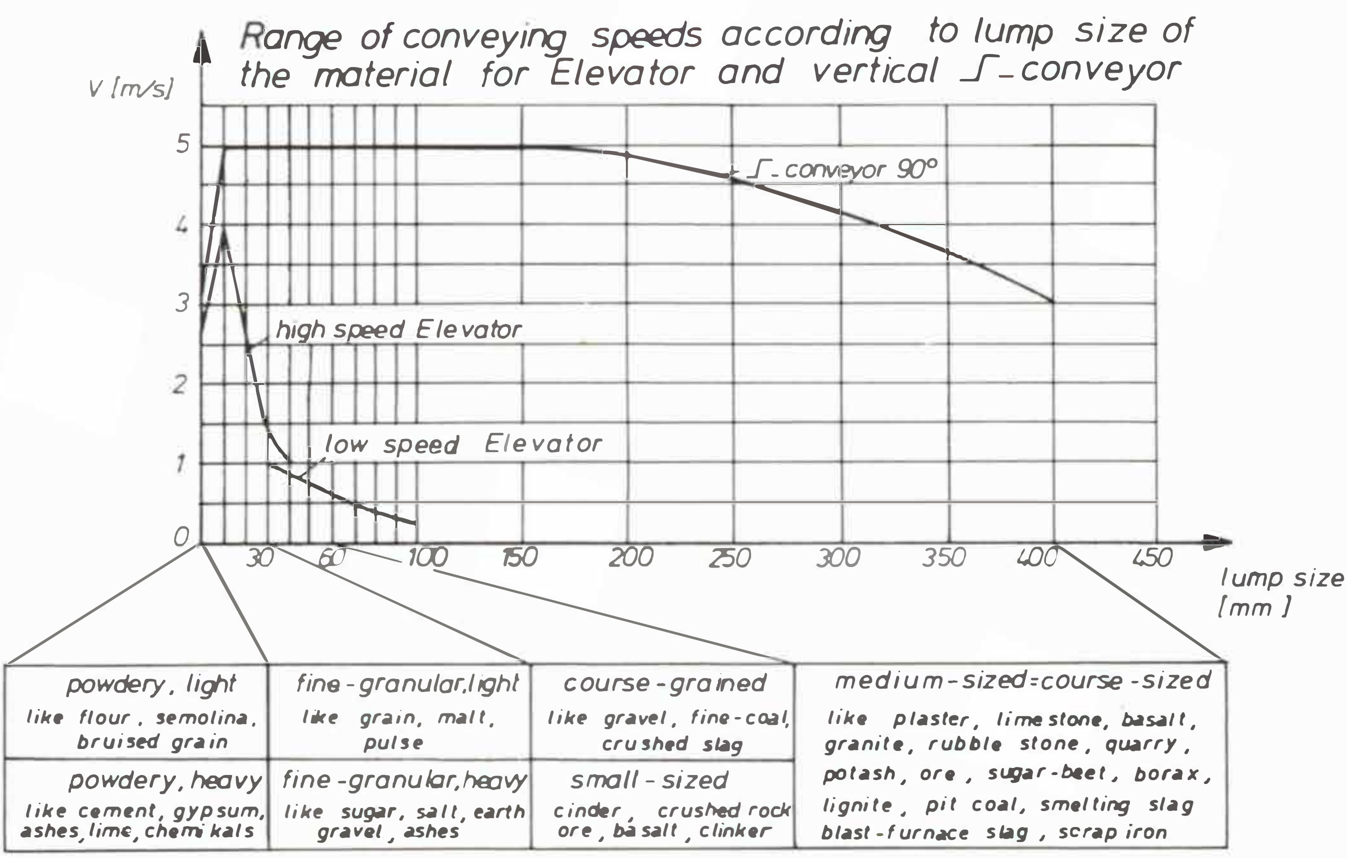

Fig. 5: Range of conveying speeds according to lump size of the material for elevator and vertical S-conveyor

scooping). In contrast to dump bucket hoisting devices: Increased continuous flow of conveyed material, noiseless quiet operation, decreased maintenance expenditure (Figs. 6 & 7).

