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Systems for Coal Car Unloading at Rail to Water Terminals

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Summary

The past and present decades have seen a rapid growth in the export of coal to foreign countries. Normally, coal is brought to the export terminal by trains made up of either unit train cars (cars of same size and capacity) or of random cars (cars of varying sizes and capacities). If the rolling stock and infrastructure required to handle coal is to be built anew, almost invariably, unit train cars are used to achieve the required high unloading rate.

However, in the case of facilities that are serviced by railroads that have a large fleet of random cars and almost a non-existent fleet of unit train cars, new ways must be found to unload random cars efficiently. This is particularly true of export terminals located on the eastern seaboard of the USA.

This paper will review traditional and modern day car unloading methods at rail to water terminals. Unloading rates and associated manpower requirements will be reviewed in terms of what is practical and achieved today. Influence of site layout on unloading schemes and efficiency will be discussed.

1. Introduction

There are many different systems for unloading coal from railroad cars. These systems have been evolving over the past one hundred years with the trend following the trends of the industry in general, that being higher capacity, less labor and more automation. This paper will attempt to review the traditional and present day systems for unloading coal with respect to the selection parameters, unloading rate and labor requirements.

2. System Selection Parameters

When building or upgrading an intermodal transfer terminal, there are many factors which bear on the proper choice of an unloading system. Many of these will be beyond the control of the terminal operator, but can significantly affect the economics of the terminal.

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Of primary interest is the type or types of railroad cars to be unloaded. If the cars are to be dedicated to the service there are a number of choices. Usually dedicated cars will be moved as a unit train because of the favorable freight rates. Herein a unit train is defined to be a "train of like cars in dedicated service between a single origin and destination." The dedicated cars may be either privately owned or supplied by the common carrier, although the former is more usual. Usually the cars will be either 100 ton hopper cars or 100 ton high side gondolas. In some services, rapid discharge hoppers fitted for automatic operation prove economical, and in rare cases, side discharge cars are also used.

When cars are not dedicated to the service, they are supplied by the common carrier and usually consists of general service hopper cars ranging in capacity from 50 ton to 100 ton. These are usually referred to as random cars.

Regardless of whether dedicated or random cars are to be used, complete car data must be developed to properly select an unloading scheme. The range of principal dimensions must be known along with the associated capacities. Also the type of coupler — rotary or fixed — must be established. Rotary couplers allow the cars to be rotary dumped without uncoupling.

The maximum annual throughput of the terminal must be established. This is a key parameter which affects many aspects of terminal design, including the unloading operation.

Site conditions also can have a significant effect on the choice of unloading system. If the site is large enough for a loop track and reasonably level, rotary coupled unit trains may work out well. If the site is small and ladder tracks must be used, a random dumping or bottom dumping operation may be better. Many systems for unloading random cars handle the empty cars by gravity. If a site slopes, the available gradient may be used to advantage. Foundation conditions can also have a considerable influence on the choice of unloading systems. The location of the water table, the depth to rock, and the bearing capacity of the soil all may favor one system over another.

Climate and location will also exert a significant influence on the design. Freshwater ports may be subject to winter shutdown, at least of the vessel loading operation. In this case, ground storage is very desirable to allow year round operation of the train unloading facilities.

Another climatic influence is the possibility of frozen coal in the railroad cars. This can be a very serious problem. Some unloading methods handle frozen coal much better than others.

Finally, local labor conditions can have a significant influence on the system chosen. Everyone wants to minimize the labor costs, but there is usually a trade off. A high degree of automation will generally be associated with a higher level of skill for operations and maintenance personnel. Of course, there are many other aspects of the local labor situation which may affect the proper choice of equipment at a terminal. Of particular interest is the location of the facility relative to the crew change point for the serving railroad. If a single crew can deliver a train, wait for it to be unloaded, and then depart within a single shift, significant savings can sometimes be attained.

All of these parameters and many others must be considered to develop an economical and functional facility.

3. Unloading Schemes and Their Applicability

There are many ways to unload coal from railroad cars. Tables 1 and 2 show a summary of the most common methods in selection chart form, along with approximate unloading rates for various car handling schemes.

Table 1: Unit train unloading — single car handling

Unit Train Car Unloading Device	Car Positioning Device	
	Locomotive	Positioner
Bottom dump cars with automatic dumping		H
Rotary car dumper		H
Rapid discharge car	H	

H = Over 23 cars/h

In general, the unloading methods can be broken down into two broad categories "bottom dumping" and "top dumping". These can then be further subdivided into several different cases, each of which will be discussed in turn.

Bottom dumping of conventional hopper cars, with manually opened gates, is one of the most common methods of unloading coal. This can be done either over an under track hopper or on a trestle. Trestles generally prove economical when site conditions permit them to be built without long approach grades. They can provide a large storage capacity for dumped coal, but because of the large open area, fugitive dust may prove hard to control. Under track hoppers can be constructed on almost any site and will have less problems with dust.

