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Pneumatic Plant for Discharging Ship's Cargo

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Summary

Some special techniques in the field of pneumatic conveying are described and general operational and technological aspects for unloading bulk ships are discussed in detail.

1. Introduction

Machinery for unloading ships has been known for as long as goods have been conveyed on rivers and canals. One of the most characteristic pieces of equipment, and one of the best known, is the crane at the gable end of a multi-storey warehouse transferring sacks or bales from ship to shore.

This method of unloading had to change when goods were no longer packaged in sacks, but transported and stored in bulk. Initially, to move a bulk cargo from ship to the warehouse, containers were filled and lifted by crane. This is the basic principle used today in the form of a grab crane. Continuous discharge equipment was not developed at this time, and this progressively evolved using various types of screw conveyors, chain and flight conveyors, conveyor belts, bucket elevators and finally pneumatic suction systems. Many characteristics set pneumatic suction systems apart from mechanical conveyor systems. Since this field has involved the development of special techniques, it is intended to explain them briefly below and then to examine general operational and technological aspects.

2. Layout of the Plant

A turbo-blower produces a high negative pressure at the end of a pipeline and ensures an adequate air velocity in the pipe, in order that the material taken up in the air is carried along with it, as with a vacuum cleaner, the difference being, of course, that the flow is considerably greater (Fig. 1).

The stream passes initially through a vertical pipe, round a bend or a flexible joint, into a horizontal pipe, and then via a flexible coupling or rotating joint into a separator.

By this stage the air has done its duty, so to speak, and the air and material are separated. The separator operates under a considerable negative pressure, and a special, discharge component ensures that the material is conveyed out into the atmosphere, in this case a rotary valve unit is used. The air, after passing through a filter, is discharged to atmosphere.

Up to a capacity of 250 t/h grain, the negative pressure is often produced by a multi-stage turbo-blower in conjunction with an air-flow regulator, rather than with the equally common rotary compressor.

The outstanding features of turbo-blowers are their sturdy construction, tolerance of dust, quiet running and cost-effectiveness.

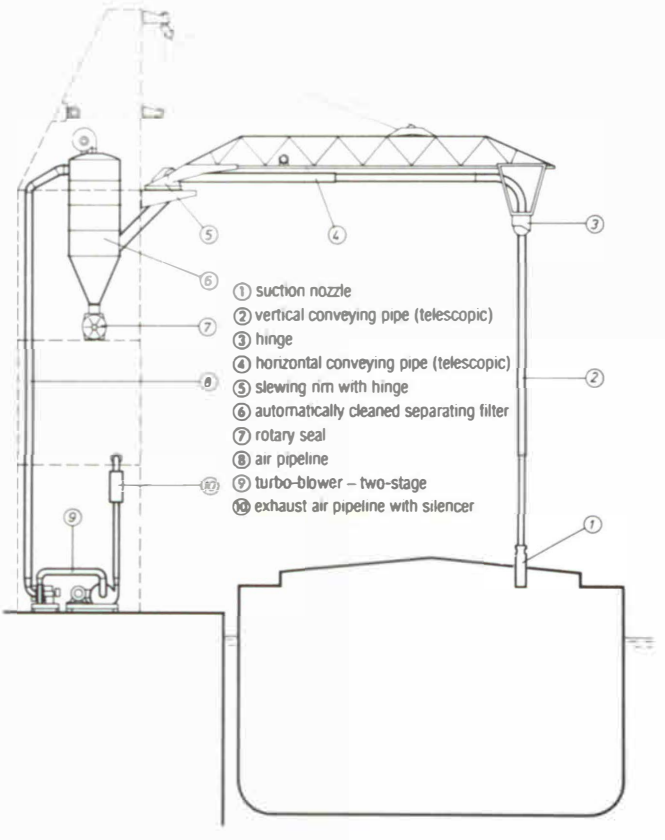

Fig. 1: Layout of a pneumatic ship unloading plant

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3. The Technology

For continuous industrial operation, the plant, simple in principle, requires components which can only be manufactured reliably with a high degree of technological knowledge and experience. For this reason there are few specialists and specialised firms in this sector.

