World's Largest Purpose Built Cement Carriers

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Summary

The world's largest purpose built cement carriers, Castillo de Javier and Castillo de Monterrey, are fitted with a Carlsen pump/Weibull screw system for self unloading. The article reviews the principle of this "Carlsen Pneumatic Bulk Screw System" and describes the implementation of the system in these two ultra-modern ships.

1. Introduction

The increased use of bulk carriers for the transport of dry bulk solids has important advantages economically. One drawback of this is, however, the reliance on port unloading facilities, often in remote areas. The design of custom built ships with self unloading capability is an increasingly important way of overcoming this difficulty. The article describes the implementation of such a self unloading system in the recently commissioned, world's largest, cement carriers.

2. Description of the Carlsen Pneumatic Bulk Screw System

The system consists of the Carlsen Powder Pump and the Weibull Double Screw Conveyor. The unloading is operated from a main control panel in the control room but can also be operated locally from a sub-panel located at each hatch opening. In principle the ship is supplied with two independent Carlsen Pump/Weibull Screw Systems.

2.1 Description of the Carlsen Pump System

The unloading system is mainly built up of the two reloader tanks, compressors, vacuum pumps, blower and auxiliary compressors (for operation of the valves).

The reloaders 1 and 2 (resp. 3 and 4) act as intermediate vessels. They are the focal point of the system. The cement is sucked into one vessel and during the next cycle pushed out of it again. The vacuum pump provides the negative pressure which causes the cement to flow from the suction bins located in the holds to the reloader. The compressors furnish the air, which applies the pressure inside the reloader and mixes with the cement; all with the purpose of conveying the cement from the reloader to the storage silos. As this is a "pull-push" system, the vacuum line and the pressure line to a particular reloader will never be open simultaneously. For this reason there are two reloader tanks for each pump unit. When the vacuum pump does not have to function for reloader 1, it can be used to fill reloader 2 and vice versa (Fig. 1).

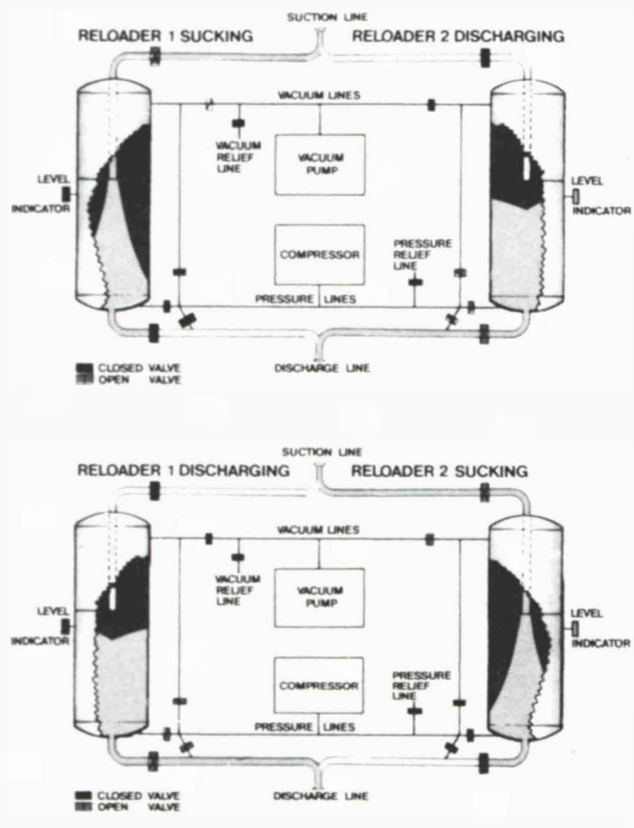

Fig. 1: Principle of the Carlsen Pump System

The same reasoning applies to the compressors. We have therefore two flow paths; one for each reloader. A number of valves are required to open and close suction lines, discharge lines, vacuum lines and pressure lines to each of the reloaders.

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28 suction bin valves control the flow of cement between the different suction bins in the hold and the reloader, and can be selected from the control panel.

Four suction valves are placed on the reloader. 16 suction connection valves enable the transport of cement from port side to starboard side and vice versa and also from one hold to the other. 4 pressure discharge line valves are situated between reloaders and storage silos.

Other valves govern the application of vacuum pressure to the reloaders.

Further valves are opened together with the respective discharge valves and feed air directly into the cement lines. On shorter distances the hand operated valve on this line can be closed, but on very long distances it can be necessary to use this line to optimize the cement/air mixture in order to prevent plugging conditions in the discharge line.