This type of bottom dump facility is used today only at facilities of modest capacity. Although substantial unloading rates (with enough hoppers, etc.) can be attained, the operation tends to be slow and labor intensive. Bottom dumping is not well suited to the unloading of frozen coal from cars. Although frozen coal causes problems for any unloading system, it can be expected to be very disruptive of a bottom dump facility even if thawing is provided.

Rapid discharge cars are capable of being unloaded in motion at very high rates (Fig. 1). This is usually accomplished by unloading over a trestle where the large, under track, storage capacity can accommodate the high unloading rate. This works very well where site conditions favor a trestle and the fugitive dust conditions can be accommodated. If under track hoppers are used, it is generally necessary to reduce the dumping rate to match the take away rate of the associated conveyor system. Of course, dedicated trains are required because of the special nature of the cars. There is a cost premium for the rapid discharge cars as opposed to the alternative cars of comparable capacity. Because of this, these cars tend to be most economical on short hauls [3, 5]. Since this is still a bottom dump scheme, frozen coal is a significant problem.

Table 2: Random car unloading — single car handling

Random Car Unloading Device	Car Positioning Device							
	Car Puller		Locomotive or Track Mobile		Positioner			Barney Haul
	No Retarder	With Retarder	No Retarder	With Retarder	No Retarder	With Retarder	With Retarder and Injector	With Retarder
Bottom dump cars	VS	S	VS	S				
High lift dumper	VS	S	S	M	S	M	H	
Rotary car dumper	VS	S	S	M	S	M	H	H
Rapid discharge car			H					

VS = 0 — 8 cars/h
S = 9 — 14 cars/h
M = 15 — 22 cars/h
H = Over 23 cars/h

Note:
1. Cars/h estimates are based on single car handling.
2. Retarder is located on the platen, over dumper hoppers, and is used to stop incoming cars.

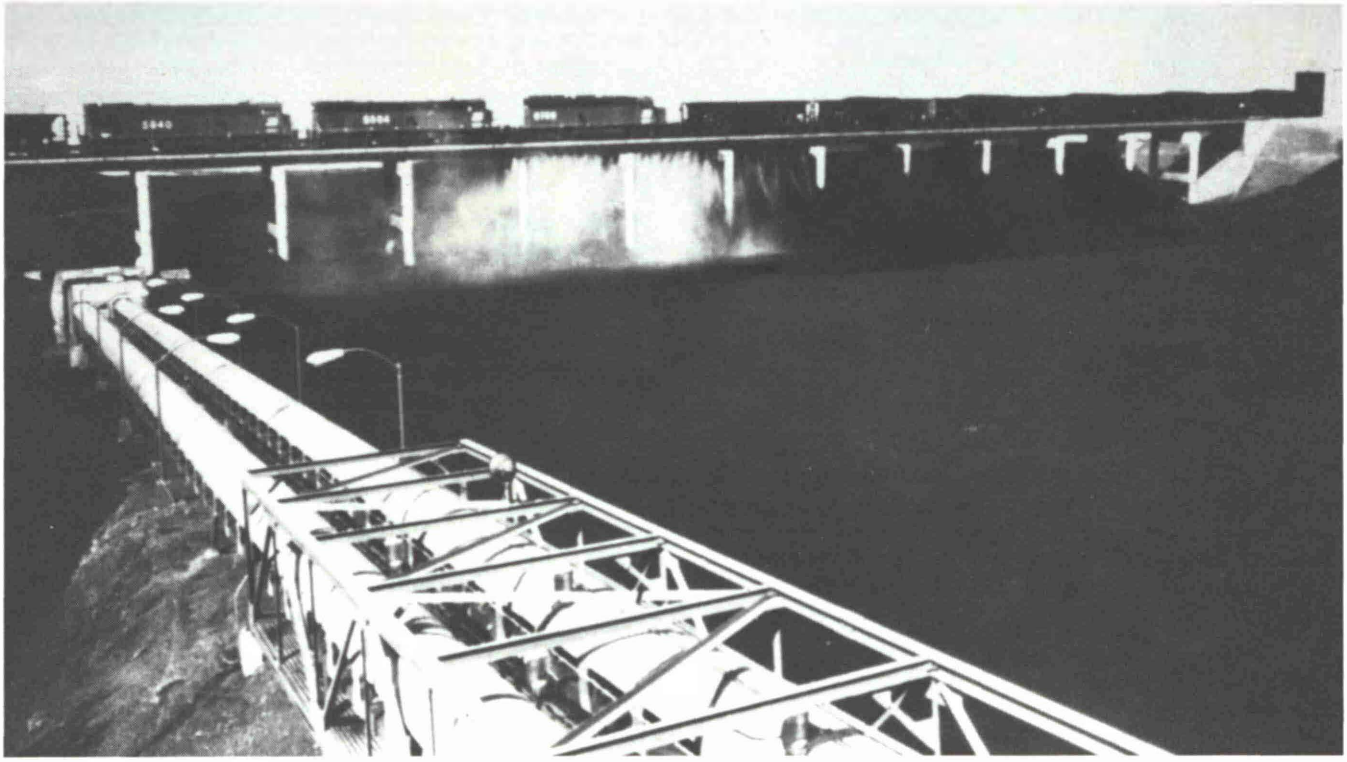


Fig. 1: Rapid discharge car being unloaded on a tresle

The top dumping schemes always require some kind of machine to turn the railroad cars over to allow the coal to flow out the top. Most commonly, this is a rotary dumper (Fig. 2), but a high lift or turnover type dumper (Fig. 3) is also used occasionally. The rotary dumper is more energy efficient than a turnover type and usually dumps faster. However, the rotary type will require a deeper pit to accommodate the hoppers and take away system. This may tend to offset the high cost of the turnover type dumper in some cases.