Let us substantiate this observation with a few key-points:

— Wear occurs as a result of friction created by materials moving at high speed, in pipelines, bends, flexible joints, filters and rotary valve units.

— Flexible joints in the pipe should be both easily accessible, impermeable to air, and naturally wear-resistant.

— Telescopic pipes (vertical and/or horizontal) are two concentric pipes which can be slid over each other by means of winches or hydraulic cylinders. The requirements for these are ease of movement (precision in manufacture) air-tightness (special seals), a long service life (wear resistant) and low weight.

— Cyclone as pre-separator, or cyclones for dust-free materials, should work efficiently, and also, since they incorporate replaceable wearing plates, have a high degree of durability.

— Filters should meet the following requirements:
They should purify air efficiently (low residual dust content).
Clean the filter socks effectively, in order to avoid blockages.
Be accessible and easy to maintain (e.g. simple replacement of the filter elements).
The filter should have a long service life.
Baffle plates should have a long service life.

— Turbo-blowers are subject to the following requirements:
High efficiency.
Low noise level.
Not affected by dust.
Long service life.
Easy to maintain.

It goes without saying that above all cost-effectiveness is a dominant factor.

As is often found when attempting to solve technical problems, the various requirements often conflict with one another.

Even today, pneumatic conveying, i.e., transporting bulk materials through pipelines in an airstream, is still one of those technologies which have not been completely explained in terms of their physical mechanisms. At present it is not possible to analyse an untried bulk material intended for pneumatic transportation, in order to accurately predict its behaviour in the pipeline. Usually the risk of design faults in a plant can be reduced by preliminary trials, but experience under similar or identical conditions provides the most reliable guide to efficient plant construction.

There are manufacturers who can offer a particularly rich fund of experience in the conveyance of individual products or product groups, e.g. grain, artificial fertilisers, cement, etc. To obtain complete satisfaction, a customer should only purchase equipment from a manufacturer with practical knowledge and experience in conveying his particular product.

4. Practical Pneumatic Conveyor Systems

Because of their versatility, mention should be made of the practical conveyors used for unloading ships and transferring grain. Such systems are built for an output of 10 to 300 t/h wheat and can be driven electrically or by a diesel engine. The latter version is to a great extent independent of local conditions and can be used in developing countries or on board ships. It is possible to suspend conveying pipes over distances up to 300 m. The largest of these machines can be moved on rubber wheels, driven by its own power unit or towed by a tractor or similar vehicle. (Fig. 2 and 3).

The principles of this system are as stated in Section 2.

The common factor in all of the systems in this group is the use of turbo-blowers as negative pressure generators, available as standard sub-assemblies produced in large quantities.

Mobile machines with a conveying capacity of up to about 120 t/h wheat are frequently equipped for combined suction-pressure conveying. The material conveyed is first drawn into a separator, discharged from the negative pressure zone via a rotary valve unit and introduced into a pressure line. (Fig. 4 and 5). In this way the long conveying distances mentioned above can be attained. Since the pipelines are equipped with quick release fittings, it is possible to adapt them to varying operating conditions at short notice. Pneumatic suction-pressure conveyors can also be fitted with a hydraulically operated telescopic boom as an option, when they represent a virtually complete cargo discharge system for smaller ships (Fig. 6).

To complete the range of equipment available let us also mention the smaller conveyor powered by a tractor via a power take-off shaft, used predominantly by large and medium-size agricultural concerns to transfer grain when filling silos, loading trucks etc. The conveying capacities of these machines are still 15, 30 or 50 tons of grain per hour (3 models available).