Examples of vertical conveyors in use

Since May 1979, work has been in progress at a depth of 82 m on the Chicago deep tunnel and reservoir project. A FLEXOWELL conveyor system transports the spoil (limestone, with lump sizes up to 250 mm) vertically through a shaft to the surface (Fig. 8).

Material:	crushed limestone
Lump sizes:	0—250 mm
Capacity:	544 m³/h
Tonnage:	816/1,000 t/h
Height of elevation:	82 m
Belt speed:	2.3 m/sec
Drive:	2 x 150 kW

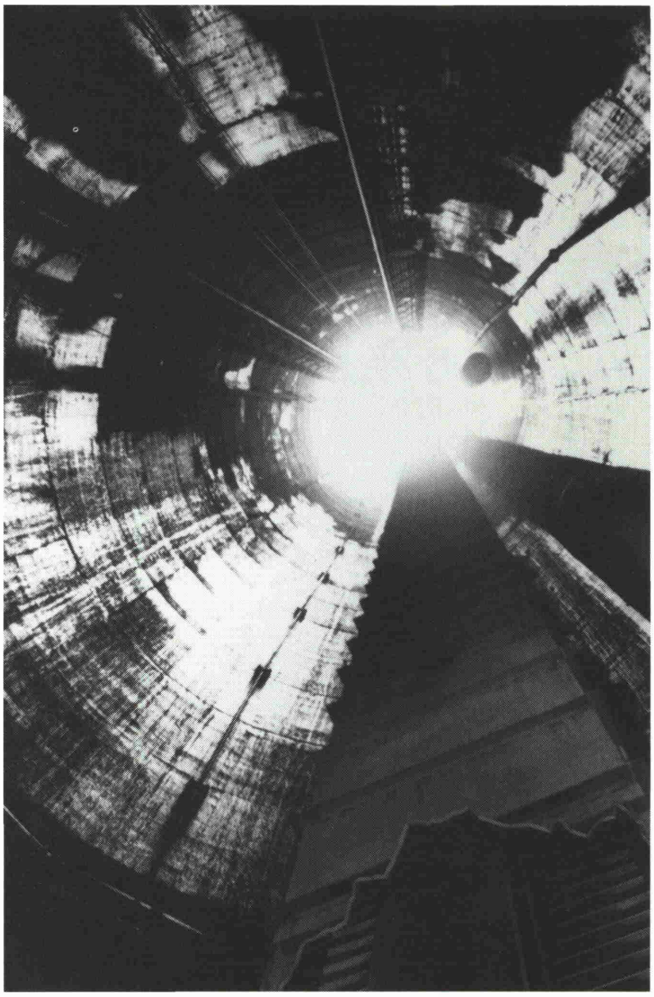

Fig. 8: Shaft conveying in tunnel construction

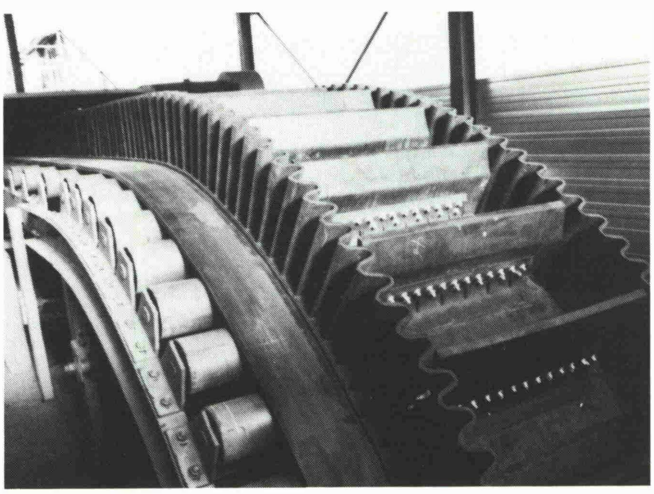

Fig. 9: Vertical S-conveyor

Since January 1981 a system has provided continuous vertical transportation of raw coal in a preparation plant (Figs. 9 & 10).

