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An efficiency analysis of underground haulage in the Tri-state mining district

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AN EFFICIENCY ANALYSIS OF UNDERGROUND HAULAGE IN THE TRI-STATE MINING DISTRICT

BY

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A

THESIS

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Professor of Mining Engineering

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The writer wishes to express his appreciation to Mr. S. S. Clarke, General Superintendent of Mines, Eagle Picher Mining and Smelting Company, for making this investigation possible.

The cooperation and aid of the Superintendents and Ground Foremen of the various mines, as well as other Eagle Picher officials, was of material importance in compiling the data for this investigation.

The author is indebted to Dr. J. D. Forrester, Chairman of the Department of Mining Engineering, for suggesting this problem and providing the opportunity for its ultimate completion.

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INTRODUCTION

Purpose of Investigation

This study was undertaken to describe and analyze the system of haulage as practiced in mines of the Tri-State District by the Eagle Picher Mining and Smelting Company.

The investigation is concerned with all of the operations involved in moving the broken rock and is composed of three distinct procedures: loading, hauling, and hoisting.

One of the important items in the cost of mining is the movement of ore and waste to the surface for further disposition. Increased efficiency of transportation should introduce lowered production costs.

In this paper the efficiency of the present equipment and the present haulage system is evaluated. Suggestions are proposed for operational changes in an effort to provide improved performance.

Field Work

The field work was completed and all data were collected from June 8, 1951 to September 5, 1951. The writer was employed by the Eagle Picher Co. during this period to conduct motion and time studies in the company mines.

The data and results introduced in this investigation represent information gathered in ten mines of the Eagle Picher Co. These properties are located in Northeastern Oklahoma and Southeastern Kansas.

SUMMARY OF PREVIOUS WORK

To the best knowledge of the writer, there has been no published report comparable to this investigation.

Previous time study analyses conducted in the district were reported by Forrester and Taylor.[1] The report is concerned, only partially, with the haulage system. Since that time this system has been completely modified and modernized. In 1944 the only trucks in operation were the battery operated type and are considered obsolete at this date. This haulage method has been discussed also by Clarke.[2, 3]

(1) Forrester, J. D. and Taylor, J. P. A. A comparative analysis of some recent mining practices in the Tri-State mining district. Missouri School of Mines & Metallurgy. Technical Series, Vol. 16, No. 1. 1945. 64 p.

(2) Clarke, S. S. Rubber-tired blitz buggies haul ore underground. Engineering and Mining Journal. Vol. 145, No. 12, pp 88-90. December 1944.

(3) Clarke, S. S. Rubber-tired mine haulage in the Tri-State District. Amer. Inst. Min. & Met. Engr. Trans. Vol. 153, pp. 153-157. 1943

A comprehensive survey of time studies applicable to underground coal mines has been made by Pennsylvania State College.[4] A few principles discussed therein are utilized in this study. However, that work is applicable primarily to mechanized coal mines.

(4) Mineral Industries Experiment Station. Pennsylvania State College. More profit in mechanical mining through studies of loading and gathering performance. Bulletin 50. 1949. 37 p.

Time studies have been applied also to quarry mining, and a complete study has been made by the U. S. Bureau of Mines.[5, 6] The controlling

(5) Thoener, J. R. and Lintner, E. J. Time study analyses. Progress Report 1. Quarry shovel loading. U. S. Bureau of Mines. Report of Investigations 3461. 1939. 24 p.

(6) Thoener, J. R. and Lintner, E. J. Time study analyses. Progress Report 2. Quarry haulage. U. S. Bureau of Mines. Report of investigations 3467. 1939. 26 p.

factor, as determined by this study, was the shovel or loader. As will be shown in the discussion, the factor, which controls the haulage system of the Eagle Picher operations, is not the same.

THE TRI-STATE MINING DISTRICT

The Tri-State Mining District, which is composed of contiguous sections of Southeast Kansas, Southwest Missouri, and Northeast Oklahoma, has been in past years one of the most important producing regions of lead and zinc in the United States. It encompasses an area approximately 40 miles long and 30 miles wide with the long axis is a Northeast and Southwest orientation. The most productive part of this area is a strip 35 miles long and 10 miles wide from Miami, Oklahoma, to Carthage, Missouri. (FIGURE 1)

The district lies in a portion of the Northwest flank of the Ozark uplift (elevation 700 to 1,200 feet above sea level).

The ore is in sedimentary beds, roughly horizontal, dipping slightly to the West, with granite forming the basement at 1,000 to 1,500 feet below the surface.(7)

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(7) Reegart, J. R. Cost of developing to the operating stage and equipping a small or medium sized mine in the Tri-State District. U. S. Bureau of Mines. Information Circular 6591. 1932. 18 p.

Mineralization is confined mostly to the Boone formation of lower Mississippian Age and is composed of beds of limestone, dolomite and chert.(8, 9) Most of the ore is found in highly silicified or flint

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(8) Fowler, G. M. and Lyden, J. P. The ore deposits of the Tri-State District. Amer. Inst. Min. & Met. Engr. Trans. Vol. 102, pp. 206-251. 1932.

(9) Fowler, G. M. Tri-State geology. Eagle Picher Number, Engineering and Mining Journal. Vol. 144, No. 11, pp. 73-79. November 1943.

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areas of the Boone formation. The principal ore minerals are sphalerite

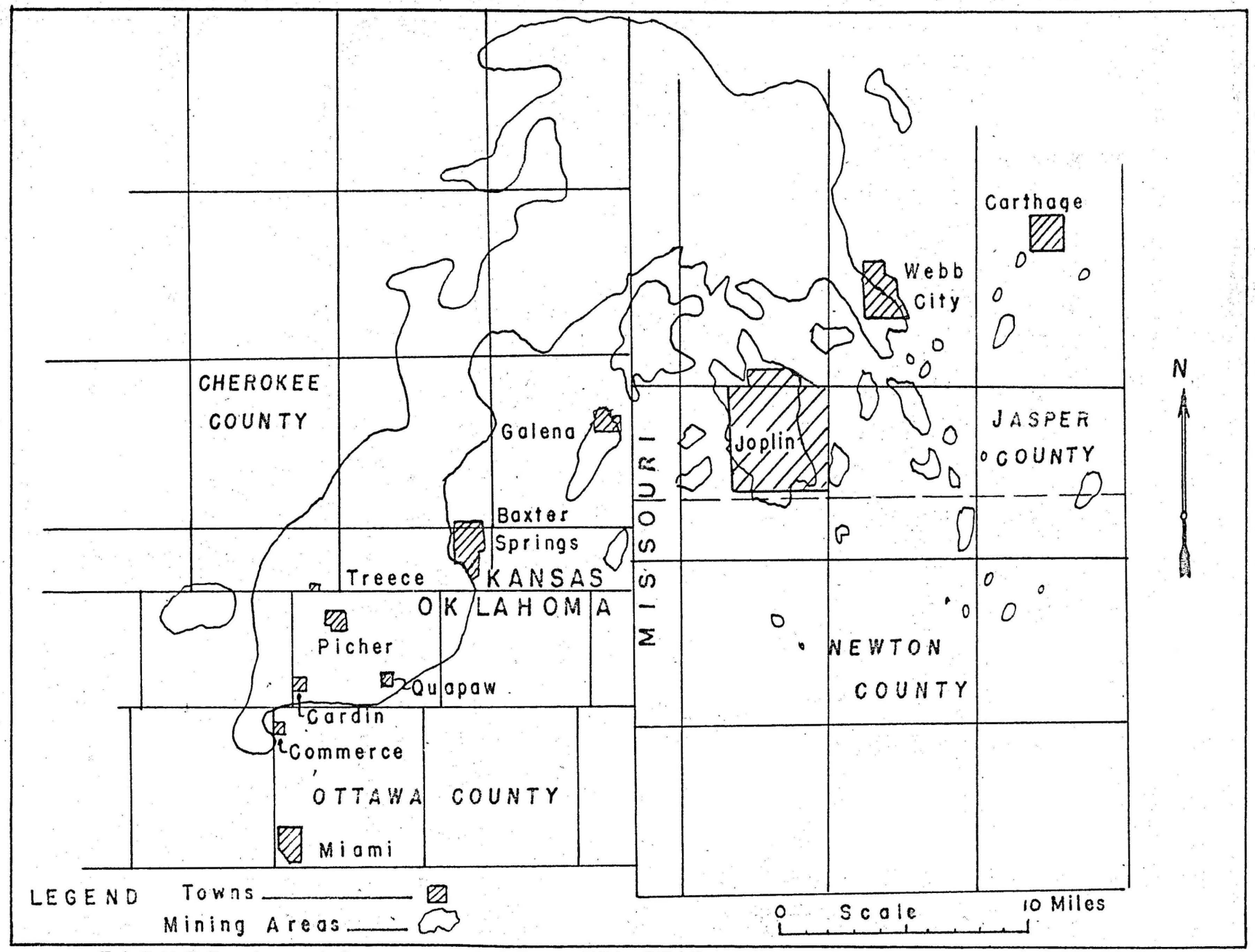

FIGURE 1 LOCATION MAP. TRI-STATE MINING DISTRICT

and galena associated with marcasite, pyrite, and chalcopyrite.

Mining practice has introduced two terms that serve to characterize the particular type of operation in use. "Sheet ground", in general, indicates room and pillar mining, where the mine workings are of wide lateral extension and relatively low back. Open stopes of narrow dimensions but with a high back, up to 150 feet in height, are known as "high ground".

THE HAULAGE SYSTEM

Development

During the many years of mining in the Tri-State District, many haulage systems have been devised and eventually discarded as improved procedures were introduced.

As mining progressed in the district, more ore bodies of marginal character were developed. This situation, coupled with increased labor costs, forced the operators to resort to mechanization to achieve greater man-hour productivity.

The old haulage systems, such as mule haulage with cans, battery locomotive haulage with cars, main and tail rope haulage, have been completely replaced by truck haulage.

Trucks were introduced in the district in September 1941 on trial to aid in the development of low grade ores.(10) The first self-powered

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(10) Clarke, S. S., op. cit. p. 2

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ore-gathering units were the Walker electric battery trucks of two general types; five ton bottom dump trailer units, and three and one half ton box hopper end dump units built on the chassis of the truck. The latter model was designed to overcome difficulties encountered in spotting the trailers under the loaders.

The electric truck was introduced instead of internal combustion trucks because of the gas hazard the latter would create.

The battery trucks proved to be effective for short haulage distances and grades up to ten per cent. As mining operations progressed and greater haulage distances had to be traversed, however, these units

were unsatisfactory due to their relative small capacity.

The problem of the reduction of harmful gas concentrations, produced by internal combustion engines, was analyzed thoroughly by the Eagle Picher Hygiene and Safety Department. Close control of ventilation is almost impossible in the large open stopes and in mines with many shafts whose workings are interconnected. State legislation, in one instance, was unfavorable toward the use of certain types of internal combustion equipment underground. It was finally decided that semi-diesel or hot tube ignited, oil burning engines with proper exhaust control could be used underground without introducing any serious gas problems. The first diesel truck was placed underground at the Paxson Mine (11) in March 1946.

(11) Clarke, S. S. Diesel truck haulage at the Paxson Mine. Engineering and Mining Journal. Vol. 148, No. 3, pp. 54-56. March 1947.

It has been found that with proper precautions diesel equipment can be safely used underground. Oil burning engines produce, in the exhaust gases, carbon dioxide, water, small quantities of the oxides of sulphur and nitrogen, carbon monoxide, and aldehydes.(12) Of these

(12) Harrington, D. and East, J. H. Jr. Diesel power can be used underground with safety. Engineering and Mining Journal. Vol. 148, No. 6, pp. 70-76. June 1947.

gases, carbon monoxide and the oxides of nitrogen are dangerous to human life, the aldehydes are irritating to the eyes and nose. In order to use diesel engines underground some device is necessary to control the exhaust gases. Such a device should lower the temperature of the gases; remove toxic gases; decrease smoke and odor; and dilute the

exhaust concentrations with air.