5. The Rotary Hoe

Until a few years ago, pneumatic unloading systems were for the most part constructed only for free-flowing bulk materials, e.g. grain. A suction nozzle is lowered into the bulk and grain flows to the suction point down a funnel-shaped depression. The increasing use of derivatives, pellets and meal products has brought this method seriously into question, since the material in most cases does not flow freely and does not feed into the suction nozzle by gravity. Mechanical devices are therefore necessary, to ensure that the material is loosened to enable it to flow to the nozzle. The simplest device is a man with a shovel — a widespread and labourious method. Alternatively, a small bulldozer or wheel loader is often used in order to feed the nozzle. The conveying capacity of a plant then depends to a considerable extent on the efficiency of the method used. NEUERO, and other manufacturers, have produced mechanical agitating devices which are built into the system, operating hydraulically at the touch of a button, which feed the suction nozzle (Fig. 7). A powered rotary hoe loosens material and moves it towards the suction intake with rotating shovels. In this way exceptionally high conveying capacities can be achieved. Several plants of this type are in successful use throughout Europe unloading feed products (soya meal, sunflower

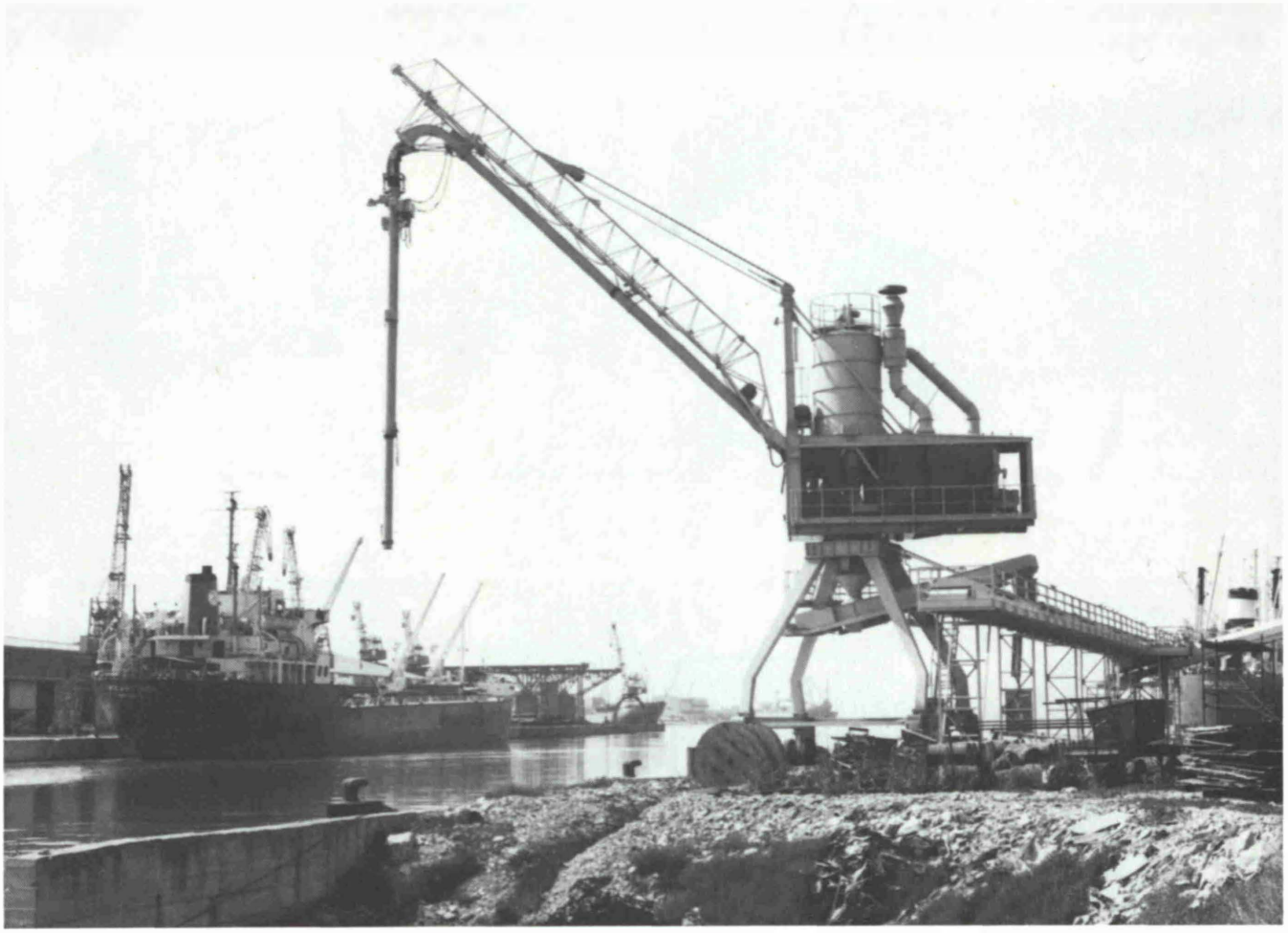

Fig. 2: Multi-port system for unloading sea-going ships (maximum conveying capacity about 280 t/h for grain)

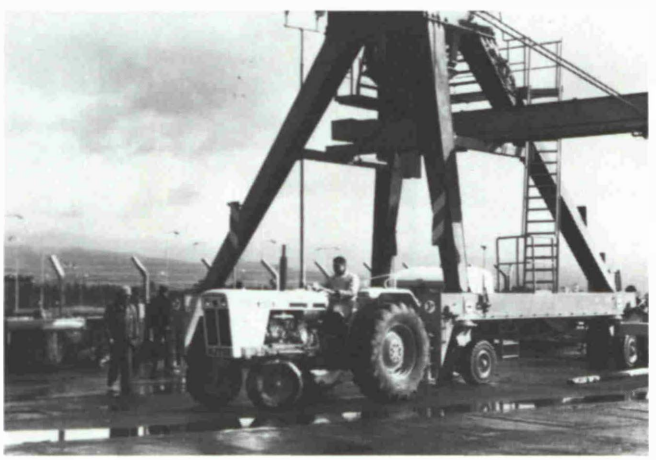

Fig. 3: The multi-port system can be operated by a towing vehicle. It can also be supplied with its own drive

pellets, tapioca pellets, meal and chips or maize gluten) from barges.

Systems with a conveying capacity of say 200 t/h grain, as mentioned under Section 2 and 3, show a considerable drop in output when used with processed products (30 to 50 t/h) but with rotary hoes, peak outputs of up to about 150 t/h are achieved at the same power consumption which represents significant progress.

6. Peak Capacity Related to Average Capacity

An important item of information to the operator of the plant is the mean unloading times of the ship.

A pneumatic ship unloading system is usually sold by the supplier with a guarantee that a peak capacity in t/h can be achieved when extracting from the bulk product (i.e., when dipping the suction nozzle into the material).