The upper part of the reloader is actually a dust collector. Air to the vacuum pump must be clean, and is filtered through the collector bags; the dust is deposited on the inside surface of the bags. When the cycle changes, the compressed air, which also passes through the bags but in the reverse direction, dislodges the dust and causes it to fall down to the lower part of the reloader.

An important factor in the flow of cement from the reloader to the discharge line is the aeration. The bottom of the reloader is provided with an aeration pad, which fluidizes the cement. Furthermore the inner tank surface has been painted to prevent cement from sticking to the wall. Thus flow to the outlet is assured.

Bypass valves are used in idle positions or waiting position. In this case, all the air is exhausted to the atmosphere. When starting the machinery, these valves are automatically open to enable one to start the motors. The suction lines of each reloader are extended into the holds through the double bottom by a pipeline to the suction bins.

The suction bin consists of sloped surfaces which converge to the suction point. Air is supplied into the air slides and distributed underneath the fabric. The aeration gives the material excellent flow qualities. Gravitational forces make it converge to the suction point. The blowers provide the aeration air for the air slides and the neck air. By means of a hand operated valve on the neck air-line (and the automatic N-valve) the quantity of neck air to each suction point can be regulated in order to get the optimum cement/air proportions for maximum suction capacity.

To regulate the airflow from the blower there is also an automatic blower by-pass valve, which regulates the blower line pressure. This pressure is preset by means of a knob on the control desk.

2.2 Description of the Weibull System

The screw conveyor consists of two parts, the gantry and the double screw. The gantry is erected on two rails, one on the port side and one on the starboard side of the hold. By means of a chain transmission the gantry can move from the aft of the hold (parking position) to the forward part of the hold. On the gantry one fixed screw is also erected.

The double screw actually consists of four screws erected on a common steel frame. By means of these screws the cement is transported from the centre line of the ship to the sides where the suction bins are located. However, the screws can also transport from the sides to the centre or from starboard to portside and vice versa to be able to trim the ship. By means of a hoisting arrangement on the gantry the double screw is lowered down into the hold.

During voyages the gantry and the double screw are locked in the parking position.

2.3 Description of the Control Panel (Main and Sub)

From the control panel the Carlsen Pumps and the screw conveyors can be automatically or manually operated. See Fig. 2.

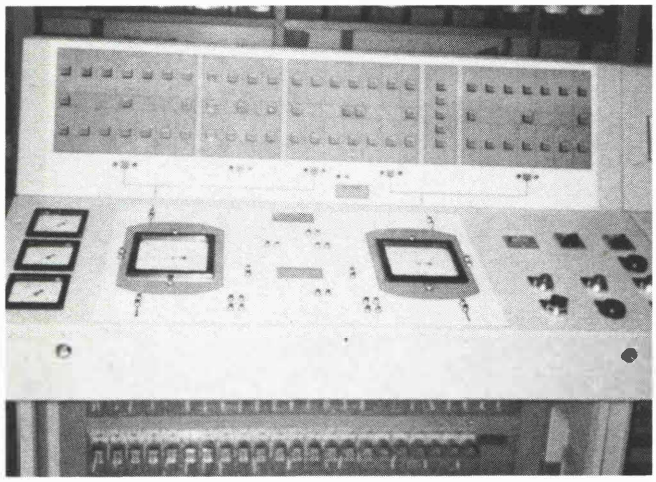


Fig. 2: Front of a typical Carlsen Control Panel for a self-unloader. From this the whole unloading operation is controlled by one man.

Each powder pump has one switch for manual or automatic operation. On manual all the valves can be remotely controlled. On automatic only those valves can be operated by the push buttons which enable the selection of the different suction bins.

However, these valves also have an automatic sequence function as follows:

The pump will start, for example, with bin No. 1, with reloader No. 1. The next suction cycle for reloader No. 1 will automatically be from bin No. 2 etc. If the operator does not want to take more cement from bin No. 2, he pushes the SB2 button taking this bin out of the sequence and the pump will automatically suck from bin No. 3 instead. The operator can also select buttons only to take from the starboard side or from the port side with both reloaders, so as to be able to trim the ship. The other valves are controlled by relays in the control panel.

If the control panel does not receive correct signals from the limit switches on the valves, the pump stops automatically. Also, if the pressure on the auxiliary compressor for any reason drops below a preset value, the pumps will go into idle position automatically.