Material:	coal
Lump sizes:	0—80 mm
Capacity:	440 m^3/h
Tonnage:	350 t/h
Height of elevation:	46.4 m
Belt speed:	2.3 m/sec
Drive:	75 kW

Fig. 10: Vertical S-conveyor

4. Radial Conveyor Systems — A Development Which Points to the Future

Previous designed systems have not satisfied the following set of parameters well: 1. Bulk material flows of over 10,000 m^3/h, 2. Minimum surface area, 3. Elevation over the largest possible difference in level. Radially guided systems have been employed for some years. However, the use which can be made of radially guided, troughed, flat belts is severely limited by the costly pulley guides and the undesirable tensions in the belt edges. These difficulties are eliminated with the use of FLEXOWELL belts. The combination of carrying belt and cover belt, which is necessary in the case of radial guidance, can be achieved without problem only by means of the FLEXOWELL sidewalls.

Utilizing corrugated sidewalls and belt speeds of 3.5 m/sec, flows of conveyed material of 10,000 m^3/h, can be achieved. Conveying tests with bulk materials of the most diverse range of lump sizes at speeds of up to 5 m/sec have confirmed the excellence of this system — the CEWELL conveyor (Fig. 11). The capacity and configuration of this system are uniquely applicable for ship loading and unloading and for port transshipment. Integrated into large equipments such as dredgers and stackers, and especially as permanent on-board equipment in self-unloading ships, this conveyor system will prove its efficiency in the transshipment of bulk materials.

5. Conveyor System for Self-Unloading Ships

Advantages of the new system: improved utilization of available hold space: complete unloading without any special aids; transportation of all kinds of bulk materials; neither the ship nor the transport system on the quay (feed hopper and conveyor belt installation) need to be repositioned during the discharging operation (Fig. 13).

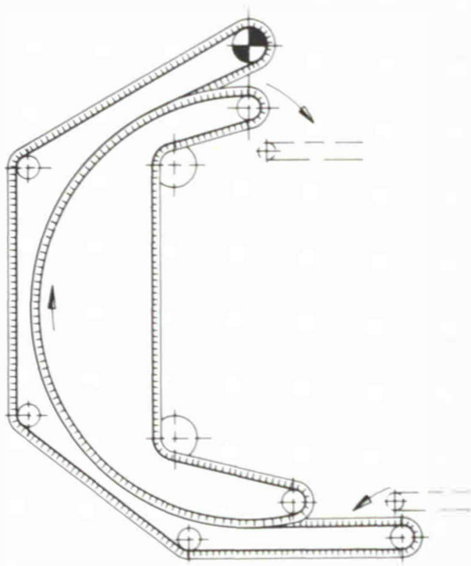

Fig. 11: Schematic representation of CEWELL conveyor

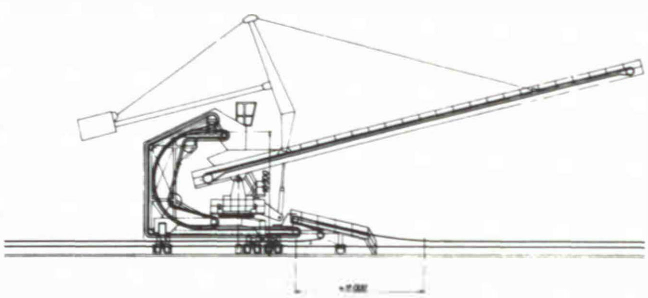

Fig 12: Stacker with integral CEWELL conveyor (in comparison with conventional stackers, the belt scraper carriage requires only 1/5 of the track length)