If a rotary dumper is to be used to dump coupled cars (Unit Trains), it must be designed to rotate about the centerline of the cars' couplers. If only uncoupled cars are to be dumped, it is advantageous to locate the centerline of rotation above the couplers. This allows a smaller diameter dumper to be used, thus saving pit depth, and frequently allows smaller dumper drives as well.

A rotary dumper can be designed to dump either coupled or uncoupled cars, whereas a turnover type dumper is always restricted to uncoupled cars. With the growing popularity of rotary coupled unit trains, this could prove to be a significant limitation.

Fig. 2: A rotary dumper dumping a coupled unit train car

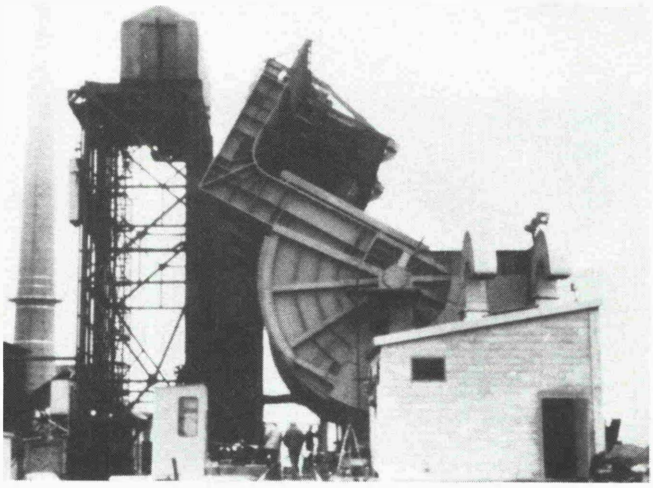


Fig. 3: A turnover type car dumper

4. Car Feed Methods

The other major consideration in designing a coal unloading system is the method of feeding cars to the unloading station. There are a number of methods of doing this, and the best method in any given situation depends on a multiplicity of factors.

A common method is to use locomotives which may be manually operated or remotely controlled by radio. Depending on the number of cars to be moved, the size can range from large road locos to a small track mobile. Locos work well with bottom dump operations where accurate spotting of cars at the unloading station is not required. They are used almost exclusively with rapid discharge cars.

When uncoupled cars are being dumped, locos may also be used either by directly spotting small cuts of cars one at a time on the dumper, or by bumping cars from larger cuts onto the dumper where they are stopped by a retarder.

Rotary coupled unit trains are never indexed by locos for dumping, except in an emergency, due to the difficulty of accurately spotting the cars on the dumper.

It is also possible to move cars by gravity using an appropriate gradient built into the track. Car speeds are controlled through the use of car riders using the car brakes or by track retarders. As a rule, gravity is not used to feed an unloading station directly, although it is common to use it to feed a barney mule (Fig. 4), which feeds cars into a dumper. Today new facilities use gravity only to handle empty cars after the unloading station. Cost and safety considerations have virtually eliminated the use of extensive retarder systems and car riders.

A barney or barney mule (Fig. 5), is a traditional method of feeding one or two cars into a dumper at a high rate. This device is not commonly used today because it tends to be

Fig. 4: A gravity feed system (background) to a barney (foreground)