The first trucks used in the Tri-State District were equipped with tanks which supplied oxygen into the exhaust manifold. This system proved to be uneconomical and ineffective, particularly in the control of the aldehydes. A gas scrubber was developed and is now in use on all underground diesel equipment. The scrubber is essentially a water filled rectangular metal box (FIGURE 2), through which the exhaust gases are forced before coming in contact with the atmosphere. In addition to water, the box contains copper wiring, which serves as a catalyst for the reaction of water and aldehydes, and calcite to keep the water from becoming excessively acidic. This cleanser does not reduce the small quantity of toxic gases produced in the exhaust, but does serve to eliminate the smoke and aldehydes.

Present Ore Gathering System

The first diesel truck used underground was a truck-duckbill-trailer of 10 tons capacity which demonstrated its suitability and efficacy as a haulage unit. A program was planned to introduce other diesel equipment and at present all haulage is performed by diesel trucks, and a large percentage of the loading is accomplished by diesel shovels.

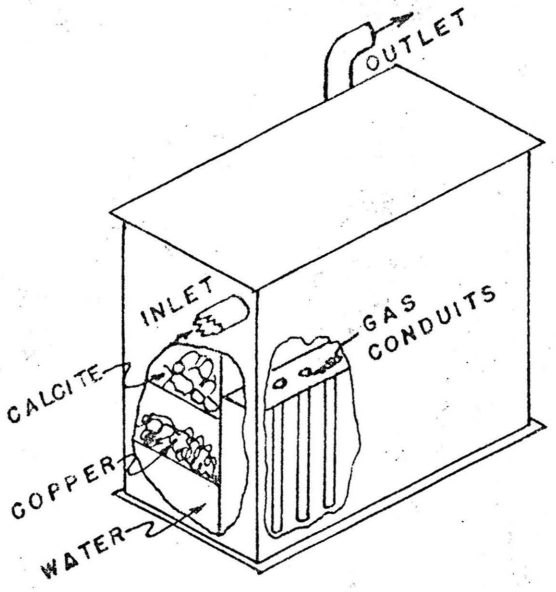
The ore is loaded in various parts of the mine and is transported by diesel trucks, over graded roads, and dumped through grizzlies into hoppers to be hoisted to the surface.

Equipment

There are two general types of trucks used for ore haulage, viz, dump and trailer. The dump truck has a rectangular bed mounted di-

F I G U R E 2

EXHAUST GAS SCRUBBER



WATER FILLED STEEL SCRUBBER
USED ON
DIESEL EQUIPMENT UNDERGROUND

rectly on the chassis (FIGURE 3); the latter is a duckbill-trailer pulled by a diesel unit (FIGURE 4). The beds are hydraulically end-dumped from the power take-off and have capacities of 10 tons. A few of the new trailers are rated at 15 tons capacity. In experimental use also is a Koehring Dumptor truck of six ton capacity.

All roads are constructed for one-way traffic, except for by-passes, and are maintained by mill tailings delivered underground through boreholes and shafts. Maintenance of the roads in the best possible condition is important so that trucks can operate at higher speeds and with less breakdowns. Graders are used in many mines to maintain the roads although a few mines still have very poor roads.

The dump trucks are very manueverable and can negotiate steep grades, whereas the truck-trailers can be loaded in areas of very low back although it is less maneuverable. The great advantage of the truck-trailer is that the load is carried by the trailer so that the tractor unit is subjected to little stress and wear.

The trucks dump directly over a grizzly into a hopper. Some grizzlies are constructed so that the truck may drive directly over a ramp, dump and drive on in the same direction. Others require the truck to back up for dumping. FIGURE 15 illustrates the drive-over type, while the back-up type is illustrated in FIGURE 19. In general, the one way ramp is better since no time is consumed in backing over the grizzly. Some mines have two dumping points, and this is an added advantage as one truck does not have to wait for another to dump or for the grizzly to be cleared. Breaking and clearing of the boulders may involve considerable time because the boulders have to be broken manually. The smallest passing dimension of most grizzlies is about 12

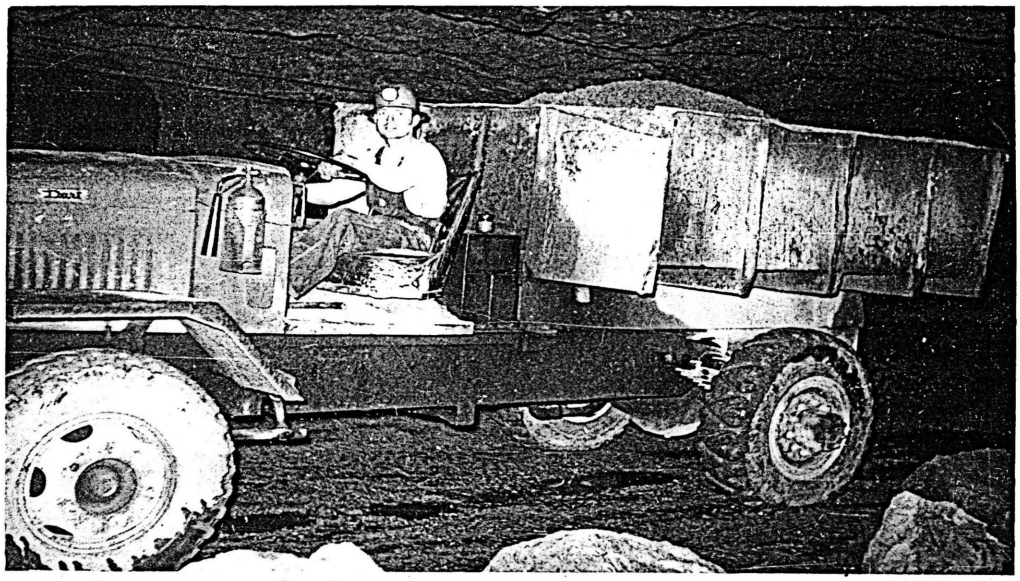


FIGURE 3

A 10 TON DIESEL DUMP TRUCK

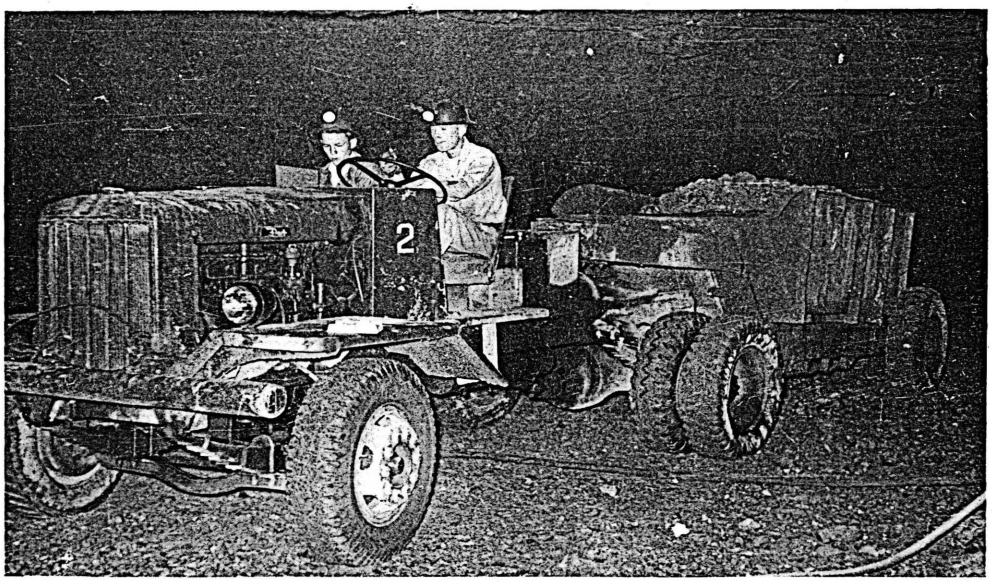


FIGURE 4

A 10 TON DIESEL TRUCK-TRAILER

inches.

Most hoppers provide surge capacity, although in some places, trucks are delayed because the hoppers are temporarily filled to capacity.

Two of the more important factors in an efficient haulage system are proper distribution of equipment, and planned dispatching of trucks to loading areas. Supervisors do not give proper attention to these factors. Trucks waste time in unnecessary trips, and often there is an assemblage of more trucks in one area than can be loaded without excessive delays.

Loading

The three loading methods in use are: chute, dragline and shovel.

Chute Loading

Where mining proceeds in beds above the haulage level, the ore is slushed into raises to be gravity fed to the lower levels. The ore is allowed to accumulate on the haulage level to be loaded by shovels or is kept in the raises from where the trucks are loaded directly by chutes. The important consideration in the design of a chute is to allow sufficient manuevering area for the vehicle. In some restricted locations, especially where the truck-trailer is used, considerable time is wasted in manuevering the truck under the loading chute. Loading is accomplished in less than two minutes through chute gates, operated manually by a lever system. In the mines visited, there were only three of these in operation.

Dragline Loading

Dragline is the term used for a self-propelled scraper type

loader (FIGURE 5 A and FIGURE 5 B). A three-drum slusher, fixed over a metal ramp, is mounted on a caterpillar chassis, which permits it to manuever into any desired position.

All motors of the loader, which operate the slusher and the caterpillar treads, are electric powered.

This loader is applicable particularly in sheet ground work. A typical situation is illustrated in FIGURE 6 which shows tail blocks at wide angles. The three-drum slusher permits wide coverage for the scraper, which drags the ore to the loader and up a metal ramp from where the charge falls into the truck through a square opening.

The dragline is the slowest type of loading equipment in use but is the most economical to operate and maintain. A 10 ton truck can be loaded in 6 to 10 minutes but the time required may be 15 minutes. The loading time depends on the skill and ability of the operator. The loader must be placed in the most advantageous position for wide coverage while restricting the distance of scraper travel. During non-loading periods, the dragline operator should use the time for scraping the ore from the most distant points to a more readily accessible spot. This in general was not practiced. The drag cables should be inspected often and replaced frequently as much time is wasted when a cable is broken during a loading operation. The same procedure should be applied to the sheave blocks.

Shovel Loading

The various types of diesel shovels engaged in loading, will be discussed briefly.

