Continuous Versus Discontinuous Shipunloading

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Summary

This paper compares the advantages, disadvantages, and status of grab and continuous coal unloading systems for ocean-going ships.

1. Discontinuous Systems

The clam shell grab bucket is the pre-eminent example of the discontinuous discharge system. The grab bucket unloader is a well-known, time-tested, proven, and reliable design. It has the advantages of flexibility, adaptability, reliability, ease of maintenance, and availability at competitive market prices.

Much of the wear and tear on the unloading machine is concentrated on the bucket which comes into direct contact with the material. A damaged bucket can be replaced or repaired as needed with minimal impact on terminal operations. There is also wear and tear on the wire ropes. However, their replacement is a straightforward operation, providing another example of the relative ease of maintenance of grab bucket systems. Another feature which facilitates the maintenance of the grab bucket system is that the complex machinery is not in contact with the material which is handled.

In spite of the widespread adoption of grab buckets, however, they have serious disadvantages. Chief among these are their predictably low efficiencies. Typically, the effective capacity of a grab bucket unloader is 40—50% of the nominal capacity. A second disadvantage is that these systems cannot be used to completely clean the bottoms of the vessel's holds. Therefore, mobile machinery is necessary in the final stages of clean-up, in spite of the slowness, inefficiency, and large man power requirements imposed by these methods. Grab bucket operations can result in dust generation and spillage of material; both of these aspects can be limited, but not eliminated. Moreover, operator skill and fatigue is a consideration that complicates manning problems. Damage to the vessel and to the bucket is also a problem.

Another aspect is the limitation on the capacity of an individual machine. In the case of smaller vessels, the size of the grab bucket limits capacity. For large vessels, it was thought that 50 to 60 ton machines represented the limit. However, the PWH 85 metric ton machine with a nominal capacity of 4,200 metric tons per hour on coal, is representative of the state-of-the-art (see Fig. 1).

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2. Continuous Unloaders in the Past

Soros Associates have followed applications of continuous shipunloaders for close to 30 years. During this time, we have seen tens of millions of dollars spent on high-capacity continuous unloader installations, none of which was a complete success and was able to achieve the expected commercial breakthroughs.

A large bucket-wheel unit used for unloading salt in Japan is shown in Fig. 2. It can be seen that its complexity is substantial. Its cost and weight are also high. The company is now developing a digging elevator.

We are quite familiar with another bucket-wheel and elevator unloader installation at one of the ports where we have worked (Fig. 3). This installation handled less than 100,000 tons before it was permanently abandoned through no fault of the manufacturer.

In the case of high-capacity coal unloading from barges, digging chain elevators have proved more commercially successful than bucket-wheels. When this technology was applied to ocean-going ships, however, it was not as successful as when used on barges. Fig. 4 shows a digging chain elevator at an electric utility, with a nominal capacity on coal of 4,000 short tons per hour which services 20,000 DWT ocean-going barges. This machine, which was manufactured by Dravo, has handled millions of tons of coal. However, the percentage of a shipload that this continuous unloader leaves for clean-up is substantial, resulting in effective rates of under 1,300 short tons per hour. Recently a grab unloader was added as a second unit. We have also observed a one year trial of a continuous unloader on iron ore pellets, and although the continuous unloader has good production when it worked, it was prone to mechanical breakdowns and was eventually taken out of service.

Even though we like to innovate, on the basis of our experience we believe that it is proper to proceed with great caution in the case of continuous unloaders.

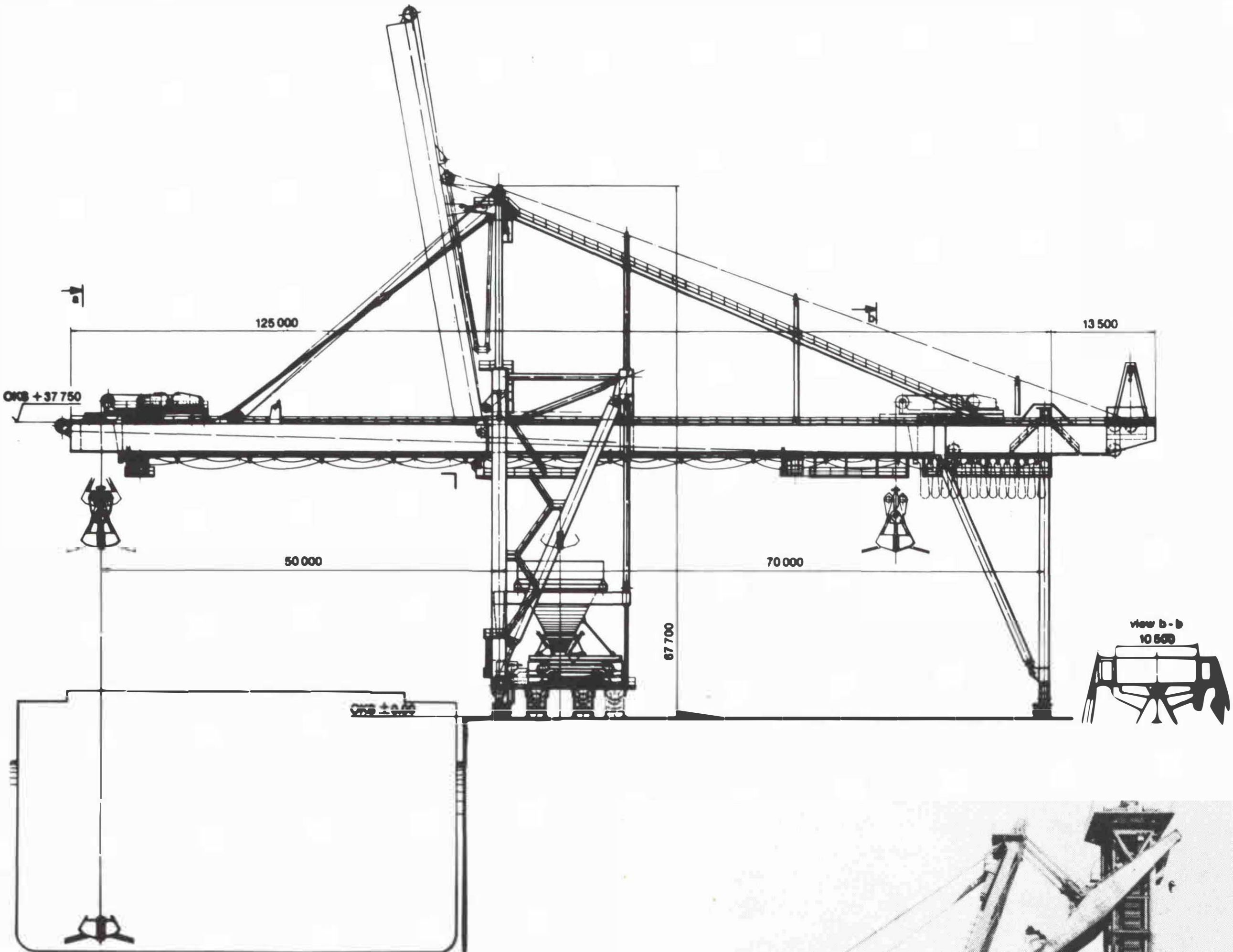
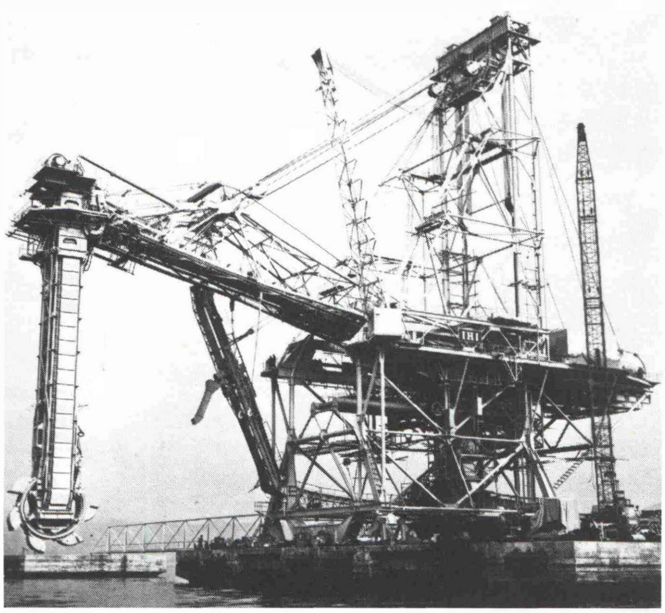