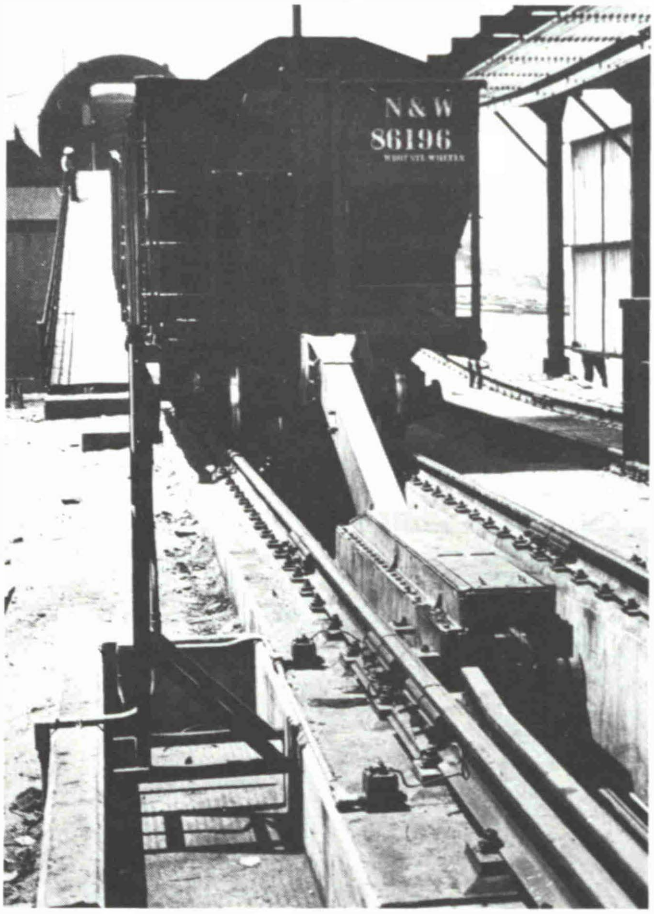


Fig. 5: A barney mule pushing a car up to a rotary car dumper

labor intensive and requires considerable infrastructure to handle the loaded and empty cars at the associated high rate. This infrastructure is costly. Although capable of quite high rates, it is a difficult task to consistently feed the barney at or near its maximum capacity.

Car pullers or car movers are also common in small to moderate capacity operations. As a rule they are only used with random cars. In its simplest manifestation, a small winch or capstan is used to pull small strings of cars through an unloading station. A variety of proprietary systems are available and are quite suitable where the volume of cars handled does not justify a more extensive car handling system.

The most popular car handling system today, at least for larger capacity systems, is the automatic train positioner (Fig. 6). This machine is capable of indexing a full train of either unit train or random cars through an unloading station at relatively high rates. The size of train which can be handled and the associated rate is generally limited by the strength of the draw gear and other ancillary equipment rather than by the positioner capacity.

Another advantage of the positioner is that it can be designed to handle a full train over a broad range of track profiles, whereas many of the other systems might place significant restrictions on the track geometry or train size.

The train positioner can be used with any of the common unloading methods, including bottom dump, although its use with this system is not common.

The positioners' most common use is with rotary coupled unit trains, where its capability to rapidly and accurately spot cars for rotary dumping is fully utilized. Trains can be turned around rapidly, and it is not necessary to bleed the air before dumping or to make up the hoses after dumping. As a rule, a unit train of a hundred or more cars can be unloaded in less than four hours [1, 2, 4].

5. Theoretical and Practical Cycle Consideration

When a new unloading system is being considered, the main concern is usually the minimum cycle that can be achieved. In other words, what is the maximum number of cars per hour which can be unloaded. With the many different systems available, it is difficult to state any particular or theoretical unloading rates. However, if we make a few assumptions, we can develop some theoretical rates which can be compared with typical operating facilities. These theoretical numbers are intended only to show an upper limit on the unloading rate and do not represent actual design rates.

The train will be assumed to consist of 100 — 100 ton cars which are 53′-1″ long. This is the common rotary coupled unit train in use throughout the western USA.

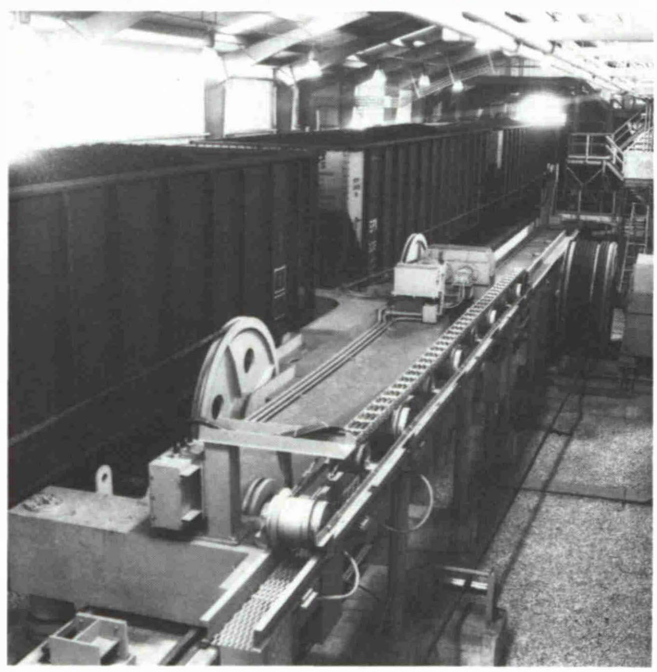
It is not possible to dump and index the train simultaneously. After dumping has been completed the indexing system will always be ready to index the train with minimal delay.

The maximum speed of the indexer during the train indexing stroke is limited to 3 ft/sec. This will roughly limit the maximum coupler force in the train to about 300,000 lbs. which is a reasonable upper limit given the repeated nature of this force.

The dump time is limited to thirty seconds which is a reasonable minimum for a rotary car dumper.

The authors believe that these assumptions would be generally accepted by the industry except for the case of rapid discharge cars which can unload in motion.