The overhead dumping shovels are the fastest loaders. These

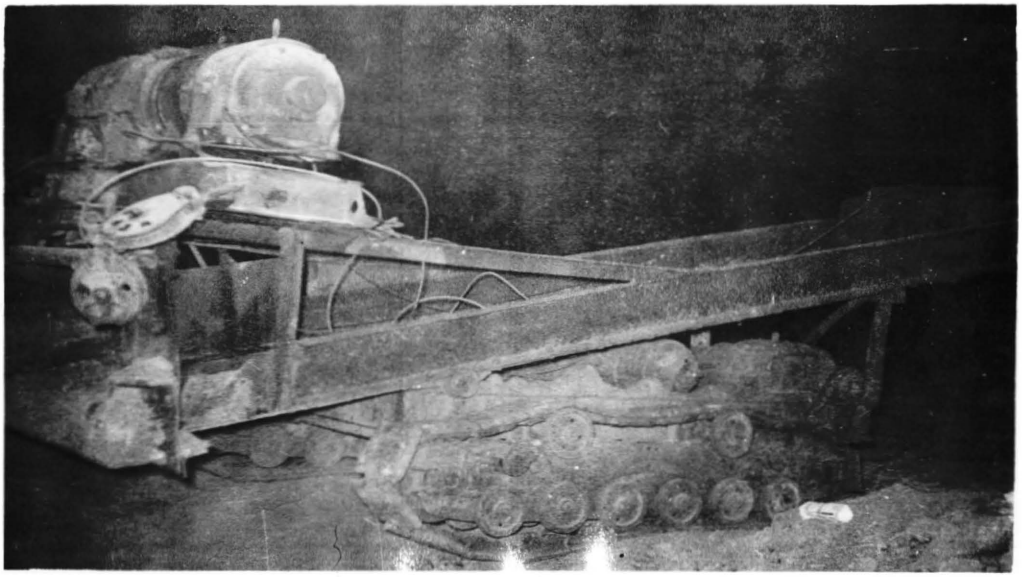


FIGURE 5 A

A DRAGLINE IN THE PROCESS OF BEING MOVED TO A NEW HEADING

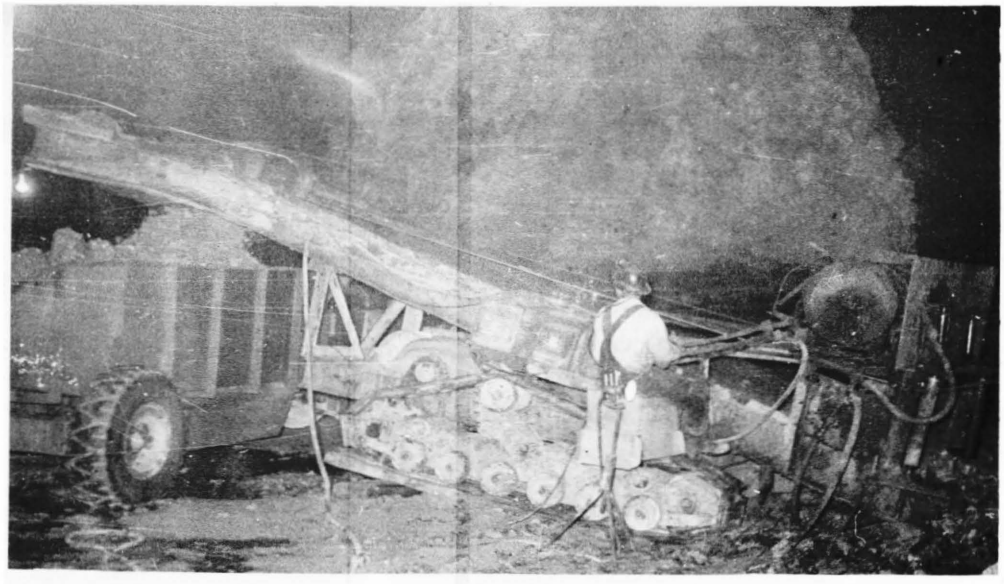


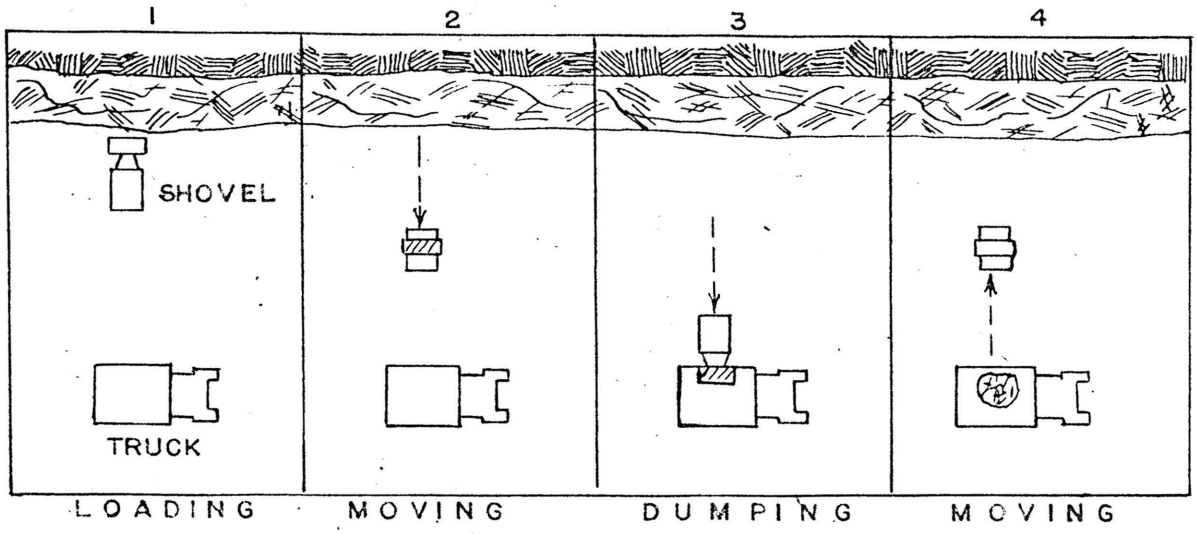
FIGURE 5 B

A DRAGLINE LOADING A 10 TON DIESEL TRUCK

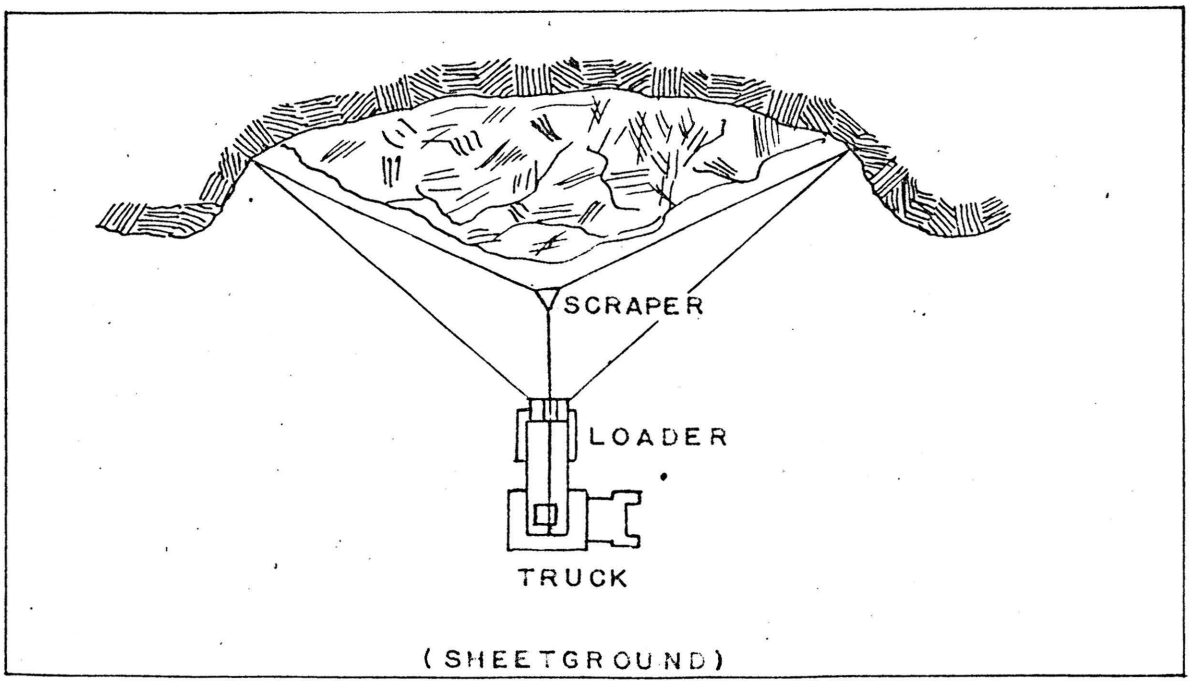
FIGURE 6

LOADING

OVERHEAD DUMPING SHOVEL



CATERPILLAR MOUNTED ELECTRIC SLUSHER LOADER



shovels move in straight lines from the face of the heading to the truck. A loading cycle is illustrated in FIGURE 6. Loading time varies from 2 to 5 minutes. Shovels of this type are Eimco Rockers (Model C-4, 102, and 104) mounted on caterpillar chassis (FIGURE 7), and International T D 9 with Lodover system. The Eimco loaders are applicable in areas where the floor is fairly smooth, and the heading does not require complete removal of broken ore. The shovel is not very effective in confined areas. Where the Eimco loader can move freely, over smooth ground, it is an effective and fast loader. An average of eight dippers for a 10 ton load can be delivered in two minutes. The truck should be spotted at such a distance from the muck pile that the shovel need only travel a distance sufficient to raise the dipper for dumping and still allow enough manuevering area. The dipper is actuated by a chain drive system.

The International Lodover may be operated as a forward or overhead loading machine, but it is faster when overhead dumping is used, as only straight line motion is required. This shovel is not as fast as the Eimco because the action of its hydraulic powered dipper is slower than the Eimco chain drive, but the shovel is better in clean-up action in restricted areas. A 10 ton truck requires 6 or 7 dippers, which can be dumped in about 4 minutes.

The great majority of shovels used underground have forward dumping dippers, diesel powered caterpillar treads (FIGURE 8). Models in use are the Allis-Chalmers H D - 5 and H D - 7 and the Traxcavator H T - 4. These loaders are slower than the overhead loaders because a considerable amount of manuevering is required during loading operations. Their advantage lies in the versatility and ruggedness of

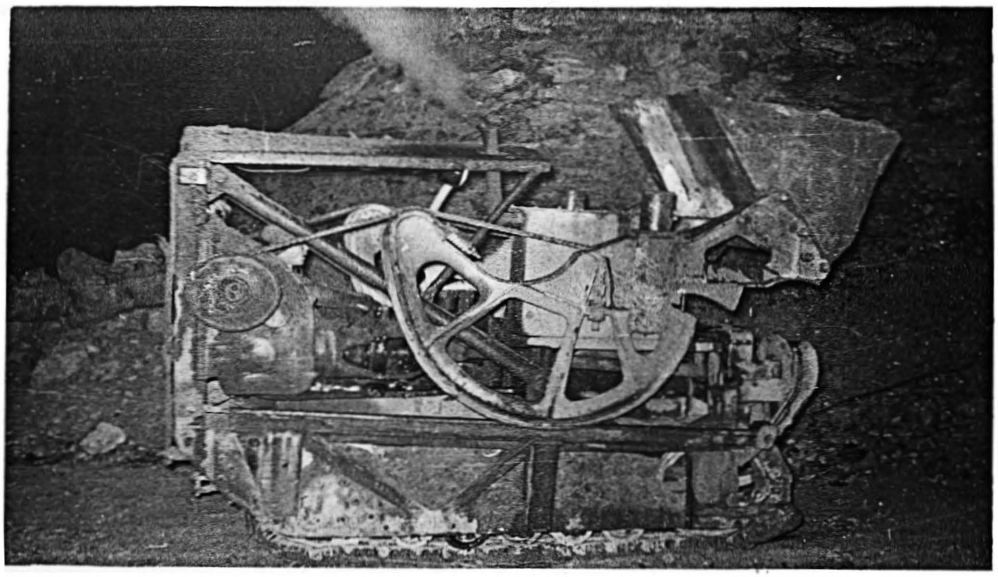


FIGURE 7

CATERPILLAR MOUNTED EIMCO 104 SHOVEL LOADER

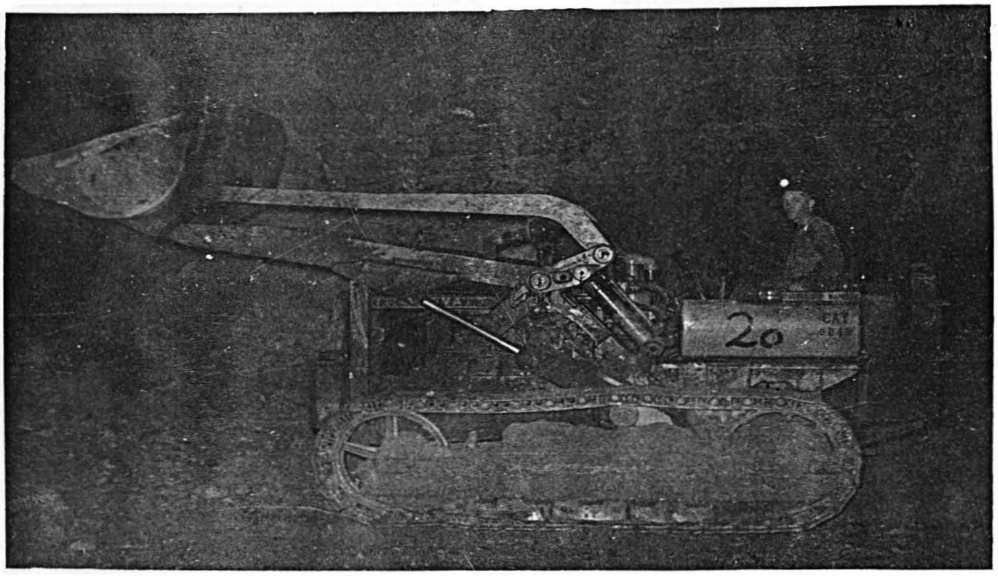


FIGURE 8

H T - 4 TRAXCAVATOR CATERPILLAR MOUNTED LOADER

construction. These shovels are employed in clearing up areas, building roads, loading and other applications. About seven dippers constitute a 10 ton load and loading can be completed in 5 to 8 minutes. The larger H D - 7 shovel requires only four dippers, and the time required is comparable to the Eimco loading time.