Fig. 1: Grab bucket shipunloader by PWH with 85 ton lifting capacity. The unloading capacity is 4,200 metric tons per hour on coal

Fig. 2: Continuous salt unloader by I. H. I. This machine has a capacity of 3,000 metric tons per hour



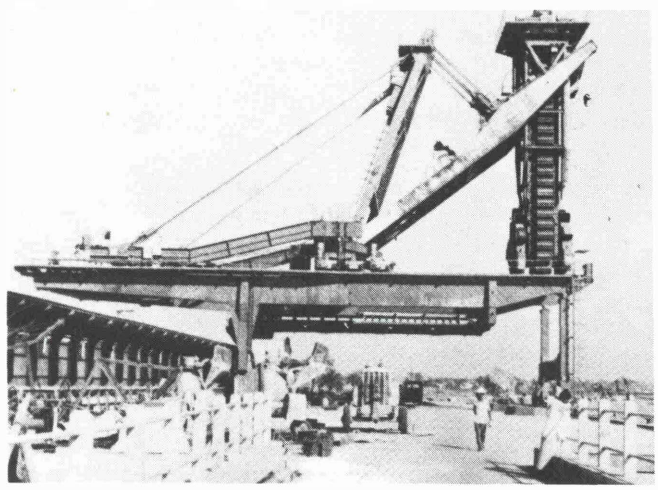
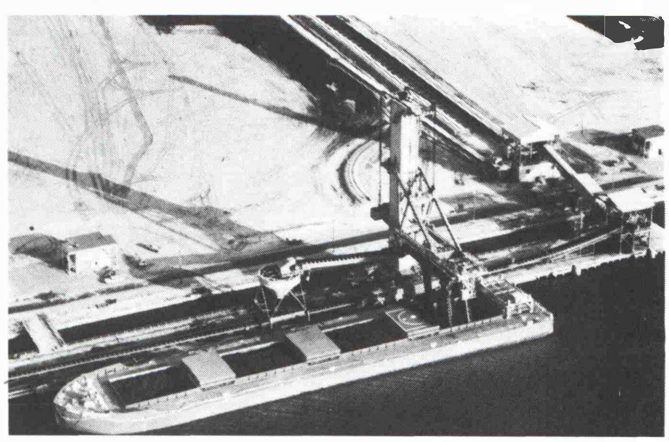


Fig. 3: Continuous unloader by F. C. B.

Fig. 4: Continuous unloader by Dravo. This digging chain elevator has a 4,000 short tons per hour capacity on coal



3. Recent Developments in Continuous Unloaders

Several continuous machines with capacities of 1,000 tons per hour for unloading coal from ships are now on order or under construction. Machines that have been working on other commodities are now being tested on coal. There are also many proposals and conceptual designs for continuous unloaders with capacities of 1,000 tons per hour and greater.

In our view, these various designs fall into three groups:

3.1 Digging Elevators

In these designs, the same element does the digging and the elevating.

Delattre-Levivier (D-L) built a 1,000 ton per hour bucket elevator machine which is in operation on phosphate at St. Malo, France (see Fig. 5). A grab crane is used to complete the unloading. A gathering device was recently added to improve operation.

I. H. I. offers an articulated bucket elevator with a capacity of 2,000 metric tons per hour (see Fig. 6). Tilting the lower portion aids operation and clean-up. The machine has been designed to unload coal.

Fig. 5: Bucket elevator continuous unloader by Delattre-Levivier. This machine has a capacity of 1,000 tons per hour on phosphate

Sumitomo has built a smaller capacity machine of this type which was designed to unload limestone at a rate of 300 metric tons per hour (see Fig. 7). The machine is presently in operation in Japan. The company has developed as second bucket elevator machine with a nominal capacity on coal of 1,000 to 1,500 metric tons per hour. Several of these machines are to be installed in Japan in the near future. Part of the column can be tilted to gain access to material under the coamings.

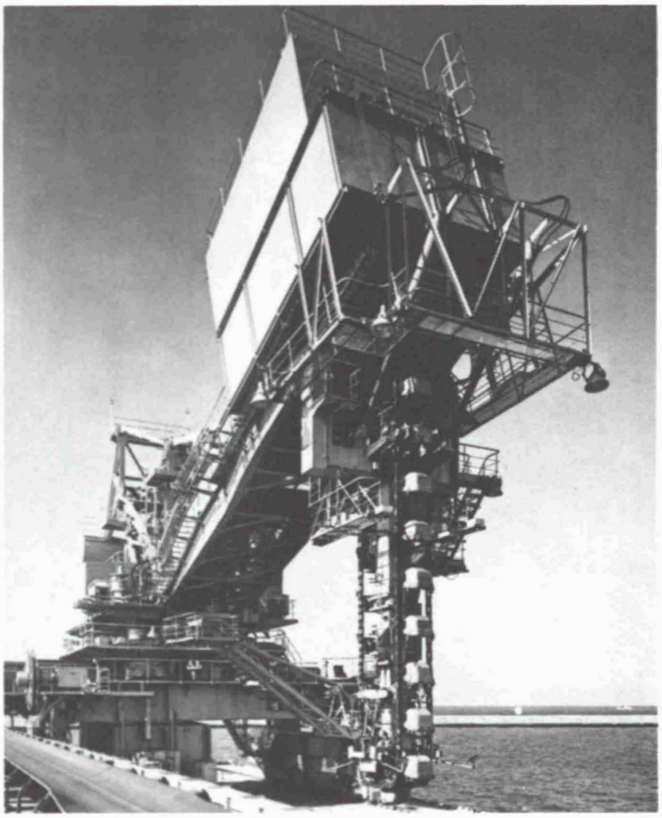
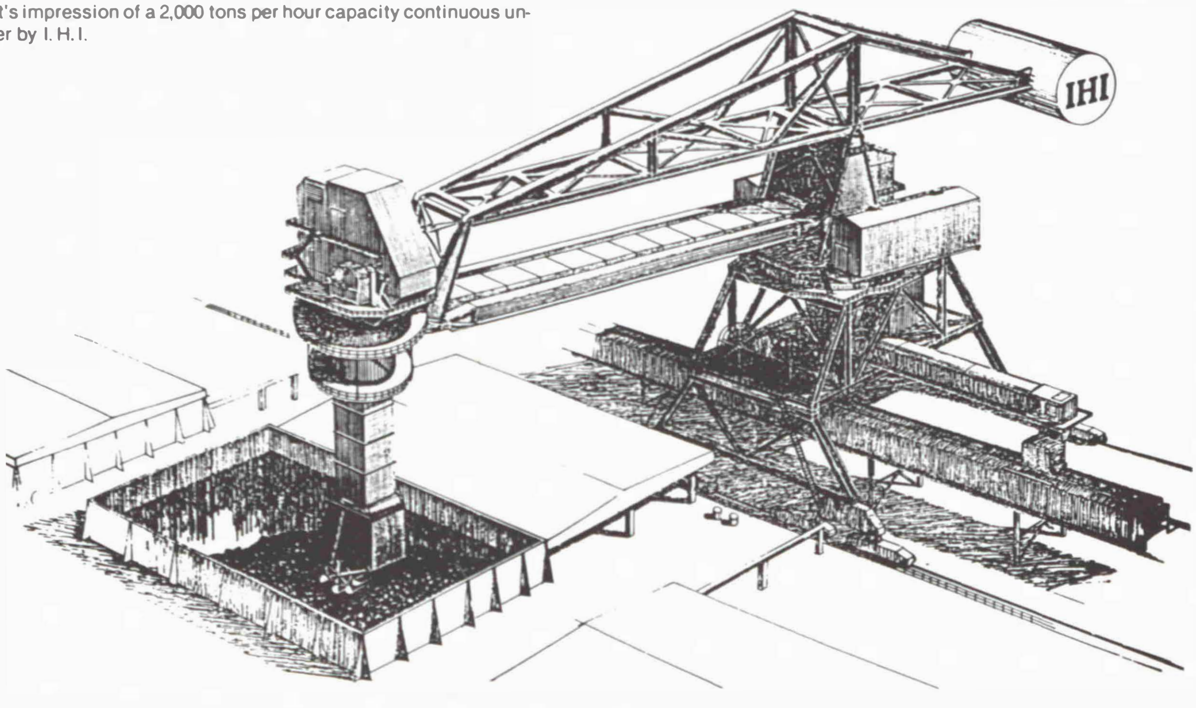


Fig. 7: Continuous unloader for limestone by Sumitomo. This machine has a 300 ton per hour capacity

Fig. 6: Artist's impression of a 2,000 tons per hour capacity continuous unloader by I. H. I.