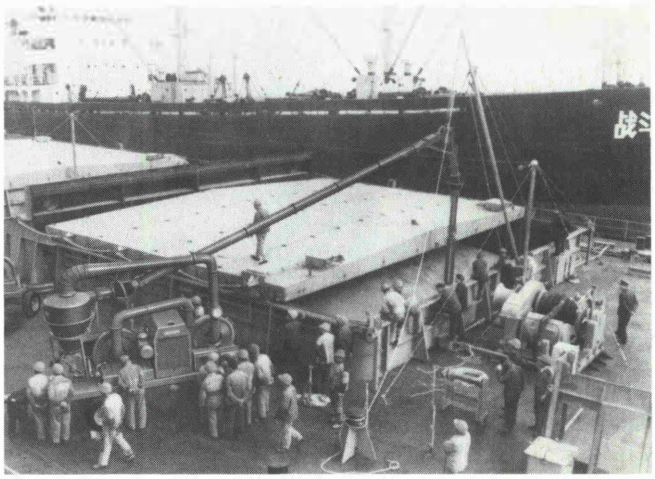

Fig. 4: A mobile conveyor in use on sea-going ships

Fig. 6: Mobile conveyor with hydraulic telescopic boom

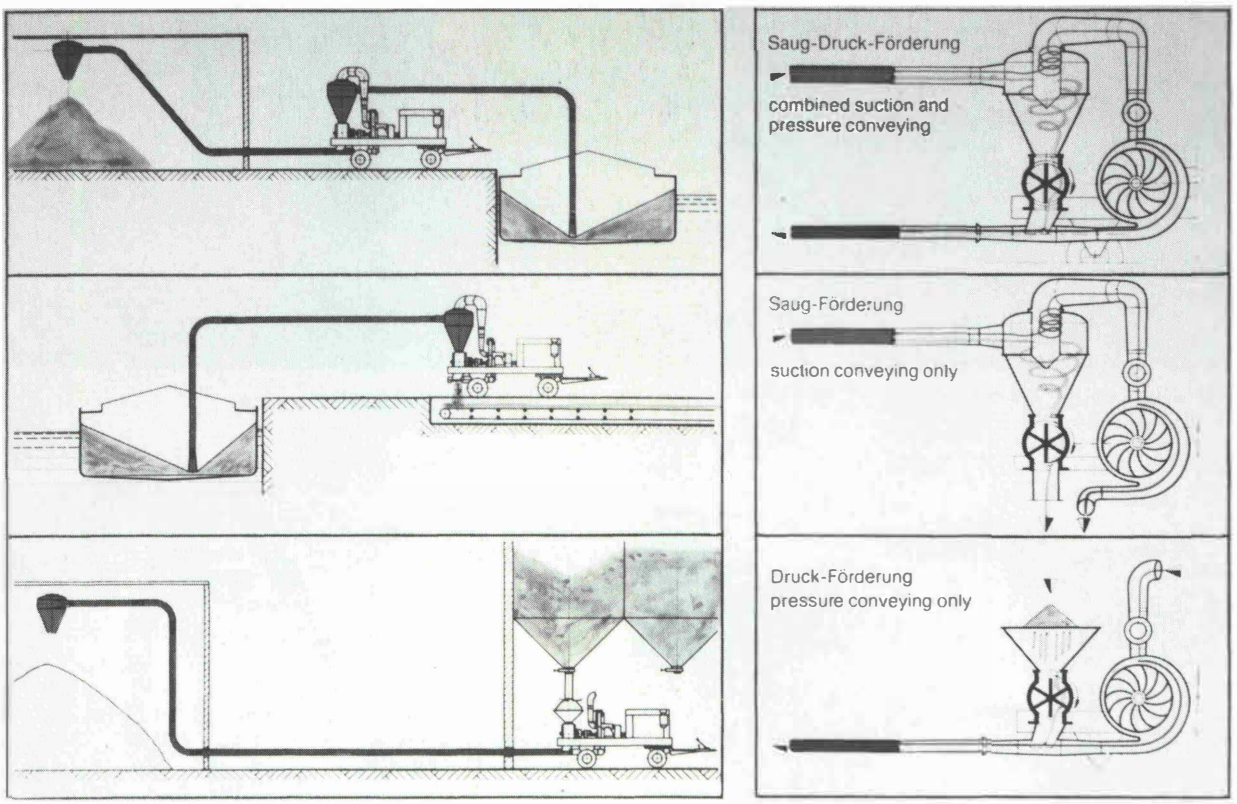

Fig. 5: Schematic diagram of combined suction-pressure conveying

The operator has a considerable interest in the total unloading time of a ship, which must also take unfavourable conditions into account. It is not possible to draw from bulk product if the suction nozzle is near the ground or is operating in corners. There are also delays caused by fitting extension pieces on the suction nozzle. Furthermore, loading hatches must be uncovered and ships secured. The total unloading time depends to a great extent on the organisation of personnel and on how efficiently the system is operated. With all newly delivered plant, after a familiarisation phase, the average capacity increases considerably, which highlights the fact that human factors play an important part. Accordingly, the type of material and the size of the ship are, in the main, critical to the total unloading time.