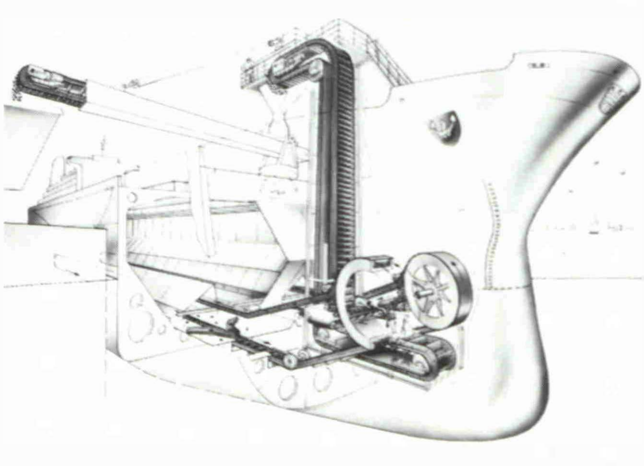

Fig. 13: 10,000 DWT self-unloading ship with a vertical conveyor

Two reclaim tunnels, each provided with one conveyor belt and plow, are installed in the ship's hold (double bottom). The bulk material is reclaimed via the wide span plows which between them cover the entire area of the hold. The material is delivered to the FLEXOWELL conveyor belts which run beneath the bottom of the hold. The saddles above the reclaim hold ensure complete unloading of the hold, since they adapt to suit the angle of repose of the bulk material. Between the saddles and the floor of the hold there are reclaim slots which must be kept closed while the ship is at sea so as to ensure that the bulk material does not shift due to the ship's movements and bury the conveyor belts. The material is carried by the two FLEXOWELL belts running the length of the ship and delivered up via lifting wheels to the transverse feeder conveyor belts which then transfer it to the vertical conveyor. The material is then removed from the ship via a hopper and boom conveyor.

In another example, there are three reclaim tunnels installed in the bottom of the hold (double bottom), with one conveyor belt and plow installed in each tunnel (Fig. 14). The bulk material is reclaimed from the entire area of the ship's hold via the wide span plows and is fed continuously onto the conveyor belts which run beneath the bottom of the hold. The saddles above the reclaim tunnels ensure complete removal of the material from the hold, since they adapt to suit the angle of repose of the bulk material. As shown in Fig. 13, there are reclaim slots between the lower edge of the saddles and the bottom of the hold. These slots must be kept closed while the ship is at sea so as to ensure that the bulk material does not shift due to the ship's movements and bury the conveyor belts.

The material is transferred from the three longitudinal, troughed conveyor belts to the transverse CEWELL conveyor which then feeds it to the CEWELL conveyor installed mid ship. The material is discharged into a hopper for removal from the ship on a boom conveyor.

6. Ship-Loading and Unloading in One System

This system is the culmination of consistently applied FLEXOWELL-technology. This continuous conveying system newly developed by Scholtz-EFS features the loading and unloading of bulk materials with one single continuous conveying system. The basis of the conveying system is the well proven FLEXOWELL-technology.

The newly designed loading and unloading system consists of the following main components (Fig. 15): The gantry, on which the conveyor belt and associated pulleys and receiving and feed hoppers are located. The main boom which is swivel connected to the gantry by cable, winch and pulleys. The lifting leg, which is suspended from the main boom, and which is designed so that it always remains vertical in every operational position. The transverse frame, which is located at the lower end of the lifting leg and swivels horizontally. The continuous conveying system is installed on the gantry and on the inside of the boom and lifting leg which leads to the transverse frame. The system is equipped with one single endless FLEXOWELL belt. There are no transfer points from the infeed to the discharge on the belt and no trimming is necessary.