The time required to complete a load depends on the skill and ability of the operator. The truck is placed usually at right angle to the muck pile, requiring the shovel to make sharp angle manuevers, which not only is time consuming but causes pronounced wear on the tread pads. The spotting should be made at an angle to the ore so that a more natural manuever can be made by the shovel. The difference in operation in these two cases is shown in FIGURE 9 and FIGURE 10.

This shovel can be used in almost any type of ground, as long as the height of the back is sufficient to permit the dipper to be raised and dumped.

A Hough Payloader (FIGURE 11) was introduced in 1951 on an experimental basis in the Goodwin Mine. This loader is very fast and maneuverable, however, it does not have sufficient traction to dig in the compacted muck pile. As a consequence, there is excessive wear of the rubber tires of the drive axle.

Hoisting

Skip and can hoisting are employed in the Eagle Picher mines.

Of the mines studied, only two, Westside and Blue Goose 2, have installed skip hoisting. This system uses balanced hoisting in a two compartment shaft. When one skip is being loaded, the other is dumping on the surface. The dumping takes place automatically when the skip

FIGURE 9

TYPICAL SHOVEL LOADING CYCLE

AS GENERALLY PRACTICED

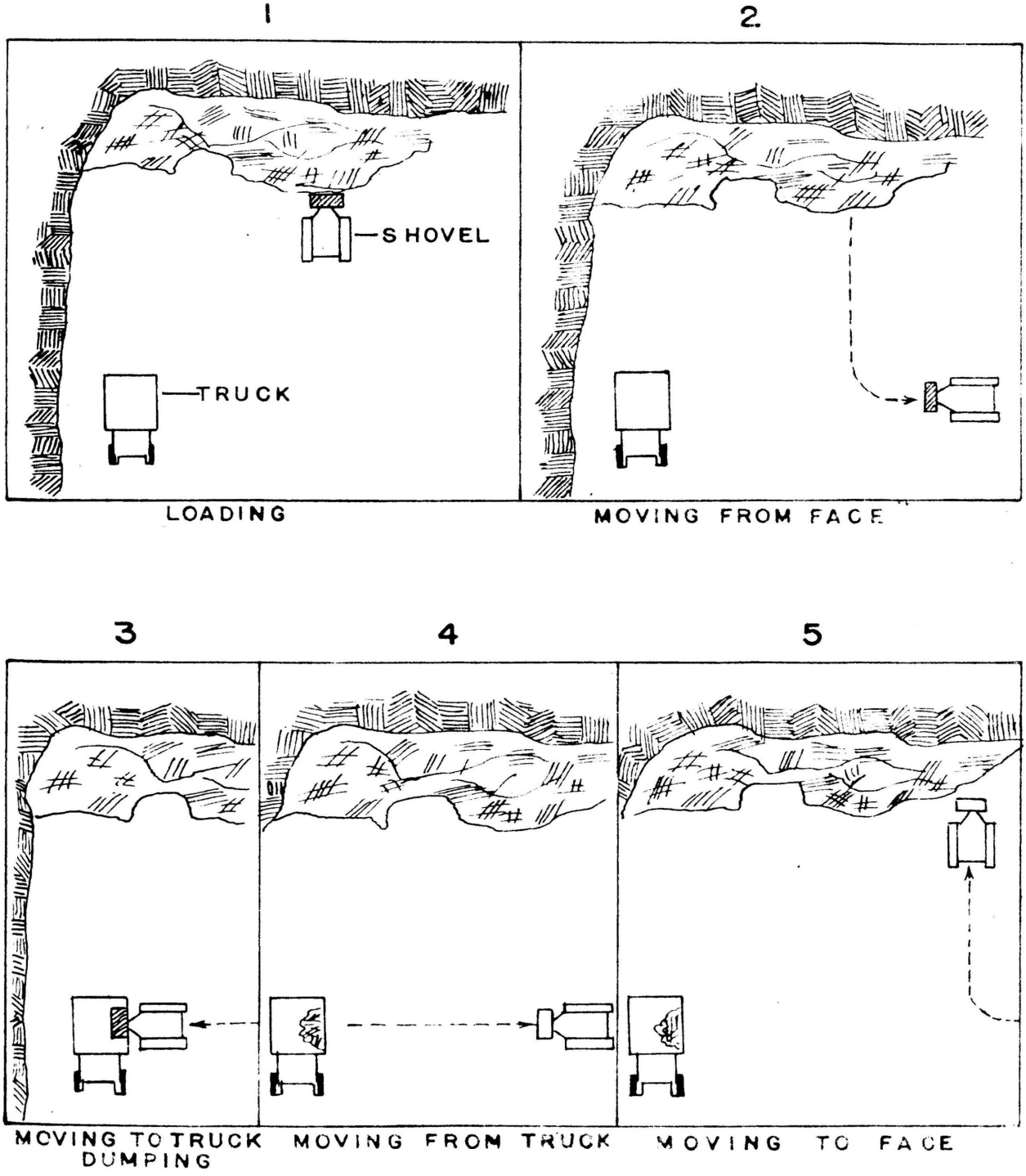
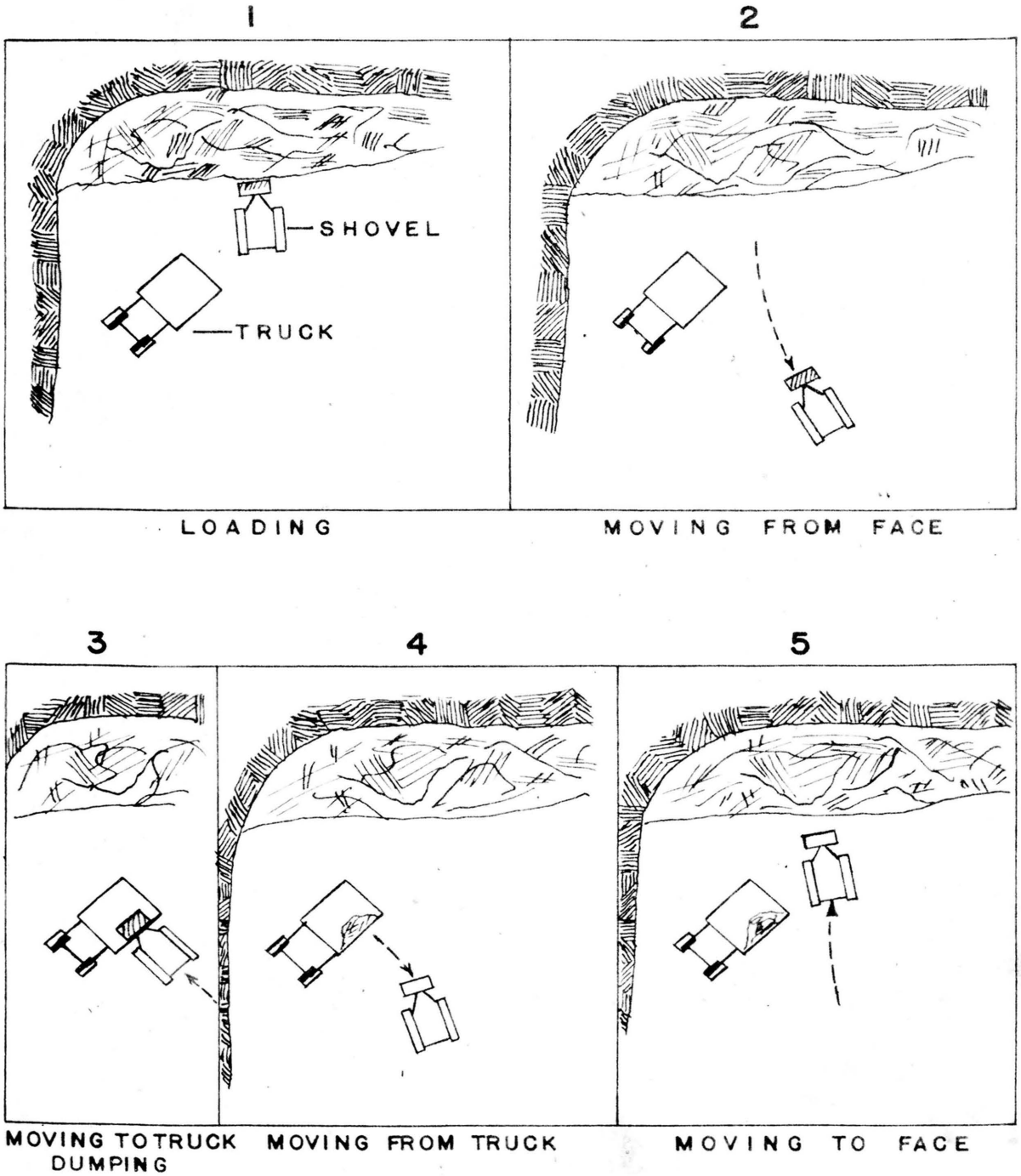


FIGURE 10

TYPICAL SHOVEL LOADING CYCLE

AS RECOMMENDED



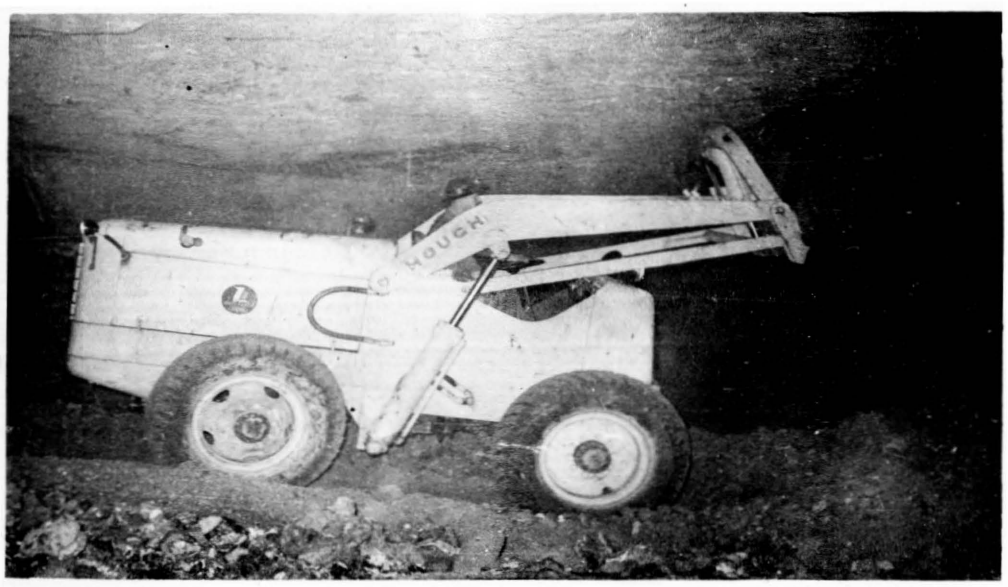


FIGURE 11

HOUGH PAYLOADER

This shovel is in experimental use as an underground loader.

engages the dumping track of the surface hopper. This hopper is illustrated in FIGURE 12. The skips have capacities slightly over two tons, and therefore the hoisting system may have a capacity of approximately 1,000 tons in one eight hour shift.