The cycle sequence can be followed on the control panel by means of indication lamps for each valve (green and red light). The pump can be stopped temporarily by pushing the button "Idle". Furthermore the cycle sequence can be checked before starting unloading by simulation of the system by means of four buttons for each reloader tank. This testing of the system can be done without starting the main machinery. Only the auxiliary compressor has to be running.

Each screw conveyor has a "manual/mid/automatic" switch for the gantry movement and for the hoisting machinery. The gantry has also one switch "gantry speed high/low" for normal running or for the first turn from aft to fore of hold with the fixed screw in operation. The reason for the fixed screw is to be able to take off any tops of material above the level of the double screw. Therefore this screw has to be operated only during the first turn around and with the speed switch on "low".

Fig. 3: First run of fixed screw, taking off tops.

On automatic, the gantry will move backwards and forwards in the hold and the double screw will be lowered down automatically in each end of the hold. The lowering distance can be adjusted from the panel by a time relay for the hosting machinery (Fig. 4). The speed of the gantry is automatically regulated by the power consumption of the screw. The operator can, on the control panel, follow the power consumption of the motors by means of meters. The position of the gantry in relation to the positions of the suction bins can be seen on the control panel.

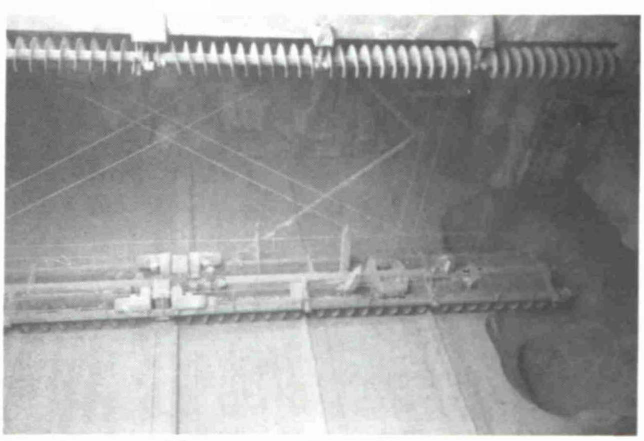


Fig. 4: Double screw gantry in action unloading.

In the manual position of the switch the gantry can be moved forwards or backwards and the screws upwards or downwards by means of push buttons. In the "mid" position of the switch, the gantry moves forward and aft and the screws are lowered in each end of the hold as on "automatic" but the travelling speed has to be regulated manually by means of a rheostat as the automatic speed control is by-passed in this case.

On the panel the operator can also see the location of the double screw vertically in the hold. Regarding the four double screws, each screw can, independently from the others, have different directions of rotation. This is achieved by two push buttons for each screw. The power consumption for the different motors can also be seen on the panel. On the sub control panel located at the hatch opening of the hold, each of the suction bins can be closed or opened and the reloader unit can be started and stopped. All the movements of the Weibull Screw Conveyor can also be controlled from this panel.

2.4 Description of the Unloading Procedure

1. The rubber hoses between ship and shore pipes to storage silos are connected.
2. The control panel is switched on.
3. The auxiliary compressors are started and the Carlsen Pumps are checked.
4. The filter for the holds are started as well as the machinery for the Carlsen Pumps.
5. It is checked that the shore silos are ready to receive.
6. The two transverse suction bins underneath each double screw in the aft part of each hold are selected by means of push buttons on the control panel.
7. The "automatic start" buttons for the Carlsen Pumps are pushed. The reloaders will now start to suck material from the suction bins and will continuously and automatically change between the selected bins every time a reloader tank is full.
8. When the vacuum starts to drop on the gauge for the reloaders, the operator switches over to the suction bins on the opposite side of the hold. When these bins are also empty, he switches over to "tripping" between the rest of the suction bins.
9. The reloaders will now start sucking from all the hold. The screw conveyor is released from "locked" position. The switch for the gantry speed is turned to position "low" and "automatic start" is pushed. The six screws are started. The gantry will now move forward in the hold with the fixed screw in operation. During the first turn of the gantry, the operator has to watch the power consumption to avoid overloading the electric motors.
10. When the gantry reaches the bulkhead in the forward part of the hold the switch for the gantry speed can be switched to position "high". The gantry screw can now be stopped and instead the double screw conveyor will run in the normal way and be lowered down in each end of the hold. All twelve bins on port and starboard side will now be in operation.
11. The screw conveyor will continue automatically down to the tank top.
12. After the completed unloading with the screw conveyor, a front-end-loader has to be lifted down in the hold in order to push down the rest of the cement into the suction bins. To get the hold completely clean, manual sweeping has to be anticipated
13. Afterwards by using the compressors and vacuum pumps air is blown through reloaders, suction pipes and discharge pipes for cleaning.