PWH has built two machines of this type. One machine is presently in operation in Nordenham, West Germany, unloading asbestos at a nominal capacity of 350 metric tons per hour (see Fig. 8). A second PWH machine is installed in Aquaba, Jordan, unloading sulphur at a nominal capacity of 550 metric tons per hour. On both machines, the elevator has an integral horizontal arm which facilitates operation and clean-up. The company is developing a machine with a nominal capacity of 600 metric tons per hour on coal to be installed at a power plant in Sweden. This machine will be capable of unloading 50,000 DWT vessels.

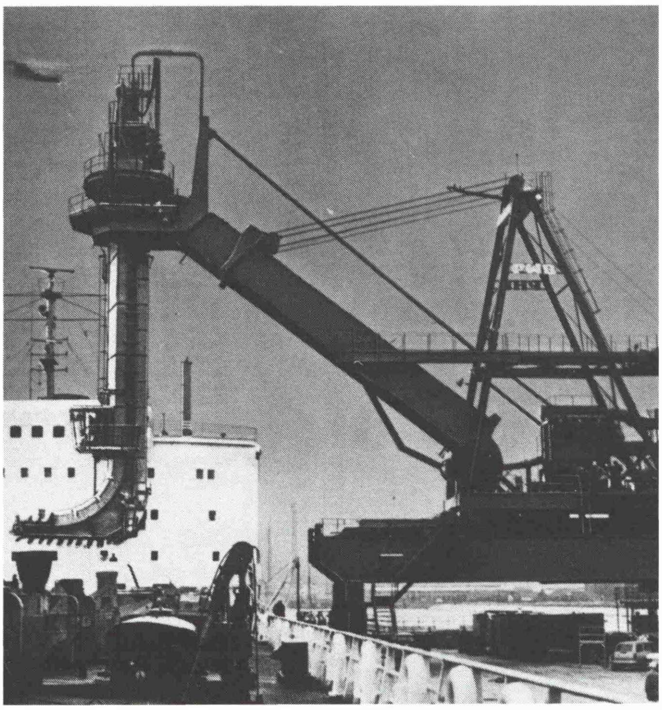


Fig. 8: Continuous shipunloader for asbestos by PWH. This machine has a capacity of 350 tons per hour

Fig. 9: Screw-type continuous shipunloader by Siwertell

Screw-type machines are available from Siwertell (see Fig. 9) and Sumitomo. An enclosed vertical screw system digs the material out from the holds and raises it to a horizontal screw which transports the material along the boom to a receiving hopper. Siwertell's screw-type machines are widely used on commodities other than coal. Siwertell machines to be used on coal are in construction. The largest of these are two units, each with a nominal capacity of 1,100 tons per hour on coal, which are to be installed at an offshore berth in Taiwan designed by Soros Associates. Siwertell is also supplying a coal unloader of 1,000 tons per hour for Denmark. Sumitomo has built a screw type unloader which is in operation in Japan. This machine unloads kaolin at a nominal capacity of 150 metric tons per hour.

Paceco has a design using a catenary rope with buckets, which is available also under license from Mitsui of Japan. A machine of this type with a nominal capacity of 1,000 short tons per hour is in operation unloading illmenite at Gulfport, Mississipi, USA. (see Fig. 10). Mitsui is adapting the Paceco design and one of these, to handle coal and limestone, will be installed in Japan.

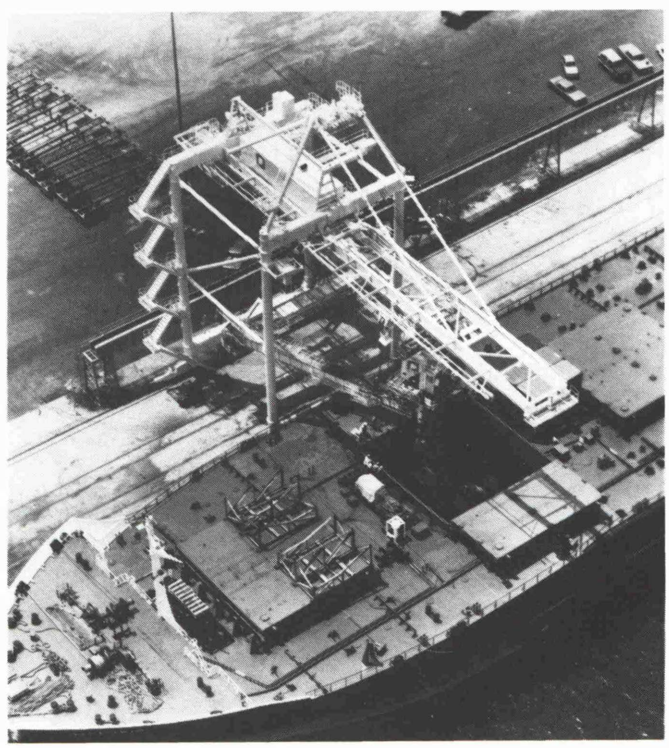


Fig. 10: Catenary continuous unloader by Paceco. This machine has a 1,000 ton per hour capacity

3.2 Elevators with Separate Digging Elements

Bühler-Miag has built a grain unloader at Tarragona, Spain which has a bucket drum as a digging element (see Fig. 11); this machine has been tried on coal at a rate of 850 metric tons per hour. Bühler-Miag predicts that it can handle fine coal at a rate of 1,500 tons per hour.

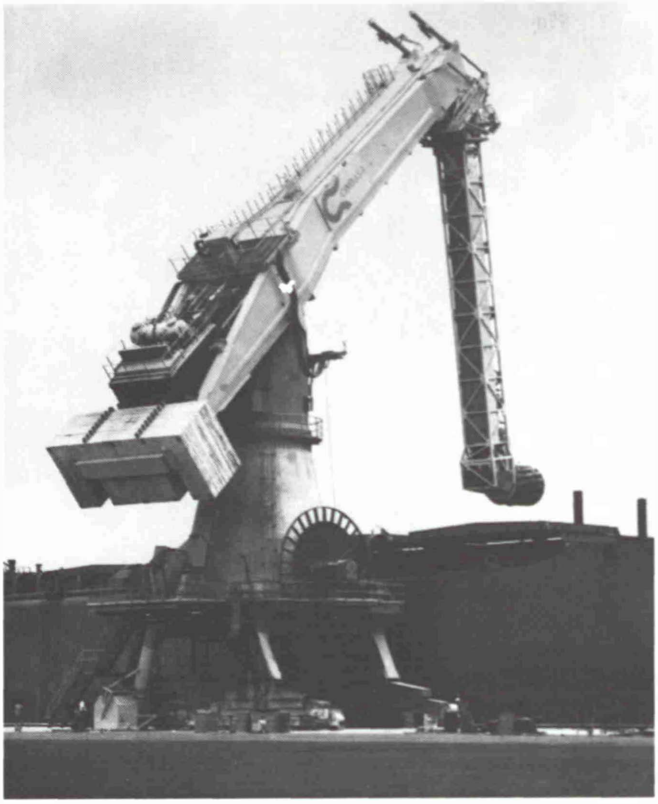


Fig. 11: Continuous shipunloader by Buhler-Miag. This machine has a capacity of 1,000 tons per hour on phosphate and 850 tons per hour on coal

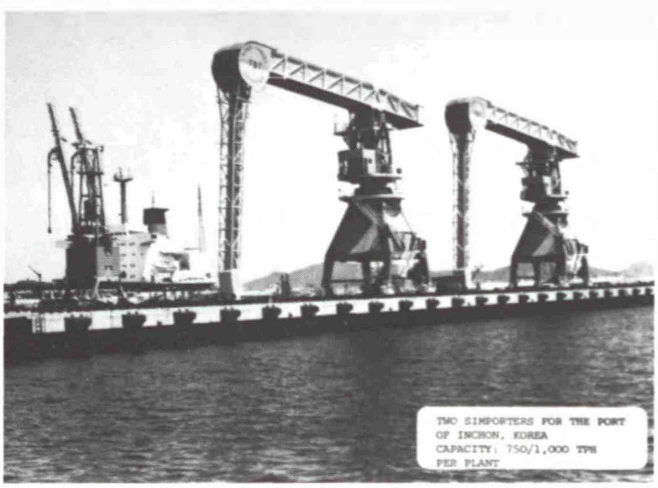


Fig. 12: Simporter unloaders by Simon-Carves

The Simporter, available from Simon-Carves (see Fig. 12), digs material out from the hold with two screw type rotating feeders. The material is then sandwiched between two conveyor belts which are held together by air pressure. The dual belt system, with material sandwiched between, lifts the material from the hold and transports it to shore. A number of Simporters have been used for grain handling and the design is now being tried on coal.