The other mines reported in this analysis employ the can hoisting system. Cans, which are cylindrical steel buckets 33½ inches in diameter and 35 inches deep, of approximately four-fifths of one ton capacity, are used to bring the ore to the surface and it is dumped into hoppers, such as illustrated in FIGURE 13 and FIGURE 14.

A typical underground hoisting station is illustrated in FIGURE 15. An air powered piston bumper-car moves the cans from the shaft center to the loading point under the hopper. At the end of the bumper-car travel the ore can is directly under the hopper chute. The can is loaded, by manually operated chute gates, and the car is returned to the farthest point. This procedure places the loaded can at the shaft center. When the empty can is returned, the hooker guides it to the front of the car, and rapidly transfers the hoisting cable hook to the loaded can which is then hoisted. The hooker is an especially trained workman who is responsible for the loading of the cans, and transferring the hoisting cable hook from the empty can to the loaded one. FIGURE 16 illustrates this operation.

From 550 to 900 cans may be hoisted in one eight hour shift, depending on the shaft depth. Hoisting is the limiting factor in the total mine production. The haulage system should be planned in order to supply the maximum hoisting capacity plus a safety factor.

From the surface hopper the ore is transported to the Central Mill (Cardin, Oklahoma) by railroad cars, illustrated in FIGURE 17.

FIGURE 12

Surface Hopper

Skip hoisting headframe
and 500 ton steel hopper.

FIGURE 13

Surface Hopper

Old type mine headframe for can hoisting and 300 ton wooden storage hopper.

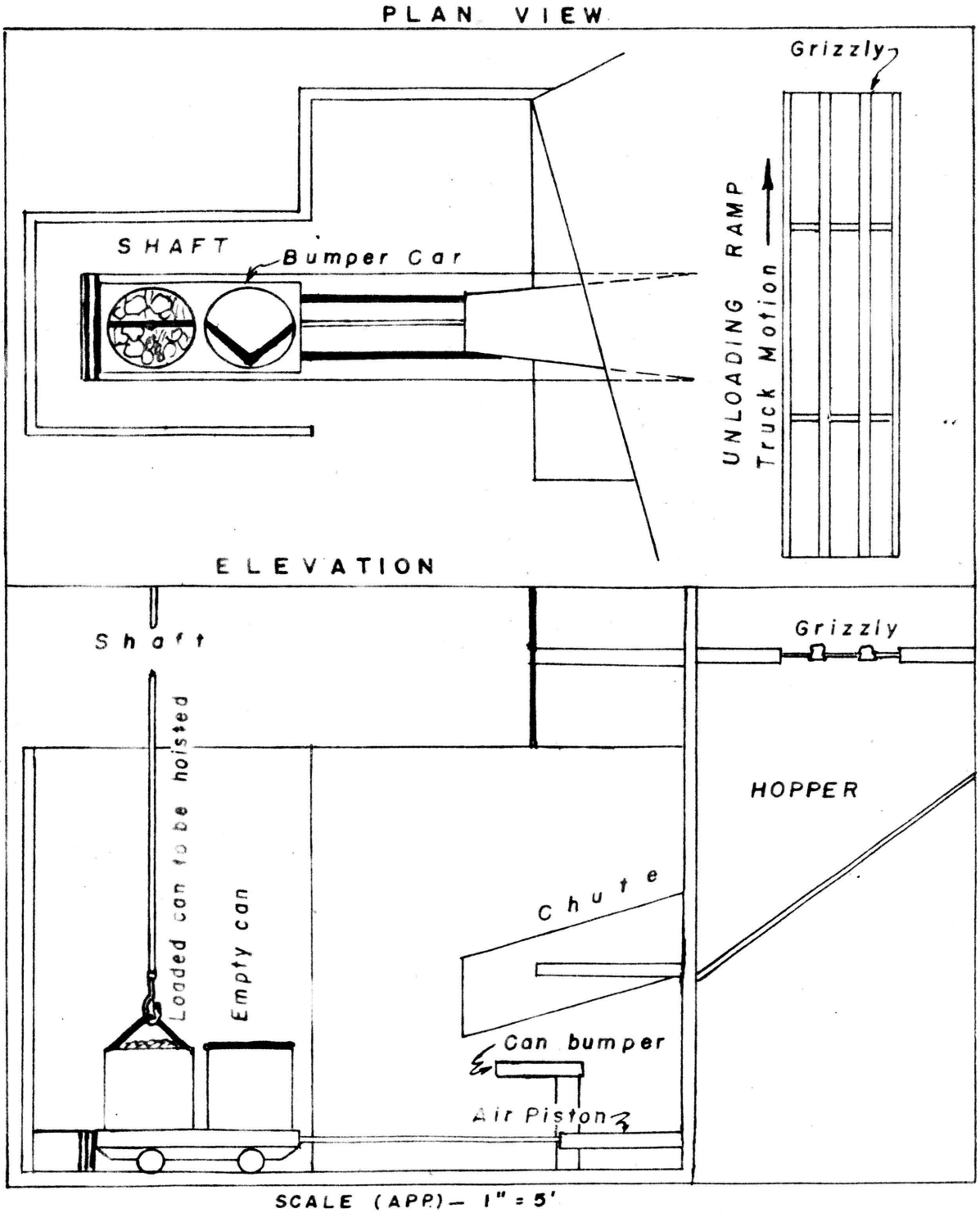
FIGURE 14

Surface Hopper

Typical can hoisting headframe
and 300 ton storage hopper
in the Tri-State area.

FIGURE 15

SHAFT STATION — UNLOADING STATION



SCALE (APP.)— 1" = 5'

NETTA MINE

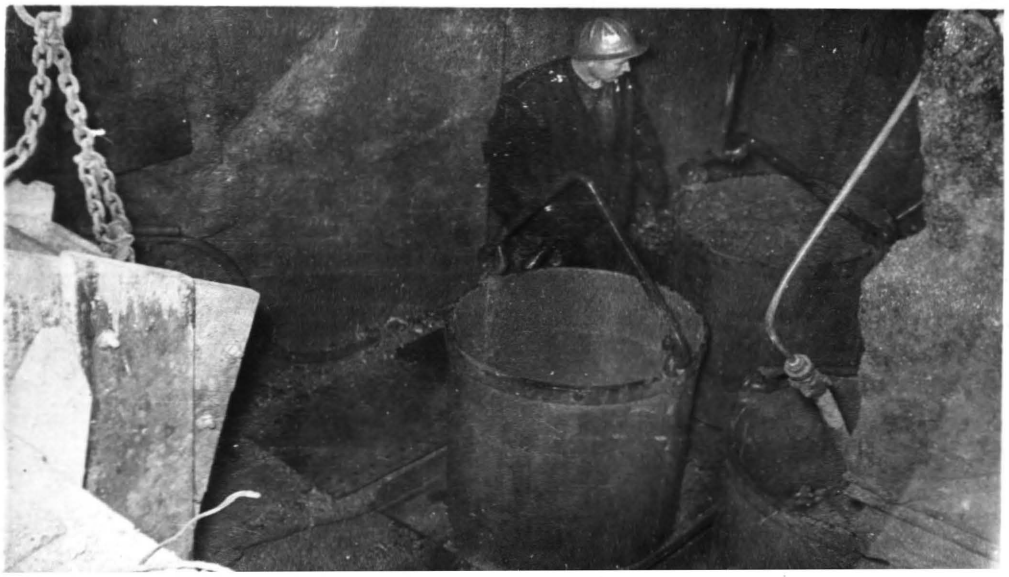


FIGURE 16

TYPICAL HOISTING PROCEDURE

The hooker has just transferred the hoisting cable hook from the empty can (at left) to the loaded can, for hoisting.

Note hopper chute at extreme left and bumper-car on which the cans are resting.

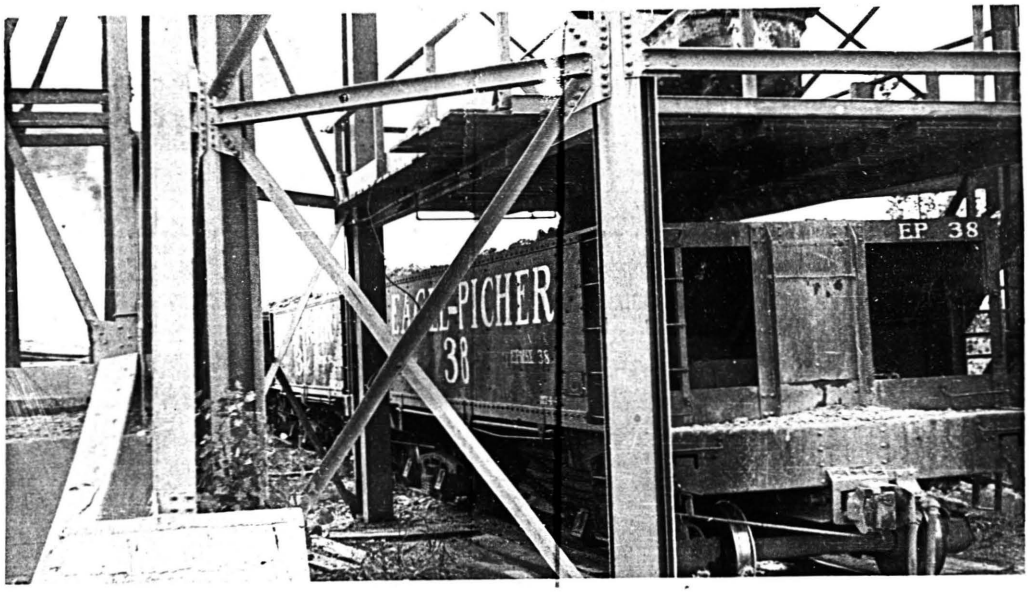


FIGURE 17

Loading Ore for the Central Mill

Railroad car is being loaded under hopper at the Blue Goose 2 Mine.

TIME STUDY PROCEDURE AND APPLICATION

General Considerations

In the ore moving process, the haulage unit or truck, is considered the controlling element. Although a loading unit may remain temporarily inactive, the truck must continue to operate to maintain production averages. If a shovel breaks down, the truck may proceed to another loading point until the shovel is in operation again. When a truck is out of commission, however, its transportation capacity is temporarily retired and no convenient substitute exists. Certain loading areas are not accessible to all types of trucks; therefore dispatching has to be carefully planned, and the loading equipment becomes subservient to the truck. With these considerations in mind, the time studies were based on the actual haulage units, with supplementary studies of other operations. All operations of the truck were observed and the timing recorded. In this manner, each truck was studied during an entire shift to determine the haulage time efficiency.