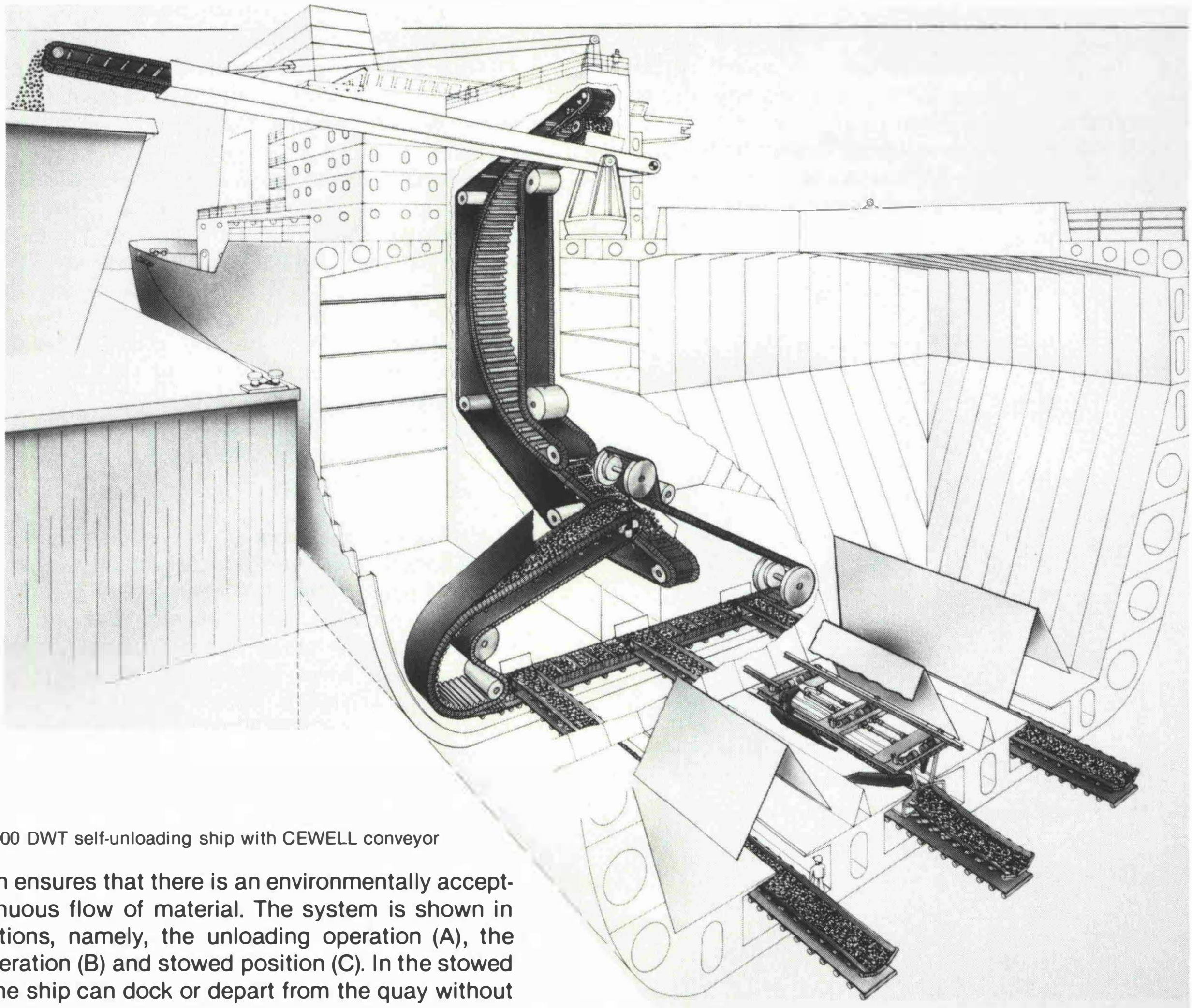

Fig. 14: 125,000 DWT self-unloading ship with CEWELL conveyor

The system ensures that there is an environmentally acceptable continuous flow of material. The system is shown in three positions, namely, the unloading operation (A), the loading operation (B) and stowed position (C). In the stowed position, the ship can dock or depart from the quay without difficulty. During unloading, the bulk material is scooped up by the collection device, the belt is loaded at the transverse frame and the material arrives at the discharge pulley on the gantry. The material is then discharged into a hopper. The collection device consists of a bucket wheel or suitable scoop rollers (Figs. 16&18). For many bulk materials, for example grain, it is also possible to use the conveyor belt itself as the collection device.

The combination of all possible movements of the gantry, the main boom, the lifting leg and the transverse frame makes it very simple to reach all points within the ship's hold during loading and unloading. Within the tube construction there are deflecting and guiding devices. One is at the transition to the lifting leg at the end of the main boom and the other one is at the lower end of the lifting leg at the point where it joins the transverse frame. If the lifting leg is swivelled and with it the bottom guide installation, a twisting of both strands of the conveyor belt occurs. The edge areas of the belt are twisted in the shape of a helix. The maximum twist of the belt is 180 degrees (Fig. 17).

Theoretical and experimental tests have confirmed that the elongation of the belt caused by the twist remains within controllable limits, even in the edge areas.

This novel loading and unloading system for bulk materials represents an innovation which opens up new applicational possibilities with capacities of up to 5,000 t/h at the present time, on the basis of well tried and reliable machine components such as pulleys, rollers and FLEXOWELL conveyor belts.