3.3 Elevators with Bucket-Wheels

In these designs the digging element is a bucket-wheel which transfers the material to a conveying and elevating system.

Fives Cail-Babcock (F.C.B.) is erecting such a machine in Marseille, France (see Fig. 13). It is expected to unload coal at a nominal capacity of 2,200 metric tons per hour and bauxite at a nominal capacity of 2,700 metric tons per hour. Vessels up to 150,000 DWT will be accommodated. The machine employs two bucket-wheels and is reported to be controlled by a microprocessor.

Babcock-Moxey has orders for two bucket-wheel elevators with capacities of 1,100 tons per hour for installation in Hong Kong (see Fig. 14). A back-hoe, fitted next to the wheel, increases the reach and will assist with clean-up. The company has developed a design for a coal unloader with a nominal capacity of 2,500 metric tons per hour, to accommodate vessels up to 250,000 DWT. The design includes two bucket-wheels for digging, instead of the one bucket-wheel employed on the Hong Kong machines.

Kone has an order for a bucket-wheel machine for a Danish power company (see Fig. 15). A 40 metric ton lift capacity grab unloader will be supplied in conjunction with the continuous machine. The continuous machine will unload coal at a nominal capacity of 1,300 metric tons per hour from vessels up to 170,000 DWT. The elevating system and boom conveyor will be a cleated rubber belt instead of the conventional bucket chain. The rubber cleats on the belt will form pockets to raise and transport the material. The lower portion of the column has an articulated joint to reach under the coaming.

4. Weight Comparisons

Figs. 16, 17 and 18 compare the estimated weights of continuous unloaders to the known weights of grab unloaders at various nominal capacities. The Simporter in Fig. 17 refers to a 1,500 tons per hour capacity machine. The following observations can be made:

1. The fewer provisions there are to handle non-free flowing materials, the less the weight of the machine.
2. At very high capacities, there is little weight advantage in favor of the continuous unloaders at present.
3. The differences in estimated weights among the continuous unloaders are so large as to be inconsistent with each other. This observation indicates an early stage in the development of these machines and the different design concepts between the groups of machines.

5. Cost Comparisons

Figs. 19, 20, and 21 compare the investment per effective ton of unloader capacity for continuous and grab bucket unloaders. It should be noted that these data represent estimates provided by the manufacturers of the machines. The effective rates of the grab bucket unloaders shown in the figures are based on an efficiency of 50%. The effective rates of the continuous unloaders are shown as their efficiency ranges from 35 to 70%. Actual efficiencies may be different than these. This range is shown for comparative purposes only. For example, the estimated weight of a Babcock-Moxey machine with a nominal capacity of 2,500 metric tons per hour, which is presented in Fig. 18, is close to the Fives Cail-Babcock estimate for their 2,000 metric ton per hour machine as shown in Fig. 17. Thus, the cost estimates of these machines which are presented in Fig. 20 and 21 are not consistent and should be considered in that light.

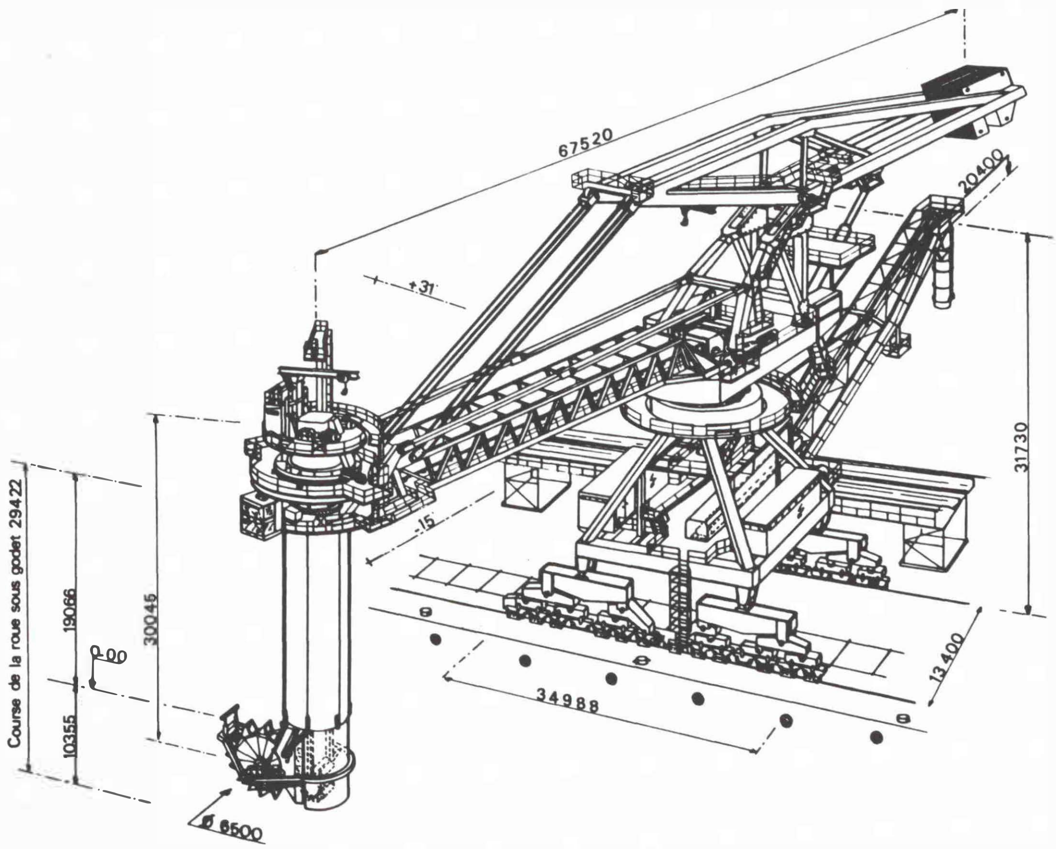
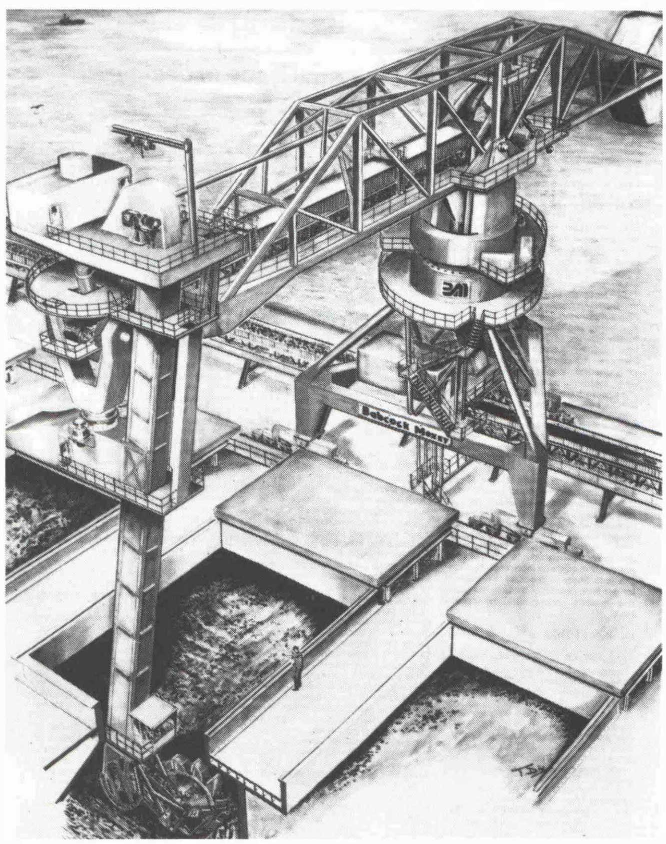


Fig. 13: Continuous unloader by Fives Cail-Babcock. This machine has a capacity of 2,200 tons per hour on coal

Fig. 14: Artist's view of continuous unloader by Babcock-Moxey for coal with a 1,100 tons per hour capacity



The figures show that the effective rates which can actually be achieved by the continuous unloaders are the key to whether the capital cost of these machines is justified in comparison to grab bucket machines. The lighter continuous unloaders would be lower in capital cost per ton of throughput than grabs provided these machines could achieve the same 50 % efficiency as grab machines.