14. The filters and machinery are stopped and the panel turned off. The rubber hoses between ship and shore are disconnected again.
15. If the ship is going to take a type of return cargo which needs completely clean cargo holds, the holds have to be sprayed with water after the above mentioned cleaning.

3. First Contract

The system was invented in 1976 and advertised for the first time in 1977. In 1978 the first equipment was contracted but the vessels were not delivered until the end of 1981. The first unloading systems had to be delivered by Spanish manufacturers due to import restrictions and a local equipment supplier to the shipyard had to be used. After having designed all the unloading system and produced all manufacturing drawings and machinery specifications in Sweden, most of the equipment was manufactured in Spain under the supervision of H.W. Carlsen AB.

H.W. Carlsen AB and their Swedish subcontractor for the screw design in this project, Weibull, then also had engineers in Spain to inspect the ships during building, at machinery tests etc., to make sure that everything was manufactured as agreed.

Finally, the first ship "Castillo de Javier" was loaded at the beginning of August and left San Carlos de La Rapita in Spain for Venezuela on August 13, 1981. A cut-away view of the ship is shown in Fig. 5 and the layout of suction bins, Weibull screws etc., in Fig. 6.

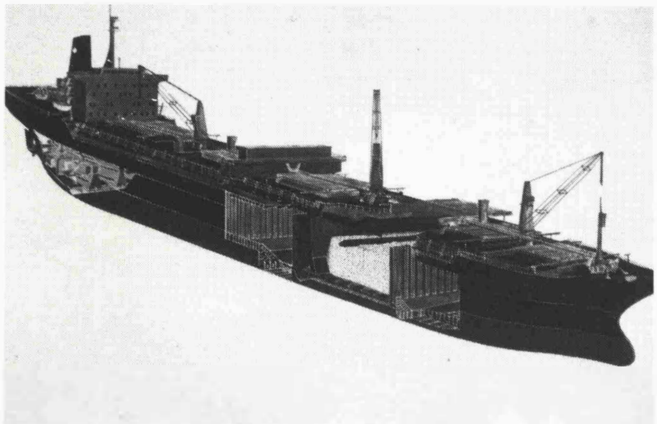
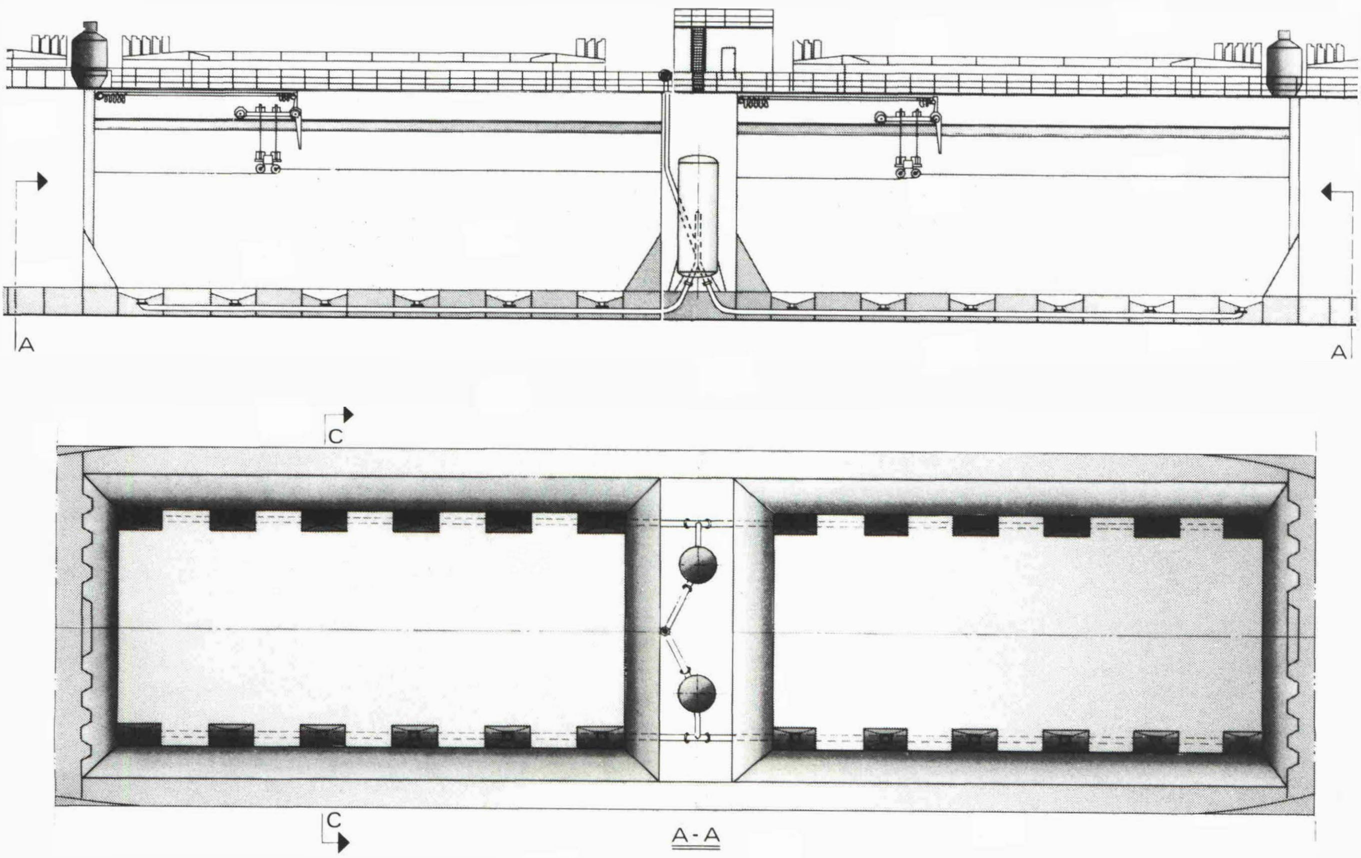