Fig. 6: An automatic train positioner indexing a unit train



When these factors are incorporated into a cycle correlation for a dumping/indexing system, the data shown in Fig. 7 can be developed. This figure shows the speed versus time graph for the train with the times for the other required functions superimposed. The upper two curves show the theoretical cycles of 58 seconds and 76 seconds for single and tandem dumpers respectively. The lower two curves show similar information for a fairly high capacity facility typical of those now in service. In this case that would be actual cycles of 90 seconds and 116 seconds respectively.

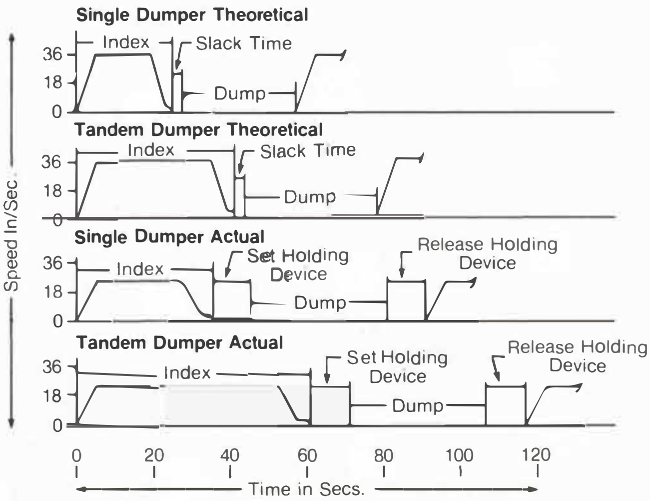


Fig. 7: Actual and theoretical (upper limit) cycle correlations for single and tandem dumpers

The decrease in rate is of course due to the need to adapt the positioner speeds to the effects of an actual track profile and the need to engage holding devices to hold the train when the positioner returns for the next stroke.

The 90 second cycle, which is equivalent to 40 cars per hour, can be thought of as a reasonable limit on the single dumper positioners with rotary coupled cars and conventional holding devices such as truck locks. Many of these facilities operate at 30 or 35 cars per hour.

It is also interesting to use this same information to investigate the increase in dumping rates associated with more than one dumper in line, that is a tandem, triple or quadruple dumper. Fig. 8 shows the dumping rate, for both the theoretical and practical cases, plotted versus the number of dumpers. It is interesting to note that a change to a tandem dumper increases the dumping rate by only about 50 %, and that the increases decline further with the addition of more dumpers.

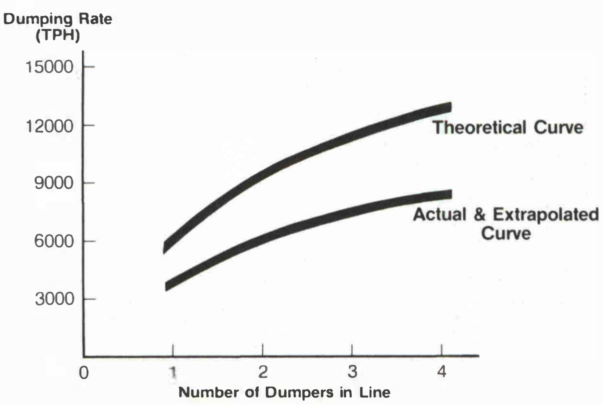


Fig. 8: Theoretical (upper limit) vs. actual dumping rates where multiple cars are dumped. (Actual data for multiple dumpers extrapolated from single and tandem dumper cases)

There are a great many different combinations of equipment which can be used to unload coal from railroad cars. It is not possible to discuss them all here, but it is useful to discuss some typical systems relative to the cycle that can be achieved and the labor requirements.

Under optimum conditions, a train of rapid discharge cars can be unloaded in twenty minutes or less with only the train crew and one or two plant people assigned to monitor the operation. If the unloading rate is limited by the takeaway system, then the time will increase proportionally.

The dumping rate for conventional bottom dump cars will vary with the number of under track hoppers and the labor available. Generally, it is a very slow operation. Rates may vary considerably at a given site depending on the condition of the hopper cars and the flow characteristics of the coal.

Fig. 9 shows the many different systems for handling random cars. Today, most rail to water terminals will use some kind of dumper. Consequently, the following paragraphs will discuss some typical systems for this type of unloading scheme.

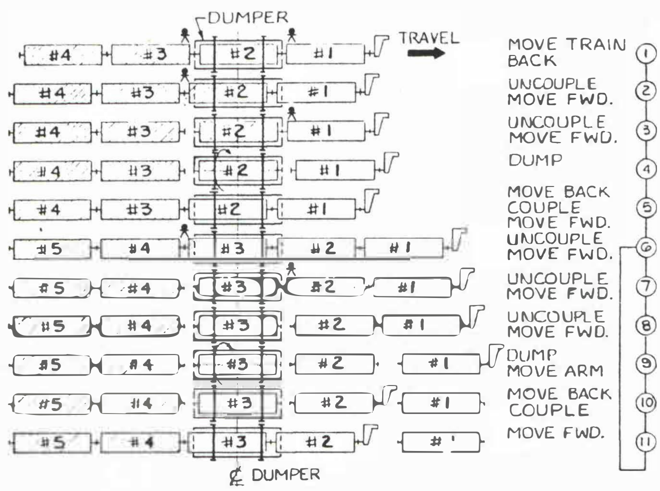


Fig. 9: Schematic showing how random cars can be unloaded using a dumper and positioner designed primarily for unit trains