The total shift time in the Eagle Picher mines is 8 hours and 15 minutes, with one-half hour alloted for a lunch period. For the purpose of this study the remaining time, 465 minutes, is considered as actual working time. From the haulage standpoint, this total time is divisible into productive and nonproductive time. Under productive time are included all activities in which the truck may engage that are connected or associated with the transportation of ore. Nonproductive time includes all delays, regardless of cause or nature.

Method of Compilation

The following classification and breakdown is used in summarizing

and tabulating the results.

I. Productive Time

A. Travel Time - Includes all productive motions made by the vehicle.

1. To Heading - The time the empty truck takes to move from the shaft station to the loading zone.

2. Maneuvering Allowance (Head) - Maneuvering time at the heading, to spot the truck under or adjacent to the loader.

3. To Shaft - Travel time involved in moving the loaded truck from the heading to the shaft or dumping station.

4. Maneuvering Allowance (Shaft) - Time required to back truck into dumping position; this is not applicable to all mines.

B. Transpetration Time - This term was developed to include the loading and dumping operations. From the roots: trans (across), petro (rock), fer (bear or carry), and ate (to make), the word transpetroferate was formed, and reduced for convenience to transpetrate.

1. Loading - Loading time at the heading.

2. Unloading - Time utilized by truck in dumping load at shaft station.

II. Nonproductive Time

A. Delays - Time involved in all delays.

1. Truck Delays - Delay time that is directly attributable to the truck.
    a. Breakdown Delays - Time lost while the truck is out of operation because of some breakdown or necessary repair.
    b. Normal Delays - This term serves to indicate all delays occassioned by the truck in necessary operations, such as, refueling and general servicing.
2. Loader Delays - Time the truck is not operating for reasons which apply to the loading equipment.
    a. Breakdown Delays - Time the truck is held up due to loader breakdown.
    b. Avoidable Delays - This includes all interruption time in loading, not attributable to the truck. In most cases, envolves wasted time by the the loader operator.
    c. Other Load Delays - Time one truck is forced to wait to be loaded, because another truck is occupying the loading position.
3. Other Delays - Delays not included in the classification above.
    a. Grizzly Delays - Time a truck has to wait before dumping, at the shaft station. The causes may be: other load occupying the dumping ramp, screen obstructed with

boulders, or a full hopper.

b. Nonoperating Time - This is the time the truck is not envolved in any operation. It includes the time in getting the men underground and wasted time not included in other delay classifications.

Procedure of Timing

The technique employed was to ride a truck during its entire daily cycle, recording the operation (by means of symbols) and the time envolved, to the nearest five second interval. An ordinary wrist watch with sweep second hand was used for timing.

Shovel performance was analyzed by studying each cycle. Each operation of the loader was timed with a stop watch and recorded. For this purpose the shovel motions are considered separately as:

1. Move Back - This represents the starting cycle when the shovel retreats from the truck.

2. Move Forward - Time taken for the loader to turn and move toward the muck.

3. Loading Dipper - Time required to load the dipper.

4. Move Back - Time involved in retreating from the muck.

5. Move Forward - Time the shovel takes in moving to the truck.

6. Dump - Time taken to dump the dipper.

The last division often is incorporated with the last movement. In the case of overhead loaders, only divisions 2, 3, 4, and 6 are applicable as there is no angled maneuver. These relations are exemplified in FIGURE 6.

Hoisting was also studied in each mine. In this case the total hoisting cycle was studied and recorded to the nearest one-half second.

Methods of Evaluation

One factor to be considered in evaluating the results is the amount of productive time expended in any shift. This, however, is not the only factor to be considered in evaluating efficiency, and it is not possible to eliminate all nonproductive time.

Time wasted in nonproductive effort may be reduced by observing the following conditions. Truck and shovel breakdowns (II. A. 1. a. and II. A. 2. a.) can be reduced with a sound program of preventive maintenance. Sundays are used for miscellaneous repairs in the mine and should be used for thorough examination of vehicles. Instituting this program should minimize most on the job breakdowns.

Normal delays (II. A. 1. b) can be expected since they are necessary operations, but should not consume more than ten minutes or 2.2 % of the total shift time, if such delays are planned carefully. Trucks have to refuel no oftener than once a shift and should stop twice for water (for radiator and scrubber). Refueling takes less than four minutes while water stops may require a three minute delay. The total time involved in normal delays would be approximately ten minutes.

Avoidable delays (II. A. 2. b) are expressions of wasted time on the part of the loader operator and should be reduced and if possible completely eliminated.

Other load delays (II. A. 2. c) exist mainly because of poor organization and failure to dispatch and distribute trucks properly. With some forethought and consideration these delays may be minimized

or stricken out.

Grizzly delays (II. A. 3. a) may be expected occasionally where only one dumping ramp exists. If a two ramp system cannot be constructed to prevent such delays, more attention should be given to secondary blasting in order to reduce boulder problems. Grizzly attendants can remove excessive numbers of boulders from the screen, and break them separately, and thus decrease unnecessary truck delays.

Some nonoperating time will necessarily result because the men are lowered into the mine on shift time. Under this time classification is included all wasted time not previously mentioned. This wasted time factor often is too large to be justified. The men that are directly concerned with the ore haulage (truck drivers and loader operators) are the first to enter and leave the mine. For this reason haulage operations can get under way soon after the start of the shift. Allowing ten minutes for the time that operations are interrupted, i.e., leaving and returning from lunch, first trip underground and final trip out, fourty minutes are accumulated. With a safety allowance of ten minutes, a total of less than 11 per cent of the time is consumed. Under the poorest conditions 60 minutes might be allowed for nonoperating time, which would represent about 13 per cent of the shift time.

It is estimated that, under the conditions discussed, a ratio of productive to nonproductive time of 70:30 (1:0.425) can be realized, and with careful planning this ratio may be increased to 80:20 (1:0.25).

Factors yet to be interpreted are other time relations and ton-mileage recorded by the trucks. These relations are travel time:transpetration time, travel time to heading:travel time to shaft:loading time ratios.

As distances and loading characteristics vary greatly, general rules and applications are difficult to establish for individual cases. The total figures in any study represent averages, and therefore certain time ratios can be used as indicators of desirable or undesirable conditions.

The travel time:transpetration time ratio should be approximately 1 : 0.5. In most mines the combined travel time (to the heading and back to the shaft station) is about twice the loading time under ideal conditions. The data obtained in this study will indicate that there is sufficient information to allow the use of such a criterion. If any study indicates material differences from the value above, either the distances are so short or so great that this relationship breaks down. Excessive loading time may influence these criteria. In the latter case, the situation can be changed by improvement of the loading method, and thus more loads may be obtained in a shift.

The second ratio, travel to heading:travel to shaft:loading time, is a variation of the ratio just mentioned. Only maneuvering and dumping times are not considered. In general a 1 : 1 : 1 ratio is desirable, but variations may be expected.

Each case will be studied and application of ratios explained and tried.

In addition to these factors, the number of loads and mileage covered should be used as criteria. Although total round trip mileages may vary from two-tenths to five miles, the average distance is approximately one mile. For distances less than one mile, with favorable loading conditions, a truck should make 25 to 30 trips, or a maximum of 9,000 ton-miles (30 loads x 10 tons/load x 30 miles). When

loading is done exclusively by draglines and/or the distances are greater than one mile, this haulage capacity will be somewhat reduced. The particular conditions of each run have to be identified before a prediction can be made as to capacity.

BIG CHIEF MINE

Location

The Big Chief Mine, in Northeast Oklahoma, comprises the E½SE¼ and NW¼SE¼ of section 17, T. 29 N., R. 23 E., Ottawa County, Oklahoma.

Production

The average ore production is 530 tons a day. Hoisting in performed with cans, each having a capacity of 0.77 ton.

Equipment

Four trucks perform the ore haulage: nos. 29 and 30 - G.M.C. dump trucks, no. 45 - Dart truck-trailer (D-100 UG), and no. 48 - Autocar truck-trailer (C-50-D 148).

As an indication of truck performance, the following data for the month of June 1951, are presented.

TABLE 1

TRUCK PERFORMANCE - BIG CHIEF MINE
(Courtesy of Eagle Picher Mn. & S. Co.)
June 1951

Truck Number	Fuel Consumed (gal.)	Number of Loads	Number of Shifts	Operating Costs
29	90	180	10	$280.
30	125	260	13	680.
45	115	221	19	333.
48	120	404	26	560.

Loading equipment includes two draglines, no. 3 H D - 5 Allis Chalmers shovel, and no. 21 Eimco 104 Shovel.

Cost records of shovels are maintained on a cumulative basis.

TABLE 2 gives performance data for the two shovels used in this mine.

TABLE 2

SHOVEL PERFORMANCE - BIG CHIEF MINE
(Courtesy of Eagle Picher Mn. & S. Co.)
Cumulative data to June 1, 1951

Shovel Number	Total Tons Loaded	Total ts	Operating Labor Costs	Total Operating Costs	Unit Operating Cost ($/Ton)
3	125,418	499	$8,548.	$33,658.	$0.268
21	96,448	310	5,962	16,218.	0.168

Unit operating cost cannot be compared without considering that the Eimco shovel generally operates under more favorable conditions, i.e., smooth floor, cleaner stopes, and is not used for miscellaneous jobs such as road construction. Working conditions, other than loading, cause severe wear on the shovels, which accounts, in part, for the large cost difference of the two types of loaders.

Hoisting

As discussed previously, the hoisting capacity limits the possible mine production. The actual hoisting capacity is apparently considerable greater than the average daily production. This conclusion is based on the timing of the hoisting cycles and actual performance.

Time study reveals that the cans are loaded and placed in hoisting position in an average of 16 seconds. The hooker then waits 9 seconds for the returning empty can, and transfers the hook in 5.5 seconds, so that the average cycle consumes 30.5 seconds. This represents an operating average that will not be realized when some major interruption

takes place. A maximum of 30 minutes was consumed in lowereing men and supplies in any shift, and allowing for contingencies, 45 minutes are subtracted from the total available time. In the 425 minutes remaining during a shift, 825 cans could be hoisted, and would represent a total of 640 tons. Actual performance indicates that this output can be closely obtained as 800 and 810 cans were hoisted in different shifts during the visit to the mine.

Loading

Shovel no. 3 was studied while operating in high ground area, with favorable loading conditions. The results are summarized in TABLE 3.

TABLE 3

SHOVEL LOADING - BIG CHIEF MINE
(Time in seconds)

Motions	Average Time Individual	Cumulative
H D - 5 no. 3		
1. Move Back	5.1	5.1
2. Move Forward	5.7	10.8
3. Load Dipper	9.2	20.0
4. Move Back	8.0	28.0
5. Move Forward and Dump	5.0	33.0

A 10 ton truck was loaded with an average of seven dipperfuls. Total loading time was then, about four minutes which indicates high shovel efficiency. This time compares very favorably with the Eimco loading time, which was approximately four minutes. The Eimco was being used in a restricted area where the ore was very heterogeneous and difficult to load, which explains the similarity of loading periods.

No independent time studies were conducted on dragline loading.

From the haulage study, however, the average loading time is determined to be slightly over eight minutes.

Haulage System

There are four principal mining areas in the mine, designated here by numbers for convenience.

Number 1 heading (Crawfish Lease), three-tenths mile from the shaft, is in sheet ground workings where loading is performed by dragline. The roads to this area are in good condition but the heading is so poorly maintained as to cause difficulty in truck maneuverings. Breakdowns can be attributed to poor drag cables and unprotected power lines which often cause short-circuits.

Number 2 heading (Big Chief Lease), in sheet ground and four-tenths mile from the shaft, produces a small proportion of ore which is loaded by the H D - 5 no. 3 shovel. The shovel generally maintains the area and the approach roads.