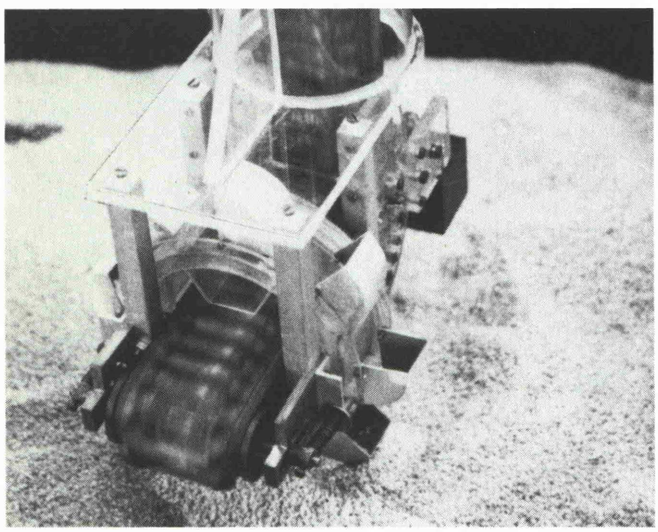

Fig. 18: Bucket wheel in use on model conveying

7. Conclusion

The new vertical conveyor technology introduced here with its flexible and wide ranging applicational possibilities will without doubt make a decisive contribution to the achievement of increased efficiency and economy in the transshipment of bulk materials.