When only uncoupled cars are to be dumped, a very good system can be put together with a rotary dumper and a train positioner. Under this system, the train is brought within reach of the positioner and the locomotives are removed. The positioner arm is coupled to the train using an automatically actuated coupler mounted on the positioner arm. The train is then indexed forward approximately one car length and stopped while retarders or other devices are engaged to hold the train. Car number one is then manually uncoupled from the train and jogged forward a few feet with the positioner. The positioner arm is then automatically uncoupled, raised and returned, and lowered behind car number one. The positioner is then used to accelerate car number one by pushing against its trailing coupler. The car then rolls onto the dumper, simultaneously bumping off the empty car on the dumper. When the car is properly spotted on the dumper, it is stopped with a retarder on the dumper. The positioner then recouples to the train and the cycle repeats.

The system described above can consistently unload trains of 100 — 100 ton cars at a rate of thirty cars per hour. Two or three operators are required for the dumping operation, depending on the degree of automation provided. With this system, empty cars must be removed from the dumper area by gravity. Additional manpower is required to bleed the train air prior to dumping, make up air hoses on the empty train, handle the empty cars, etc. Depending on circumstances, some of these functions may be performed by the railroad.

It is also possible to design systems to be able to dump both uncoupled random cars and rotary coupled unit trains, although usually some compromise in dumping rate is required for one case or the other. The difficulty arises from the fact that empty random cars are best handled by gravity. The necessary gradients for the random cars increase the equipment required for the unit train case. Further, when coupled cars are dumped, the overall length of the dumper must be the same as the length of a unit train car. This then constrains the maximum size of random car which can be dumped. This is not an insignificant consideration since there are a number of cars in service larger than the standard 53′-1″ unit train car.

In spite of these constraints, there have been a number of facilities built for unit trains which can also dump random cars at a reduced rate and with additional manpower. Fig. 9 shows schematically how this is done using a coupler mounted on the positioner arm. The coupler is designed to swing out of the way during unit train operations.

When operating in the unit train mode, one operator can unload a full 100 car train at a rate of 30—40 cars per hour. In the random car mode, 3—4 operators will be required to attain a rate of approximately 10—15 cars per hour. For this system to work properly, a substantial amount of level track is required on both sides of the dumper.

Today some facilities are being designed or contemplated which can achieve high unloading rates with either unit trains or random cars. The details tend to be very site specific, but it is safe to say that considerable extra equipment and/or labor is required. However, rates of 30 cars per hour for a single dumper and 50 cars per hour for a tandem dumper can be achieved.

When random cars must be unloaded at a rate faster than can attained with a dumper and positioner, it is possible to add additional equipment to increase the rate. One obvious possibility is a tandem dumper. Another possibility is some kind of supplementary indexing device. This device is so located that it can inject the uncoupled car (or cars) into the dumper as soon as the main positioner arm is clear of the train. Thus the time required for the positioner arm to return and inject the car or cars into the dumper is saved and the dumping rate is increased. Again, two or three operators are required and rates of approximately 50 cars per hour can be attained on a tandem dumper.

One last possibility is a barney system which can theoretically attain very high rates. One existing facility which utilizes a tandem dumper has a theoretical rate of 126 cars per hour. This rate is not actually attained because of difficulties in feeding the barney at this rate, but it can still dump at 6,000—8,000 tons per hour which exceeds any presently contemplated random car system using a positioner.

Unit train facilities, as has been stated previously, can unload at a rate of 30—40 cars per hour using only a single operator.

6. What is Being Done Today

In almost all cases, the relatively high capacity facilities are being designed for rotary coupled unit trains. These trains are unloaded with rotary dumpers and automatic train positioners at a rate of 30—40 cars per hour. Very high capacity facilities may use a tandem rotary dumper to attain higher unloading rates.

There seems to be only two notable exceptions to the trend to rotary coupled unit trains. The railroads serving the eastern seaboard area of the USA have a very large fleet of random hopper cars. This, along with the congested nature of the terminals, tends to favor random car type unloading operations in this area. Generally, a dumper of some kind is combined with a train positioner to attain an unloading rate of 15—50 cars per hour. Even in this area, many of the facilities are being designed so that they may be readily converted in the future to handle unit trains.

The other exception would be those cases where the short haul and/or favorable site conditions favor rapid discharge type bottom dumping.

Low to moderate capacity facilities usually utilize a simple feed system such as a locomotive, track mobile or car puller. These may be used with a rotary or turnover type dumper or simply be used to spot cars for bottom dumping.