The heavier and more elaborate designs for continuous machines would require effective rates substantially greater than 50 % of the nominal capacities in order to be economically attractive.

Therefore, the effective rates, rather than the nominal rates, are the true basis of an informed cost comparison.

6. Effective Rates

There are two aspects which influence the effective rate of a continuous unloader. These components are the rates which can be achieved during both free digging and clean-up operations.

Fig. 22 is taken from a Siwertell brochure. It illustrates the machine operating inside a ship's hatch.

Fig. 23 is a diagram provided by Kone on how the bucket-wheel type continuous unloader is expected to operate. The important question is whether the bucket-wheel will continue unloading during repositioning. Similarly, during what percentage of the repositioning moves will there be reduced production?

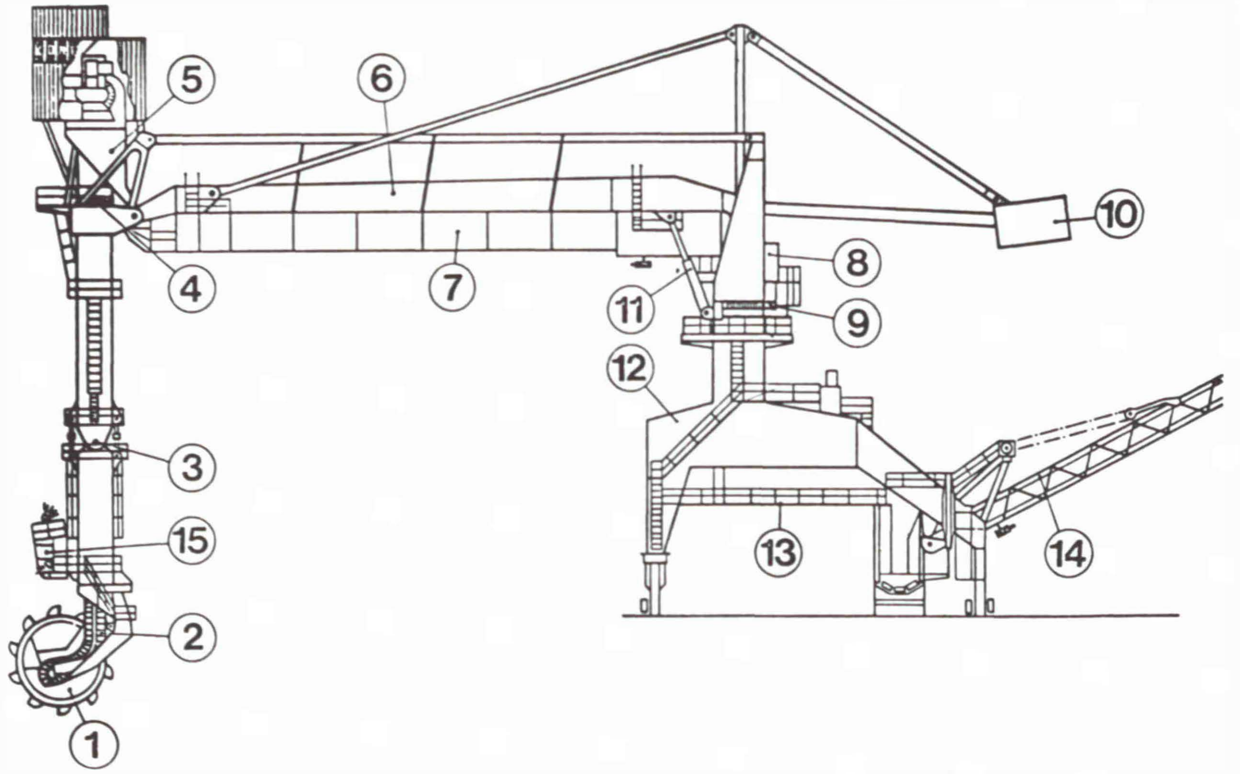


Fig. 15: Bucket wheel continuous unloader by Kone. This machine has a 1,300 tons per hour capacity on coal

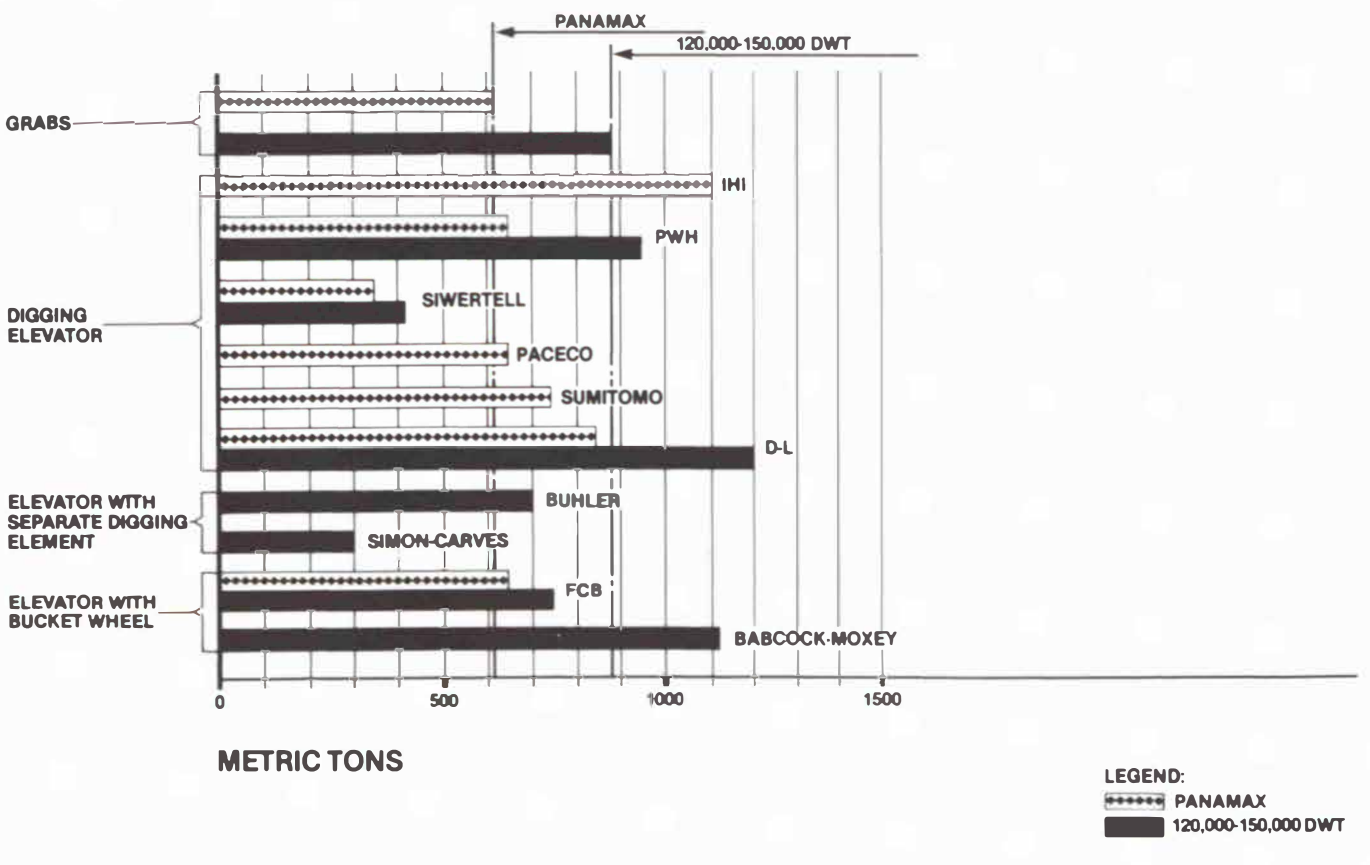


Fig. 16: Weight comparisons of 1,000 metric tons per hour continuous and grab shipunloaders