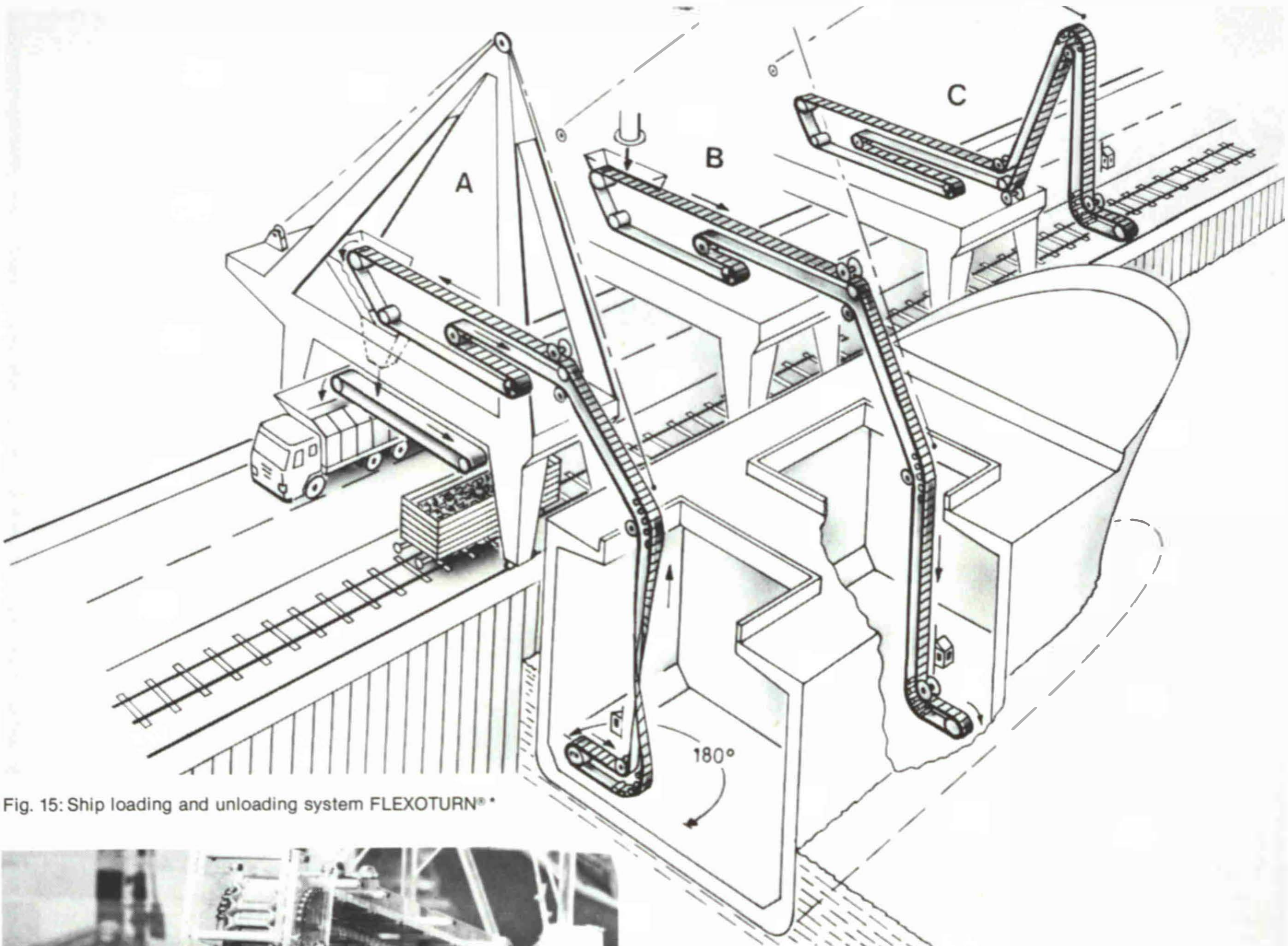

Fig. 15: Ship loading and unloading system FLEXOTURN® *

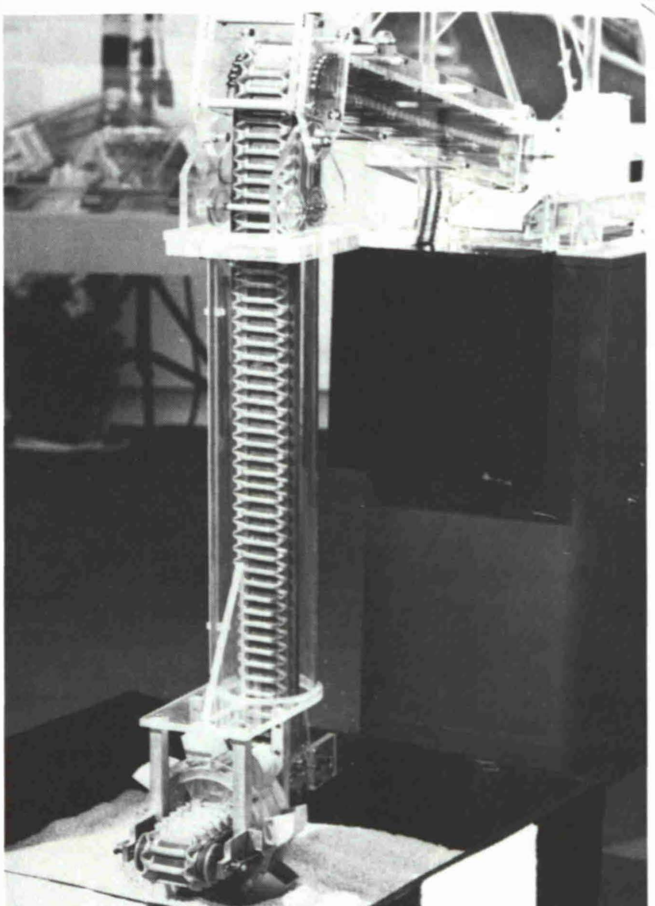

Fig. 16: Model of a ship loader and unloader

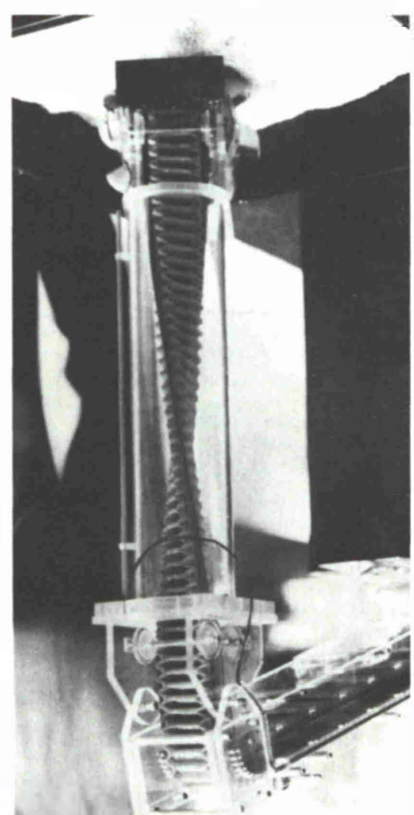

Fig. 17: Belt twisted through 180 degrees

* Now registered under the trade mark FLEXOTURN®