The manufacturer of pneumatic unloading plant has no control over these parameters and he cannot therefore guarantee an average conveying capacity. Naturally there are empirical values which can be taken as a guide to the selection of peak capacity in plant, but they must be continually supplemented by the results of further observations.

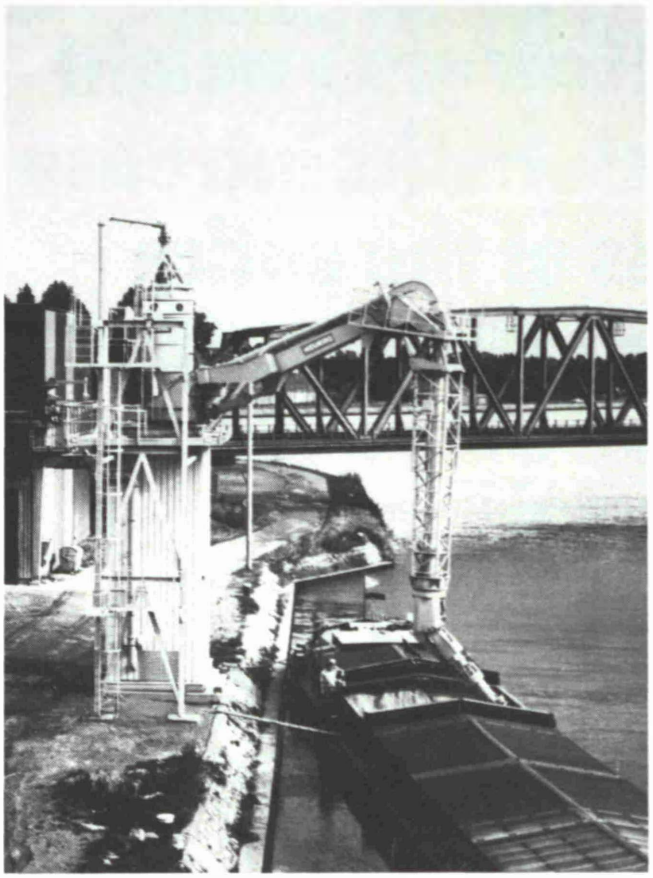

Fig. 7: Ship unloading plant with rotary hoe. The material is loosened by mechanical action and fed to the suction nozzle

7. Environmental Protection

A factor of decisive importance to the construction of a pneumatic ship unloading system may be the question of environmental protection. Since effective filtering is absolutely essential, particularly with meals and powders, pneumatic conveying methods offer decisive advantages since the material is conveyed in sealed pipework, and high-efficiency self-cleaning filters are used. Noise can usually be controlled at acceptable levels but sound attenuation equipment can be expensive. However, the exacting requirement of the factory inspectorates/health and safety executives can be complied with (Fig. 8).

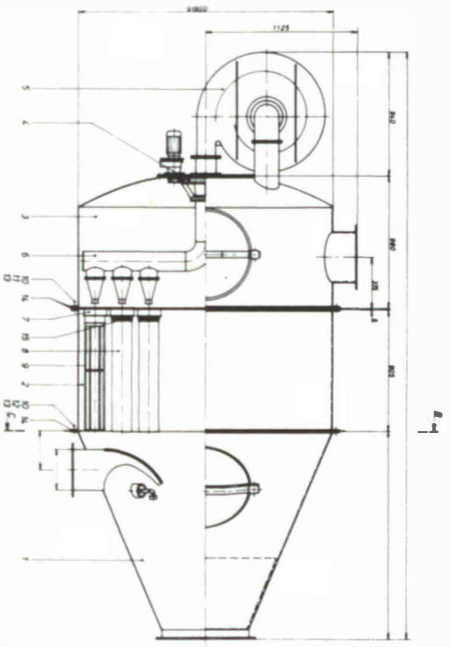

Fig. 8: Diagram of an automatically cleaned bag filter