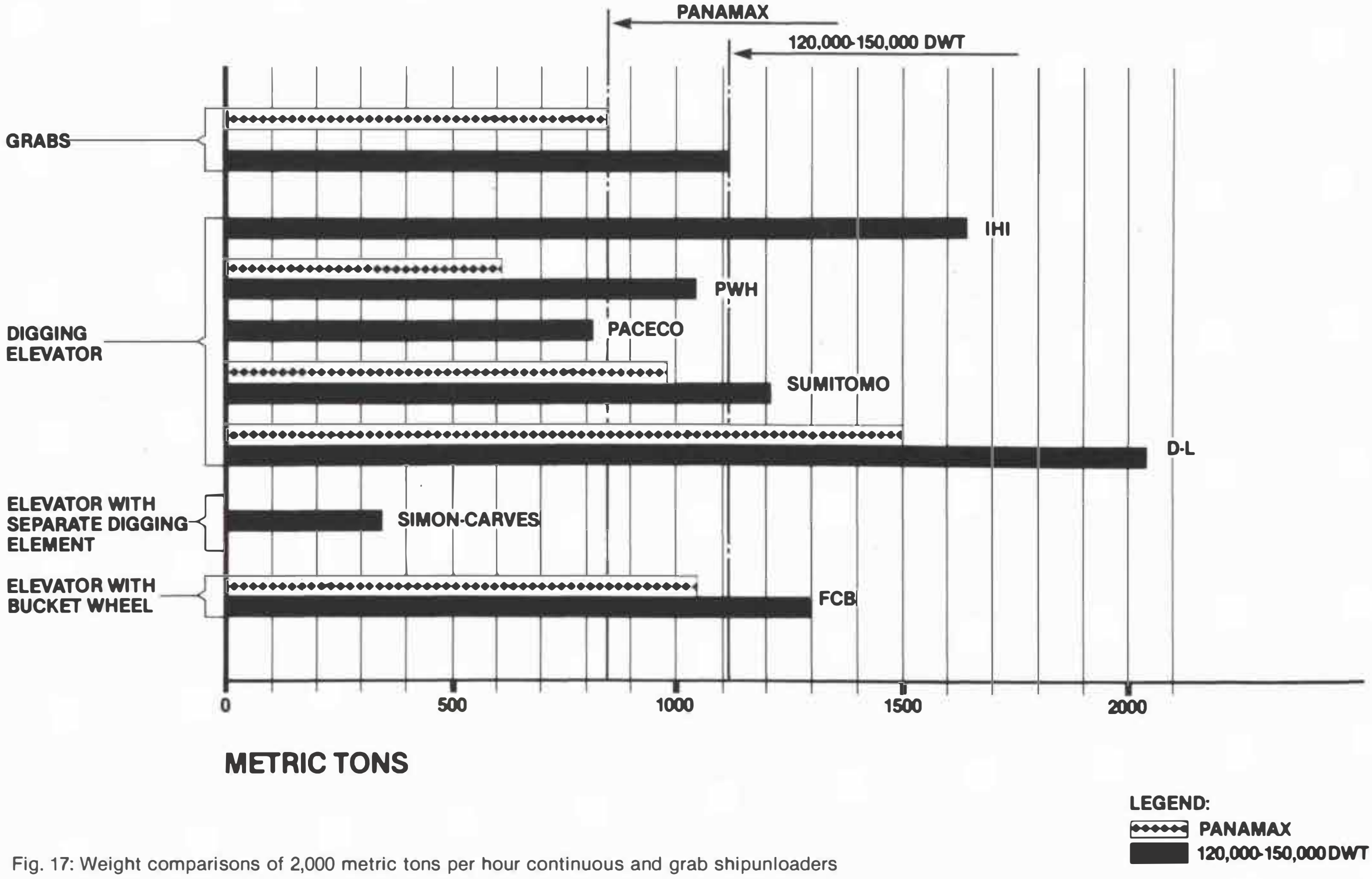
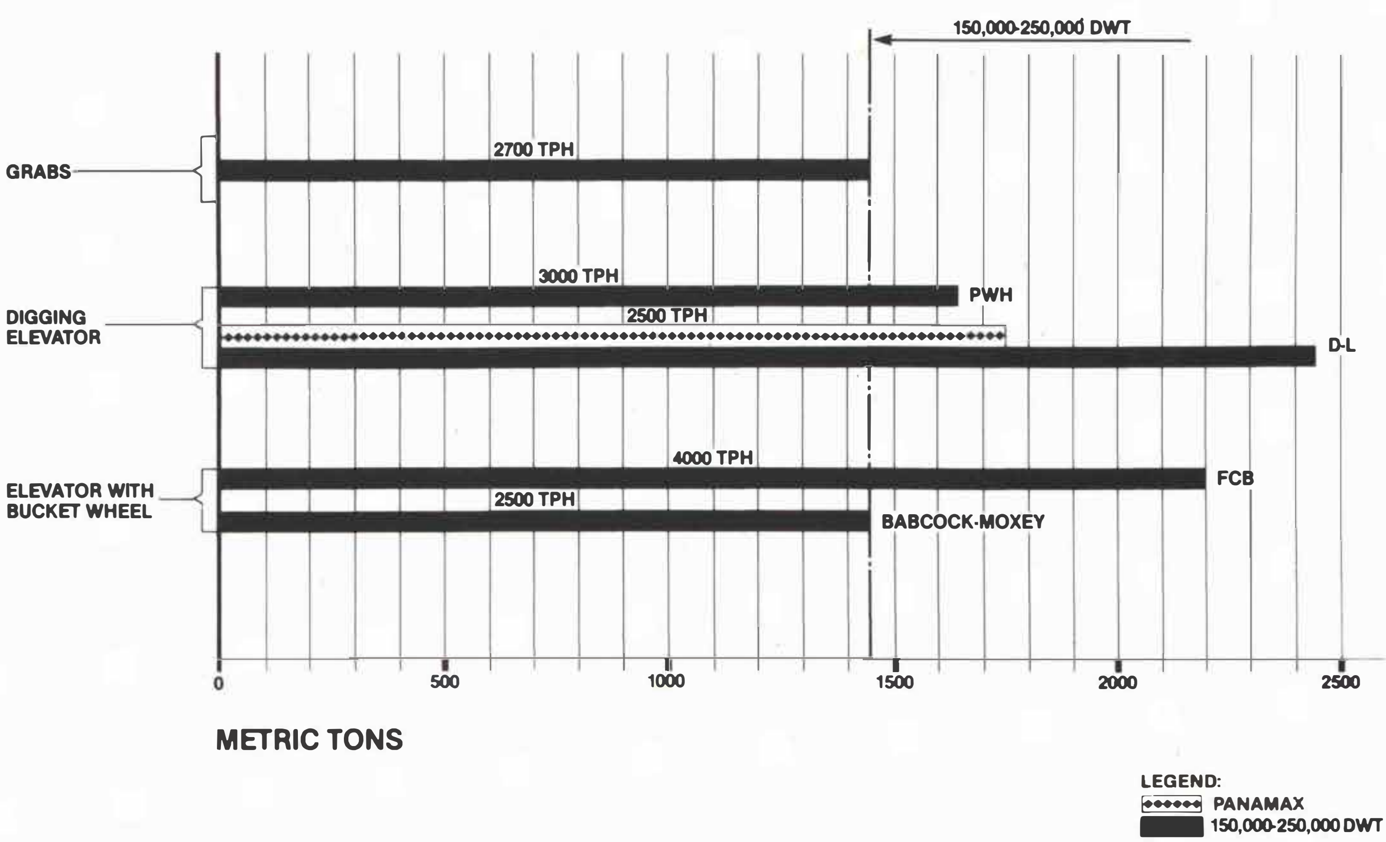


Fig. 17: Weight comparisons of 2,000 metric tons per hour continuous and grab shipunloaders

Fig. 18: Weight comparisons of 2,500 to 4,000 metric tons per hour continuous and grab shiploaders