7. Future Trends

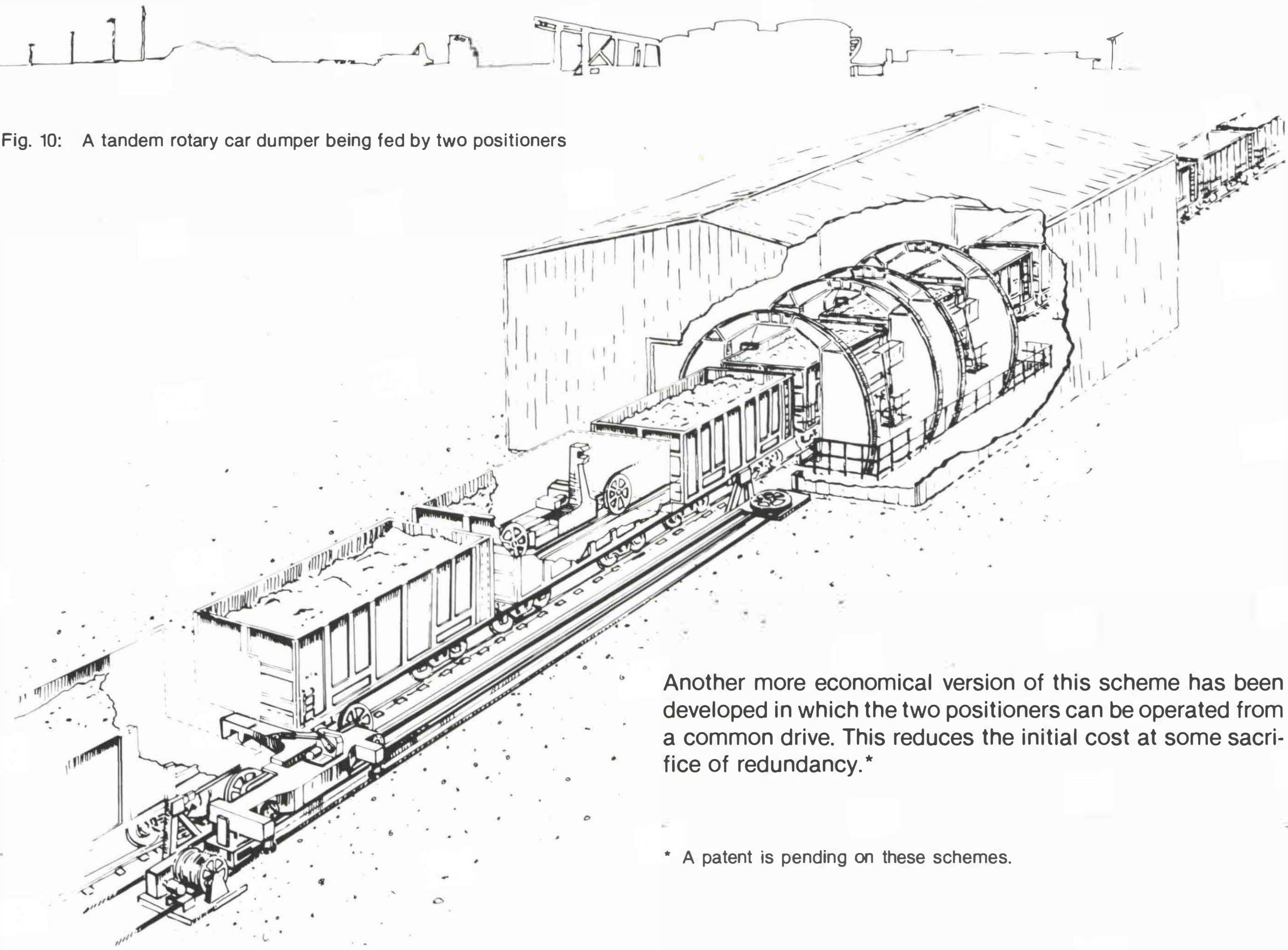
As in the rest of the bulk materials handling industry, increased automation and higher throughput rates are clear trends. Unit trains will continue to increase their proportion of the coal being handled by rail. The increasing availability of low tare weight, high capacity gondola cars will provide further economic impetus to this trend.

The authors' firm is presently (early 1982) in the process of designing dumping/positioning equipment which uses new concepts for two high capacity coal terminals.

Fig. 10 shows a rendering of the unloading equipment for a coal terminal in western Canada. The unique feature of this facility is the use of two positioners, located on opposite sides of the train track, which work alternately to feed the tandem dumper. This arrangement has several advantages. Because one positioner can return while the other is indexing, the system is always ready to either index or dump. Consequently, there is little idle time for holding devices to engage, etc. The two positioners act as their own holding device. The specific facility shown in Fig. 10 is designed to dump 75 57′-8″ one hundred ton capacity cars per hour.

A further benefit is the large amount of redundancy provided. The facility is designed to operate with either barrel of the tandem dumper or either positioner out of service. Auxilliary holding devices are provided for those cases where the positioners are used singly. The various components can be operated in any combination. Clearly this scheme provides a very high dumping rate and a high reliability at the same time.

Fig. 10: A tandem rotary car dumper being fed by two positioners



Another more economical version of this scheme has been developed in which the two positioners can be operated from a common drive. This reduces the initial cost at some sacrifice of redundancy.*

* A patent is pending on these schemes.