Fig. 5: Cut-away view of bulk cement carrier Castillo de Javier

The ship arrived at El Palito on August 27 for discharging 18,000 tons under the supervision of one of H.W. Carlsen's engineers. The discharge capacity was only 180 t/h in one 14″ line, 300 m long, as less than half the compressor capacity could be utilized due to the too small diameter of the discharge line (14″ instead of optimum 16″) and the fact that only one line instead of two could be used.

At this port the screw conveyors did not have to be operated at all as the 18,000 tons of cement could be taken out only by aerating the small suction bins in the double bottom and sucking the cement to the four reloader tanks (two Carlsen

Fig. 6: Layout of Weibull screws, suction bins and reloader units in the Castillo de Javier.
a) elevation
b) plan



Double Reloader Units DR 400-S) onboard and then discharging the cement from there directly into the silos 300 m away.

After a few days the ship continued to Palm Beach in Florida for unloading the rest of the cement; also under the supervision of a Carlsen engineer.

The ship started to unload on September 7. The capacity here was 2 x 170 t/h = 340 t/h in two pipelines 100 m long and with a diameter of 10″ each. Also here the capacity was far from the optimum 600 t/h as the installation is designed for two 16″ lines from the ship to the silos to be able to utilize all the machinery installed. Not all the remaining cement was discharged in Palm Beach. Instead a minor remaining quantity was finally discharged in the Bahamas.

The capacity of the screw system and the suction side of the reloader units has been proved to be 800 t/h instead of 600 t/h as guaranteed. This means that with the correct discharge pipe system on land (2 lines with ID 400 mm each) the average discharge rate would be above 600 t/h.

Only very minor problems occurred during this first unloading. More than half the load of cement could be discharged without starting the screw system. The screw system also worked very smoothly and the cement was evenly fed from the top layer and down into the suction bins along the ships sides just as anticipated. The discharge could naturally take place without opening the hatch covers. Only a layer of 100 mm was left on the tank top after the final turn of the screw conveyor for the bulldozers (Bobcats) to feed into the suction bins.

The ship showed already on this first voyage her ability and there will certainly be many of her kind on the oceans in a few years' time. The second ship "Castillo de Monterrey" in fact was delivered one month later and both ships are now running on regular routes between Spain and the USA. Bearing in mind that these vessels can take any kind of return cargo although they are specially designed cement carriers, there must be a great future for them.

Besides cement, this pneumatic system can also handle, for example, Alumina, Bentonite, Flyash, Lime or any other fine powder material.

Acknowledgements

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