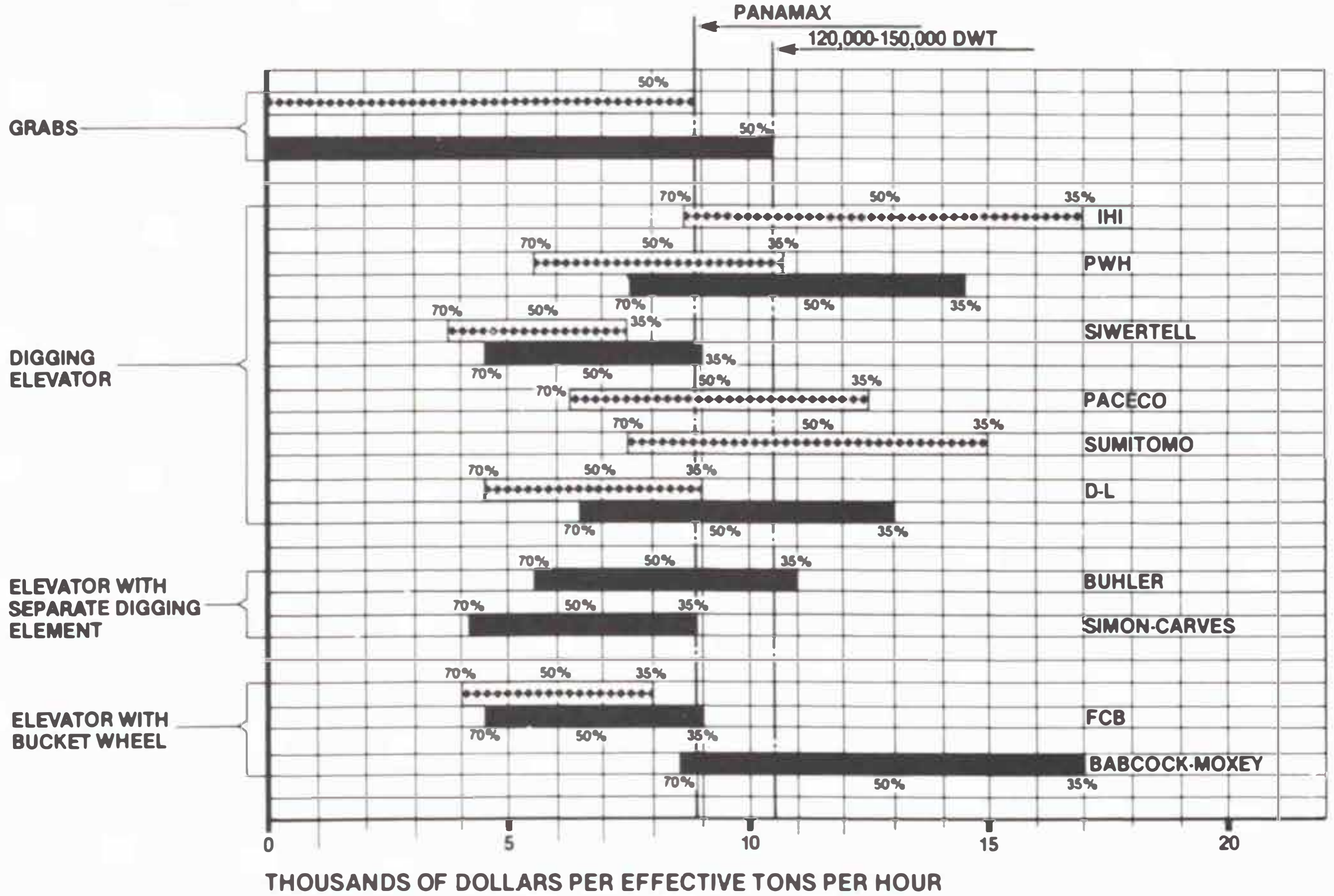
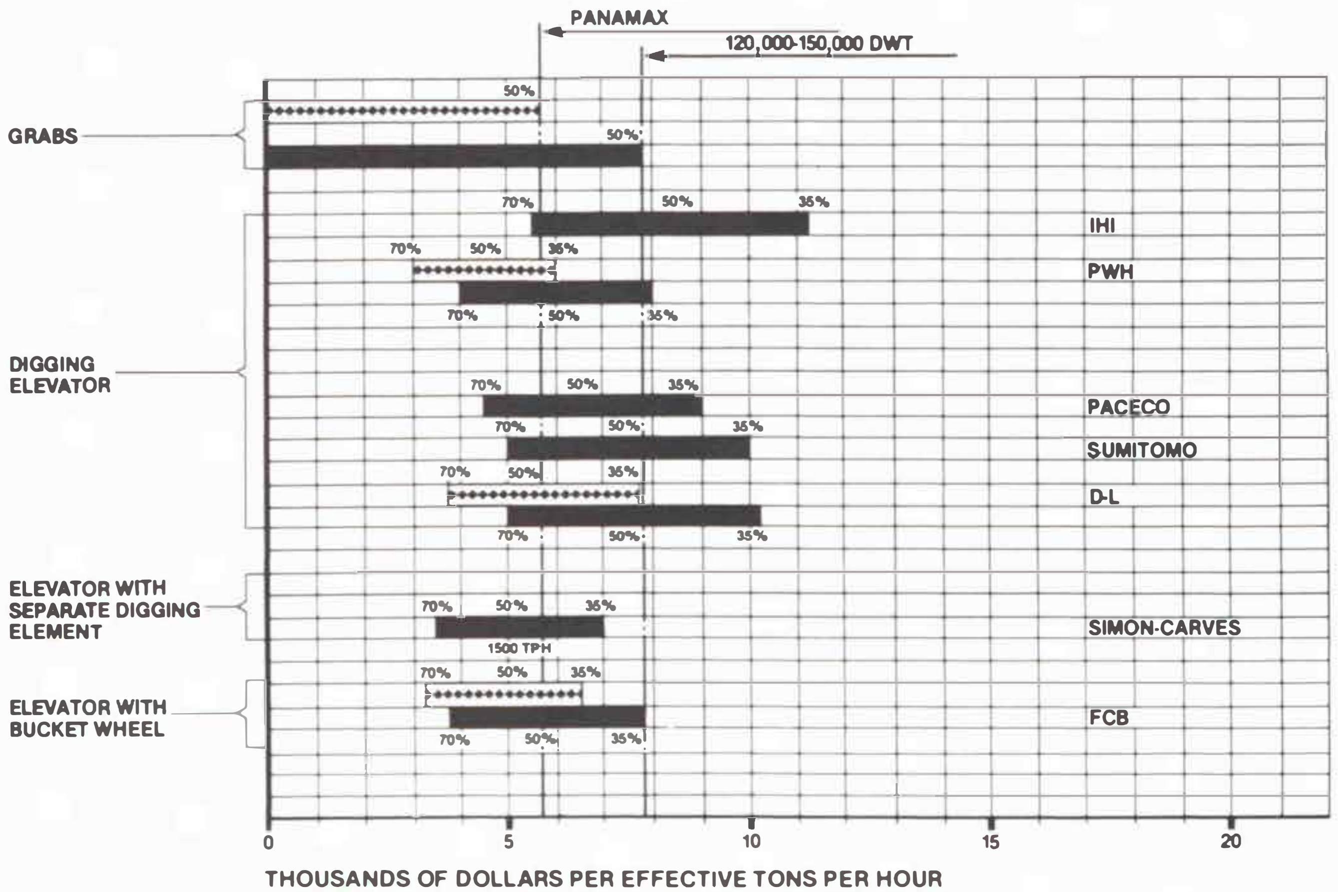


Fig. 19: Cost comparisons at various shipunloading efficiencies. 1,000 metric tons per hour

LEGEND:
PANAMAX
120,000-150,000 DWT

Fig. 20: Cost comparisons at various shipunloading efficiencies. 2,000 metric tons per hour