The closest heading to the shaft, one-tenth mile, is no. 3 heading (Big Chief Lease) which is a room and pillar area of low back. Loading is performed with dragline in very restricted space. The area is above the main haulage level and of difficult accessibility.

The largest area is number 4 heading (Otis White Lease). This is a large open stope in high ground area, one mile from the shaft. Loading is accomplished exclusively by shovels and is performed generally by the Eimco no. 21. The floor is very uneven and loading conditions unfavorable.

The dumping station at the shaft is inadequate and poorly designed. There are two grizzlies, but because of their close spacing only one

vehicle can dump at a time. The approach road is narrow and, on leaving the dumping ramp, the truck has to make a right angle turn for the exit road, even though the ramp is of a drive over type. The hopper seems to provide adequate surge capacity under ordinary conditions.

Time Study Results

The results of time studies of the haulage system are summarized and tabulated in TABLES 5 through 12. TABLE 4 shows time ratios that will be considered in conjunction with the truck time tables. These ratios are based on time totals for each truck-shift of the time study observation tables.

TABLE 4

TIME RATIOS OF HAULAGE SYSTEM
Big Chief Mine

Table Number	Ton-Mileage	Productive / Nonproductive Time Ratio	Travel / Transpetration Time Ratio	Travel to Heading / Travel to Shaft / Loading Time Ratio
	T-Mlg	Pdt/Npdt	Trv/Trpt	TH/TS/Ld
5	5,500	1/0.66	1/0.80	0.95/1/1.28
6	3,900	1/0.66	1/1.06	0.88/1/1.73
7	5,100	1/0.63	1/0.96	0.85/1/1.52
	8,830	1/0.54	1/0.81	0.97/1/1.36
8	3,170	1/0.48	1/1.78	0.72/1/2.84
9	2,250	1/0.84	1/1.16	1.04/1/1.68
10	1,015	1/0.97	1/2.21	0.94/1/2.76
11	485	1/1.80	1/2.16	0.94/1/2.89
12	208,000	1/0.75	1/1.20	0.91/1/1.86
Ideal		1/0.425	1/0.50	1.00/1/1.00

Each truck was timed during two complete shifts and the result of these studies are presented in TABLES 5 through 11. TABLE 12 contains the summation of all tables, representing eight shifts.

TABLE 5

TIME STUDY OBSERVATION
Truck no. 29 Type - G.M.C. Dump
Mine - Big Chief Date - July 19
Time in Minutes

Time Division	Heading 3	Heading 4	Total	%
I. PRODUCTIVE TIME				
A. Travel Time				
1. To Heading	17.5	35.0	52.5	
2. Maneuvering Allowance (Head)	12.5	11.0	23.5	
3. To Shaft	21.0	39.0	60.0	
Total	51.0	85.0	136.0	29.3
B. Transpetration Time				
1. Loading	66.5	37.5	104.0	
2. Dumping	26.5	13.0	39.5	
Total	93.0	50.5	143.5	30.9
Total Productive Time			279.5	60.2
II. NONPRODUCTIVE TIME				
A. Delays				
1. Truck Delays				
a. Breakdown			13.0	
b. Normal			3.0	
2. Loader Delays				
a. Breakdown	3.5		3.5	
b. Avoidable	11.0	4.5	15.5	
c. Other Load				
Total			35.0	7.5
3. Other Delays				
a. At Grizzly			104.0	
b. Nonoperating			46.5	
Total			150.5	32.3
Total Nonproductive Time			185.5	39.8
TOTAL TIME OBSERVED			465.0	100.0
Number Tons Transported	130	80	210	
Mileage Recorded	2.6	16.0	18.6	

TABLE 6

TIME STUDY OBSERVATION
Truck no. 29 Type - G.M.C. Dump
Mine - Big Chief Date - July 21
Time in Minutes

Time Division	Heading 4	Heading 3	Total	%
I. PRODUCTIVE TIME				
A. Travel Time				
1. To Heading	62.5	8.0	70.5	
2. Maneuvering Allowance (Head)	11.0	1.0	12.0	
3. To Shaft	69.0	5.0	74.0	
Total	142.5	14.0	156.5	33.6
B. Transpetration Time				
1. Loading	60.5	34.0	94.5	
2. Dumping	24.0	6.0	30.0	
Total	84.5	40.0	124.5	26.8
Total Productive Time			281.0	60.4
II. NONPRODUCTIVE TIME				
A. Delays				
1. Truck Delays				
a. Breakdown			77.5	
b. Normal			13.0	
2. Loader Delays				
a. Breakdown				
b. Avoidable	9.5		9.5	
c. Other Load	21.0		21.0	
Total	30.5		121.0	26.0
3. Other Delays				
a. At Grizzly			4.0	
b. Nonoperating			59.0	
Total			63.0	13.6
Total Nonproductive Time			184.0	39.6
TOTAL TIME OBSERVED			465.0	100.0
Number Tons Transported	150	30	180	
Mileage Recorded	30	0.6	30.6	

TABLE 7

TIME STUDY OBSERVATION
Truck no. 30 Type - G.M.C. Dump
Mine - Big Chief Date - July 24, 23
Time in Minutes

Time Division	Head. 4	%	Head. 4	%
I. PRODUCTIVE TIME				
A. Travel Time				
1. To Heading	60.5		74.5	
2. Maneuvering Allowance (Head)	13.5		15.0	
3. To Shaft	71.0		77.0	
Total	145.0	31.2	166.5	35.8
B. Transpetration Time				
1. Loading	107.5		105.0	
2. Dumping	32.5		31.0	
Total	140.0	30.0	136.0	29.2
Total Productive Time	285.0	61.2	302.5	65.0
II. NONPRODUCTIVE TIME				
A. Delays				
1. Truck Delays				
a. Breakdown	20.0		38.0	
b. Normal	7.5		6.0	
2. Loader Delays				
a. Breakdown	6.0		20.0	
b. Avoidable	7.0		25.0	
c. Other Load	31.5		14.0	
Total	72.0	15.5	103.0	22.2
3. Other Delays				
a. At Grizzly	8.0		11.5	
b. Nonoperating	100.0		48.0	
Total	108.0	23.3	59.5	12.8
Total Nonproductive Time	180.0	38.8	162.5	35.0
TOTAL TIME OBSERVED	465.0	100.0	465.0	100.0
Number Tons Transported	160		210	
Mileage Recorded	32.0		42.0	

TABLE 8

TIME STUDY OBSERVATION
Truck no. 45 Type - Dart trailer
Mine - Big Chief Date - July 24
Time in Minutes

Time Division	Heading 1	%
I. PRODUCTIVE TIME		
A. Travel Time		
1. To Heading	47.0	
2. Maneuvering Allowance (Head)	0.5	
3. To Shaft	65.5	
Total	113.0	24.3
B. Transpetration Time		
1. Loading	186.0	
2. Dumping	14.5	
Total	200.5	43.1
Total Productive Time	313.5	67.4
II. NONPRODUCTIVE TIME		
A. Delays		
1. Truck Delays		
a. Breakdown		
b. Normal	12.0	
2. Loader Delays		
a. Breakdown	29.0	
b. Avoidable	9.5	
c. Other Load	20.5	
Total	71.0	15.3
3. Other Delays		
a. At grizzly	28.5	
b. Nonoperating	52.0	
Total	80.5	17.3
Total Nonproductive Time	151.5	32.6
TOTAL TIME OBSERVED	465.0	100.0
Number Tons Transported	230	
Mileage Recorded	13.8	

TABLE 9

TIME STUDY OBSERVATION
Truck no. 45 Type - Dart trailer
Mine - Big Chief Date - July 19
Time in Minutes

Time division	Heading 1	Heading 4	Heading 2	Total	%
I. PRODUCTIVE TIME					
A. Travel Time					
1. To Heading	7.5	16.0	28.5	52.0	
2. Maneuvering Allowance (head)	2.0	3.0	10.0	15.0	
3. To Shaft	7.5	13.5	29.0	50.0	
Total				117.0	25.2
B. Transpetration Time					
1. Loading	27.5	19.0	37.0	83.5	
2. Dumping	4.0	35.0	13.5	52.5	
Total				136.0	29.2
Total Productive Time				253.0	54.4
II. NONPRODUCTIVE TIME					
A. Delays					
1. Truck Delays					
a. Breakdown					
b. Normal				7.5	
2. Loader Delays					
a. Breakdown					
b. Avoidable		11.0	4.5	15.5	
c. Other Load	23.0			23.0	
Total				46.0	9.9
3. Other Delays					
a. At Grizzly				118.0	
b. Nonoperating				48.0	
Total				166.0	35.7
Total Nonproductive Time				212.0	45.6
TOTAL TIME OBSERVED				465.0	100.0
Number Tons Transported				150	
Mileage Recorded	3	3	9	15	

TABLE 10

TIME STUDY OBSERVATION
Truck no. 48 Type - Autocar Trailer
Mine - Big Chief Date - July 23
Time in Minutes

Time Division	Heading 1	Heading 4	Total	%
I. PRODUCTIVE TIME				
A. Travel Time				
1. To Heading	23.5	11.0	34.5	
2. Maneuvering Allowance (Head)	1.5	2.5	4.0	
3. To Shaft	23.5	12.5	36.0	
Total			74.5	16.0
B. Transpetration Time				
1. Loading	81.0	18.5	99.5	
2. Dumping	48.0	17.0	65.0	
Total			164.5	35.4
Total Productive Time			239.0	51.4
II. NONPRODUCTIVE TIME				
A. Delays				
1. Truck Delays				
a. Breakdown			45.0	
b. Normal				
2. Loader Delays				
a. Breakdown	34.5	6.5	41.0	
b. Avoidable	44.5		44.5	
c. Other Load		8.0	8.0	
Total			138.5	29.8
3. Other Delays				
a. At Grizzly			49.0	
b. Nonoperating			38.5	
Total			87.5	18.8
Total Nonproductive Time			226.0	48.6
TOTAL TIME OBSERVED			465.0	100.0
Number Tons Transported	100	30	130	
Mileage Recorded	6.0	1.8	7.8	

TABLE 11

TIME STUDY OBSERVATION
Truck no. 48 Type - Autocar Trailer
Mine - Big Chief Date - July 24
Time in Minutes

Time Division	Heading 1	%
I. PRODUCTIVE TIME		
A. Travel Time		
1. To Heading	23.5	
2. Maneuvering Allowance (Head)	4.0	
3. To Shaft	25.0	
Total	52.5	11.3
B. Transpetration Time		
1. Loading	72.0	
2. Dumping	42.0	
Total	114.0	24.5
Total Productive Time	166.5	35.8
II. NONPRODUCTIVE TIME		
A. Delays		
1. Truck Delays		
a. Breakdown	160.0	
b. Normal	5.0	
2. Loader Delays		
a. Breakdown	30.0	
b. Avoidable	25.0	
c. Other Load	15.0	
Total	235.0	50.5
3. Other Delays		
a. At Grizzly	23.5	
b. Nonoperating	40.0	
Total	63.5	13.7
Total Nonproductive Time	298.5	64.2
TOTAL TIME OBSERVED	465.0	100.0
Number Tons Transported	90	
Mileage Recorded	5.4	

FIGURE 18 shows more clearly the time distribution for the total time analyzed; the illustration depicts the results in TABLE 12.

In all cases, there is less time expended in productive work than would be expected. Only one truck-shift, presented in TABLE 8, approaches the minimum desired Pdt/Npdt ratio of 1/0.425, while others fall below this minimum. Delays that are attributed to the truck and shovel are equally distributed and in most places can be eliminated. Most grizzly delays may be decreased also. A large number of truck breakdowns are indicated by the time consumed and represent 9.4 per cent of the total time investigated. There is evidence of poor inspection and maintenance program. Nonoperating time falls well within the expected limits. The ton-mileage per shift is 2570. This is a very unfavorable result.