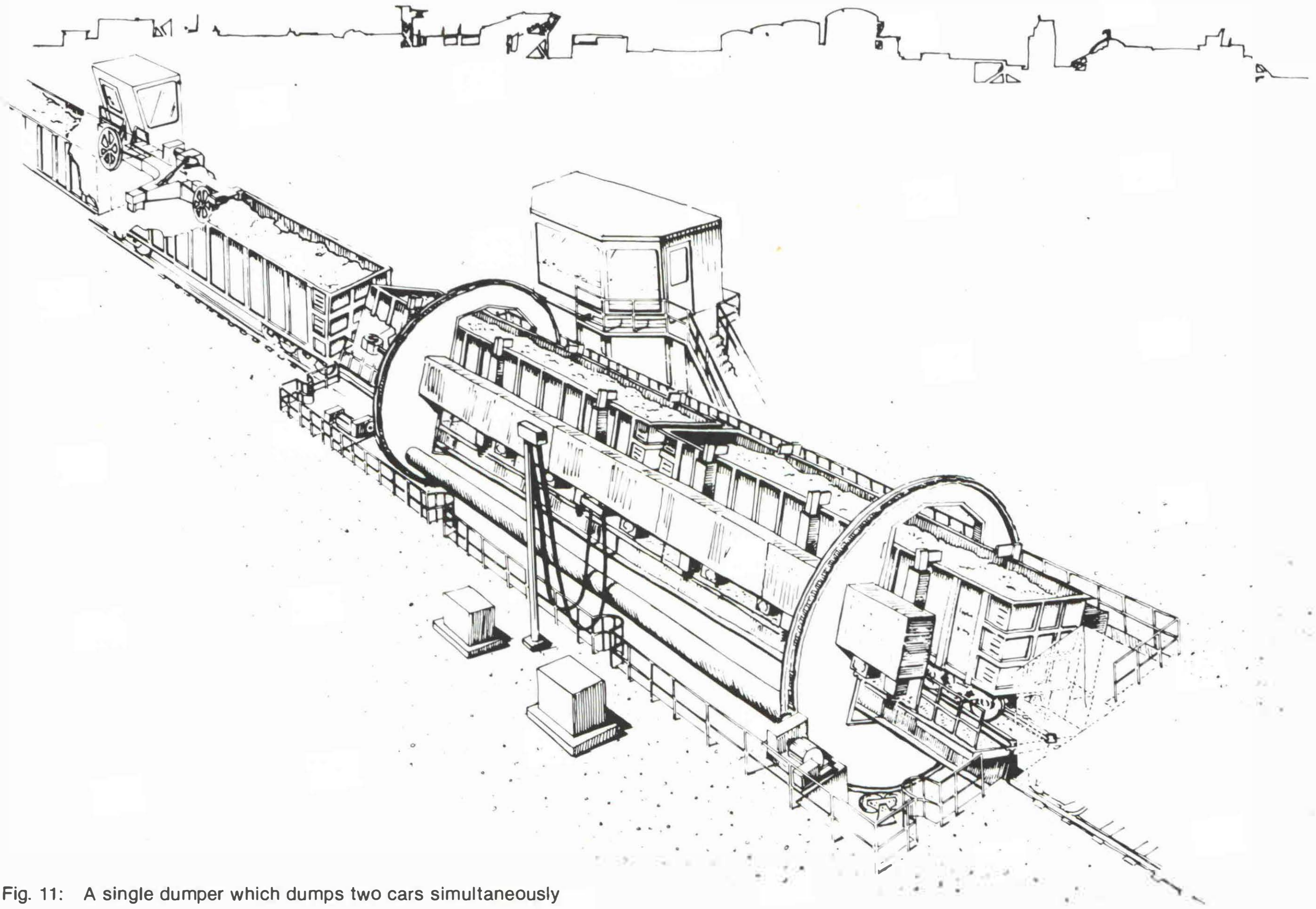


Fig. 11: A single dumper which dumps two cars simultaneously

The unique feature of the second terminal is depicted in Fig. 11. This facility has a single dumper (only two end rings), designed to dump two random cars simultaneously. Since each car can be 55′ long and of 100 ton capacity this will probably be the largest rotary car dumper in the world. The advantage of this arrangement is that the initial cost is reduced due to decreased weight and fewer, but larger parts to erect. The facility will have the capability to dump 50 random cars per hour. It is also being designed for future conversion to rotary coupled unit trains with only minor structural modifications.

8. Conclusions

There is a great variety of systems for unloading coal from railroad cars. The proper choice of equipment at any given facility depends on a multitude of factors and a thorough economic analysis is required to select the best system. This paper has attempted to survey the most common systems, past and present, and provide general guidelines for their applicability.

For moderate and high capacity facilities rotary car dumpers are clearly the most popular, and generally an automatic train positioner is used as well. Low capacity facilities generally use some form of bottom dump arrangement.

In special circumstances special rapid discharge bottom dump cars are quite attractive.

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