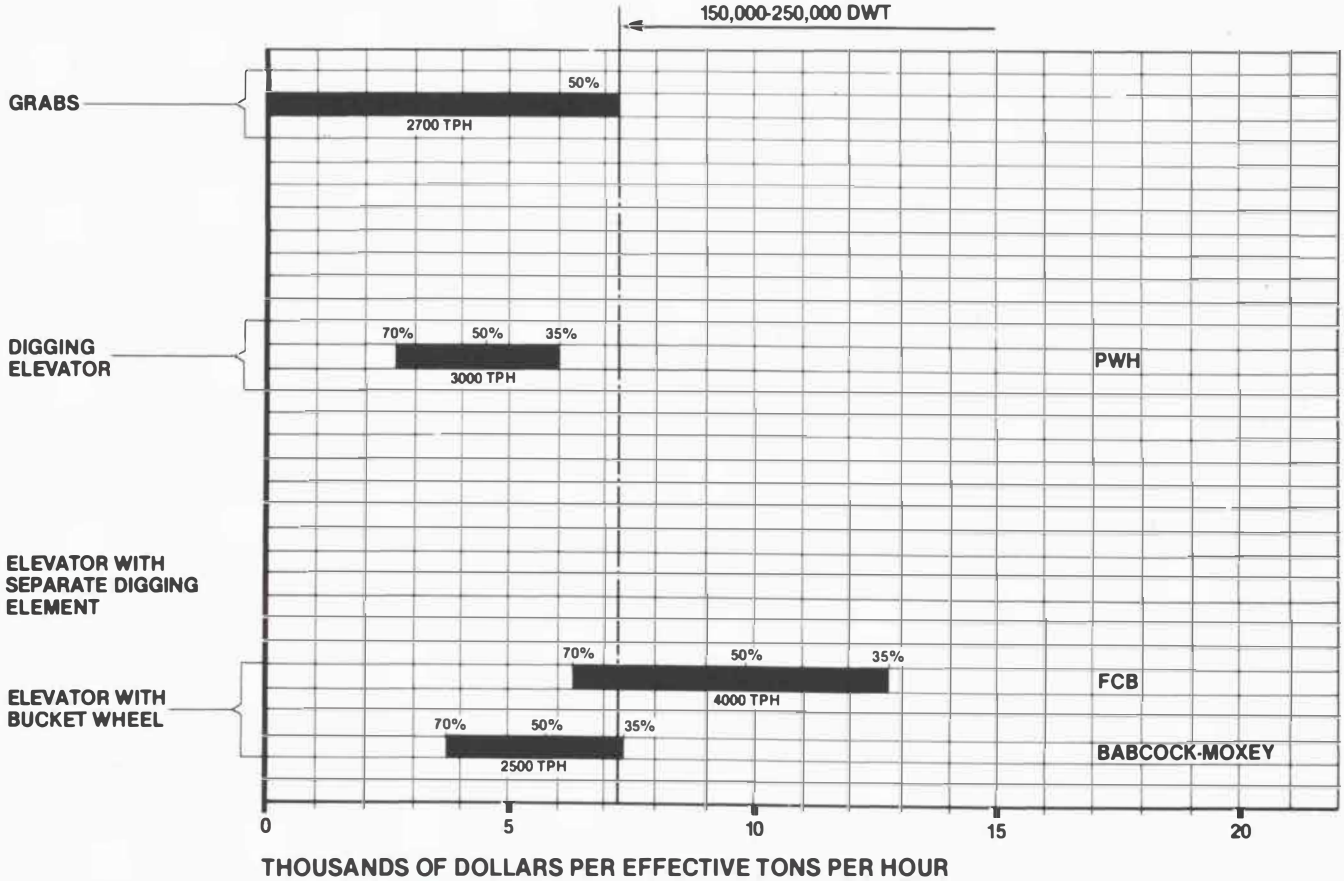


Fig. 21: Cost comparisons at various shipunloading efficiencies. 2,500 to 4,000 metric tons per hour

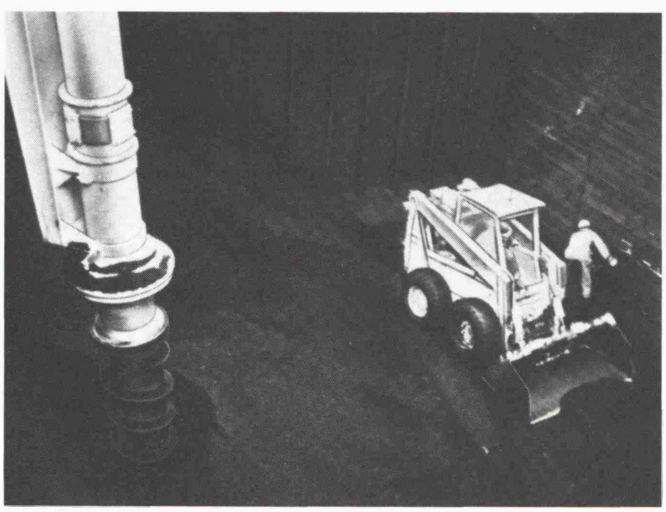


Fig. 22: Siwertell screw type continuous unloader operating inside a ship's hatch

The answers to these questions will determine the effective rate of the machine as a percentage of the free digging rate. We shall have answers to these questions in the next couple of years. The other aspects of the effective rate issue is what percentage of the cargo the bucket-wheel and other types of continuous unloaders will be able to unload during free digging. We think Fig. 23 is rather optimistic. Again, we will know more in a few years.

It will be recalled that Babcock-Moxey has added a hydraulic backhoe to help increase the percentage of the cargo which can be unloaded by free-digging. However, 20 to 25 years ago most digging elevator manufacturers offered plow and backhoe attachments. These attachments did not work as planned, and the shipunloading operations had to rely on dozers.

Thus, the effective rates of the continuous machines will depend on four factors:

— The percentage of the free digging rate which can actually be achieved during the free digging period;
— the percentage of the cargo which can be unloaded during free digging;
— the loss of time in shifting between holds; and
— the loss of time during clean-up.

7. Advantages and Disadvantages of Continuous Unloaders

Continuous unloaders have a clear advantage over grab type unloaders in controlling environmental dust and noise emissions. However, some designs for continuous machines have more environmental advantages than others. With regard to down-time, we expect more break downs with the continuous unloaders than with the grab type unloaders. The more complex the continuous unloader, the more prone it

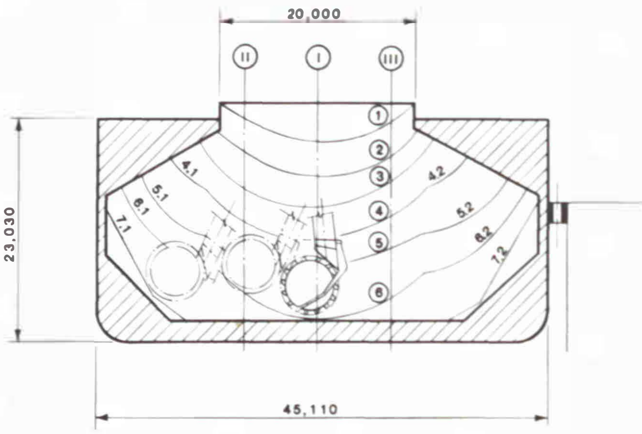


Fig. 23: Operating sequence for a bucket-wheel type unloader inside a ship's hatch (by Kone)

will be to breakdowns, in our view. Repairs to continuous machines will probably require more time than repairs made on grab unloaders.

In comparing the maintenance requirements of continuous and grab machines, the simplest continuous unloaders will probably require slightly more maintenance than grab type machines when the maintenance requirement is calculated on a per ton basis. The more complex continuous unloaders will probably require substantially more maintenance than grab machines when calculated on a per ton basis.

However, the continuous unloaders offer the potential of lower electrical operating costs, but these electrical costs do not represent a significant part of the total costs of unloading.

8. Conclusions

In the past, the perceived advantage of continuous unloaders was their high capacity, which would be in the range of 3,000 to 4,000 metric tons per hour and more. Soros Associates have incorporated high capacity continuous unloaders in their master plans, but they were part of the expansion and not part of the initial installation. Our reasoning was that an annual throughput in the range of 4 to 8 million tons of coal can be handled conveniently by two medium or large grab unloaders. We realized that a single high capacity continuous unloader could handle the same tonnage for a comparable or slightly lower capital cost, but for reasons of reliability, we preferred to have two grab unloaders to one continuous machine.

To achieve an annual throughput of 12 million tons and more is another matter, however. In this case, a continuous unloader could be considered, with grabs to provide stand-by and clean-up capacity.

The situation is now quite different. The high capacities offered by the continuous unloaders are no longer the main attraction of these machines, because grab unloaders can also offer high capacities, at least on large vessels. Increased environmental control provides the one clear advantage in favor of continuous machines. In situations where this advantage is a decisive factor, continuous machines offer a viable alternative to grab unloaders.

The economic advantage presented by continuous unloaders of lower investment than a grab machine for the same effective unloading capacity is attractive. This claim is as yet unproven, however. The next few years will show which designs can realize this economic potential.

If we are to offer our opinion on future developments, we would expect the following:

- Bucket-wheel units will be designed with a single belt running from the bucket-wheel to the pier conveyor. This design would make these machines much simpler and bring down their weight and price.
- Unloading systems consisting of a high capacity continuous unloader and a low cost crane for clean-up may become the most common application of continuous unloading machines.
- A low cost continuous unloader working in conjunction with one or two dozers during the clean-up operation may become an attractive option for facilities with modest annual throughputs.
- Any of the low cost continuous unloader designs which can actually unload 80 % or more of a cargo of wet coal at a high effective rate will be a success.

In any event, developments over the next five years will be very interesting to anyone involved in the subject of continuous versus discontinuous ship unloading.

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