Compendium

On the over-all basis, the haulage system at Big Chief Mine can be considered inefficient.

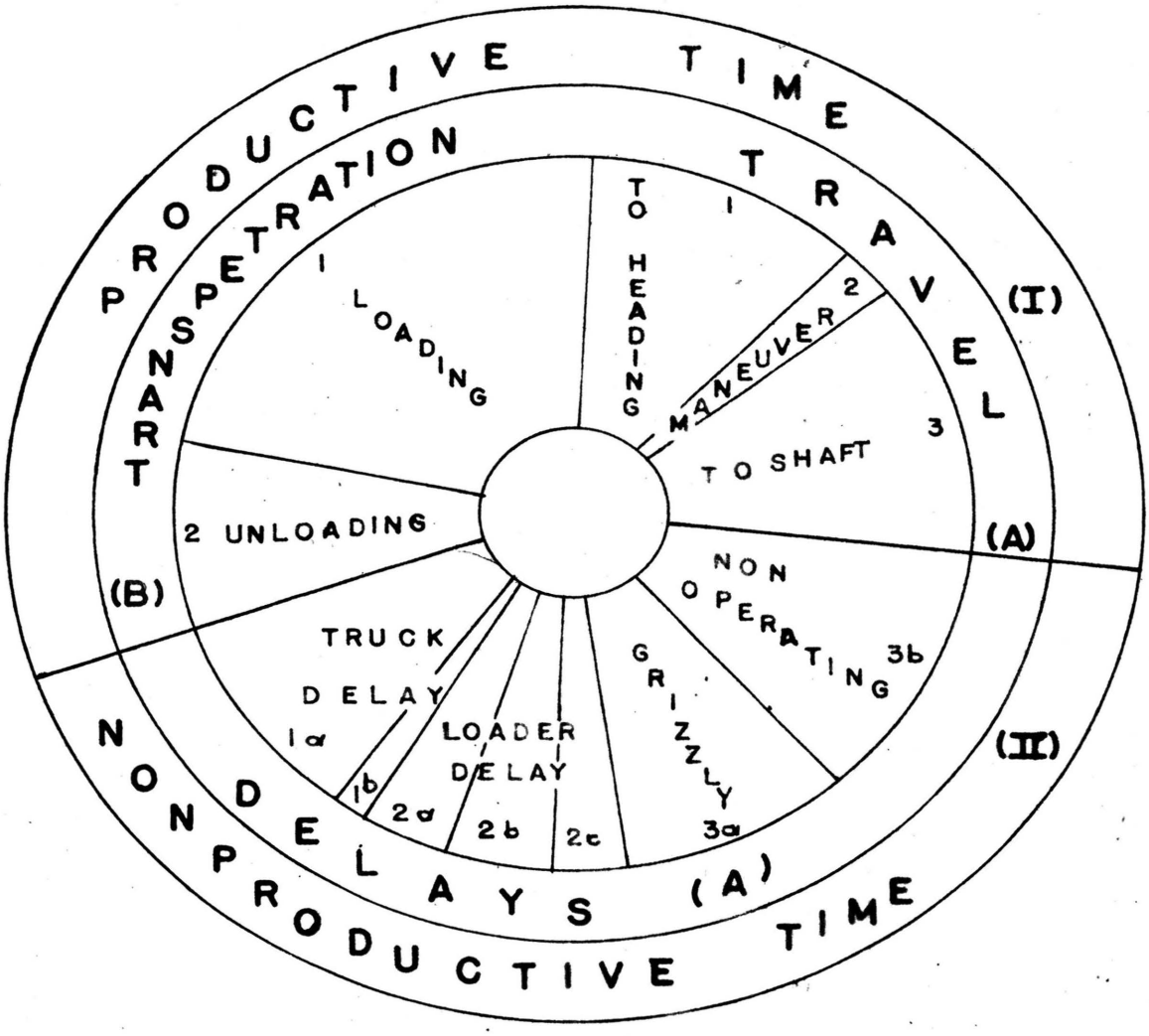
At the present production, 53 truck loads per shift would be required to deliver 530 tons at the shaft station. Assuming that the truck actually transports only 0.9 capacity load, about 59 loads in a shift would be necessary. At the calculated maximum possible production of 640 tons in a day 64 full loads or 70 loads (at 0.9 capacity) would have to be transported. If three trucks were being used, a minimum of 20 and a maximum of 24 loads in a shift would have to be transported. This should be accomplished if attention is given to distribution and dispatching of equipment. The retired truck could be kept as a reserve element in case of breakdown. A rotation plan should be instituted so

TABLE 12

TIME STUDY OBSERVATION
General Summary
Mine - Big Chief Date - June 19 to 24
Time in Minutes

Time Division	Total	%
I. PRODUCTIVE TIME		
A. Travel Time		
1. To Heading	415.0	11.2
2. Maneuvering Allowance (Head)	87.5	2.3
3. To Shaft	458.5	12.3
Total	961.0	25.8
B. Transpetration Time		
1. Loading	852.0	22.9
2. Dumping	307.0	8.3
Total	1159.0	31.2
Total Productive Time	2120.0	57.0
II. NONPRODUCTIVE TIME		
A. Delays		
1. Truck Delays		
a. Breakdown	353.5	9.4
b. Normal	54.0	1.4
2. Loader Delays		
a. Breakdown	129.5	3.5
b. Avoidable	151.5	4.2
c. Other Load	133.0	3.6
Total	821.5	22.1
3. Other Delays		
a. At Grizzly	346.5	9.3
b. Nonoperating	432.0	11.6
Total	778.5	20.9
Total Nonproductive Time	1600.0	43.0
TOTAL TIME OBSERVED	3720.0	100.0
Number Tons Transported	1260	
Mileage Recorded	165.2	

FIGURE 18



TIME DISTRIBUTION CHART

TRUCK HAULAGE

BIG CHIEF MINE

TOTAL TIME 3,720 MIN LOADS 126

that each truck can be suitably checked and maintained in the best of operating condition. This plan would minimize truck breakdown delays by providing a replacement; reduce grizzly delays as fewer trucks are occupying the same dump ramp; and inhibit other load delays at the loaders because there would be less likelihood of the trucks concentrating in one zone. The productive time percentage (57.0) could be raised easily to over 70, and the entire haulage system would be operating on a more efficient basis.

When one truck is retired the dragline in heading number 1 also could be removed. The shovel operating in heading 2 could perform loading operations in both areas, as they are less than one-tenth mile apart. By careful planning both units could be retired without affecting production.

BIG JOHN MINE

Location

The Big John Mine includes the SE½ of section 3, S½SW¼ of section 2 and the N½NW¼ of section 11, T. 35 S., R. 23 E., Cherokee County, Kansas.

Production

Approximately 360 tons a day are produced from the Big John Mine. For this output, 480 cans are hoisted in a shift.

Equipment

Four trucks are available for ore transportation, nos. 19, 35, and 41 Dart dump trucks (D-100 UG), and no. 22 Ford truck-trailer (F-8). The oldest trucks have been in operation since February 1949.

Truck operation and costs for the month of June 1951, are presented in TABLE 13.

TABLE 13

TRUCK PERFORMANCE - BIG JOHN MINE
(Courtesy of Eagle Picher Mn. & S. Co.)
June 1951

Truck Number	Fuel Consumed (gal.)	Number of Loads	Number of Shifts	Operating Costs
19	160	325	26	$544.
22	95	181	25	376.
35	140	337	26	358.
41	180	450	26	348.

Available loading equipment includes, one dragline and two shovels, nos. 8 and 15, Allis Chalmer H D - 5 models. Operating characteristics for these loaders are shown in TABLE 14.

TABLE 14

SHOVEL PERFORMANCE - BIG JOHN MINE
(Courtesy of Eagle Picher M. & S. Co.)
Cumulative data to June 1, 1951

Shovel Number	Total Tons Loaded	Total Shifts	Operating Labor Costs	Total Operating Costs	Unit Operating Cost ($/ton)
8	66,075	491	$6,283.	$24,625.	$0.373
15	82,130	566	6,884.	21,955.	0.267

Hoisting

Hoisting is done by cans in a 286 feet shaft. The actual hoisting capacity is far greater than actual mine production. Time study reveals that the average hoisting cycle is completed in 36.5 seconds. Cans are loaded and ready to be hoisted in 18 seconds and the delay for the return of the empty can is 12 seconds. A man shaft is in operation so that ore hoisting is not interrupted for lowering men and supplies during the shift. For this reason, actual available hoisting time may be more than 425 minutes, assumed previously, but this figure will be used as a minimum allowance. In this time period 720 cans or 540 tons can be hoisted.

At present the hoisting cycle is interrupted for lengthy periods of time because no ore is available.

Loading

Shovels operate alternately in the same areas with similar efficiency. This can be verified from results shown in TABLE 15.

An average of eight dippers were required to complete a 10 ton load, or 5.6 minutes were consumed in one load. Under ordinary condi-

tions this timing could be improved, except that most loading areas provide little maneuvering space for the vehicles.

TABLE 15

SHOVEL LOADING - BIG JOHN MINE
(Time in seconds)

Motion	Average Time Individual	Cumulative
H D - 5 no. 8		
1. Move Back	6	6
2. Move Forward	9	15
3. Load Dipper	12	27
4. Move Back	11	38
5. Move Forward and Dump	4	42
H. D. 5 no. 15		
1. Move Back	7	7
2. Move Forward	6	12
3. Load Dipper	12	24
4. Move Back	12	36
5. Move Forward and Dump	6	42

Figures in TABLE 16 represent operations in one stope alone, under inimical conditions.

TABLE 16

SHOVEL LOADING - BIG JOHN MINE
(Time in seconds)

Motions	Average Time Individual	Cumulative
H D - 5 no. 15		
1. Move Back	7	7
2. Move Forward	8	15
3. Load Dipper	15	30
4. Move Back	13	43
5. Move Forward and Dump	9	52

The dragline completes a 10 ton loading cycle in an average time

of 7.5 minutes. In general, the operator had little opportunity to prepare for following loads, although pressed continuously for loading. Excessive haulage capacity existed for a fixed loading capacity.

Haulage System

Ore is transported from six mining areas, and these will be discussed briefly. Number 1 heading (Big John Lease), one-tenth mile from the shaft, is a narrow stope in high ground area. The approach is extremely restricted, requiring the truck to back in almost the entire distance. It would seem advisable to construct a turn-out point close to the loading area. The shovel also operates in a very restricted area.

Ore is shovel loaded in heading 2 (Big John Lease) located one-tenth mile from the shaft in a small room and pillar area. Approach roads to this area are in poor condition.

Heading 3 (Black Eagle Lease) is a large stope in high ground area, six-tenths mile from the dumping station. The roads in the zone are poorly conditioned and thus loading is difficult and truck maneuvering laborious. Time and wear on equipment could be avoided if more attention was devoted to road maintenance.

Headings 4 (Big John Lease) and 5 (Lucky Jew Lease) are in sheet ground, located five-tenths and one mile, respectively, from the ore shaft. Efficient loading by shovels is accomplished under favorable conditions.

A dragline is used in heading 6 (Big John Lease) which is six-tenths mile from the unloading station. Effective loading in this sheet ground area is curtailed because of frequent truck congestion.

The roads to most headings are poorly maintained and in immediate need of repair. Rough roads not only slow down vehicle movement but cause unnecessary wear damage.

The grizzly is of the back-in type. In this place, the trucks have to swing away from the dump station and back in over the ramp. This dumping station is illustrated in FIGURE 19. The hopper has a very small surge capacity although at the present production rate, this is sufficient.

Time Study Results

Time study results are summarized in TABLES 17 through 26.

TABLE 17

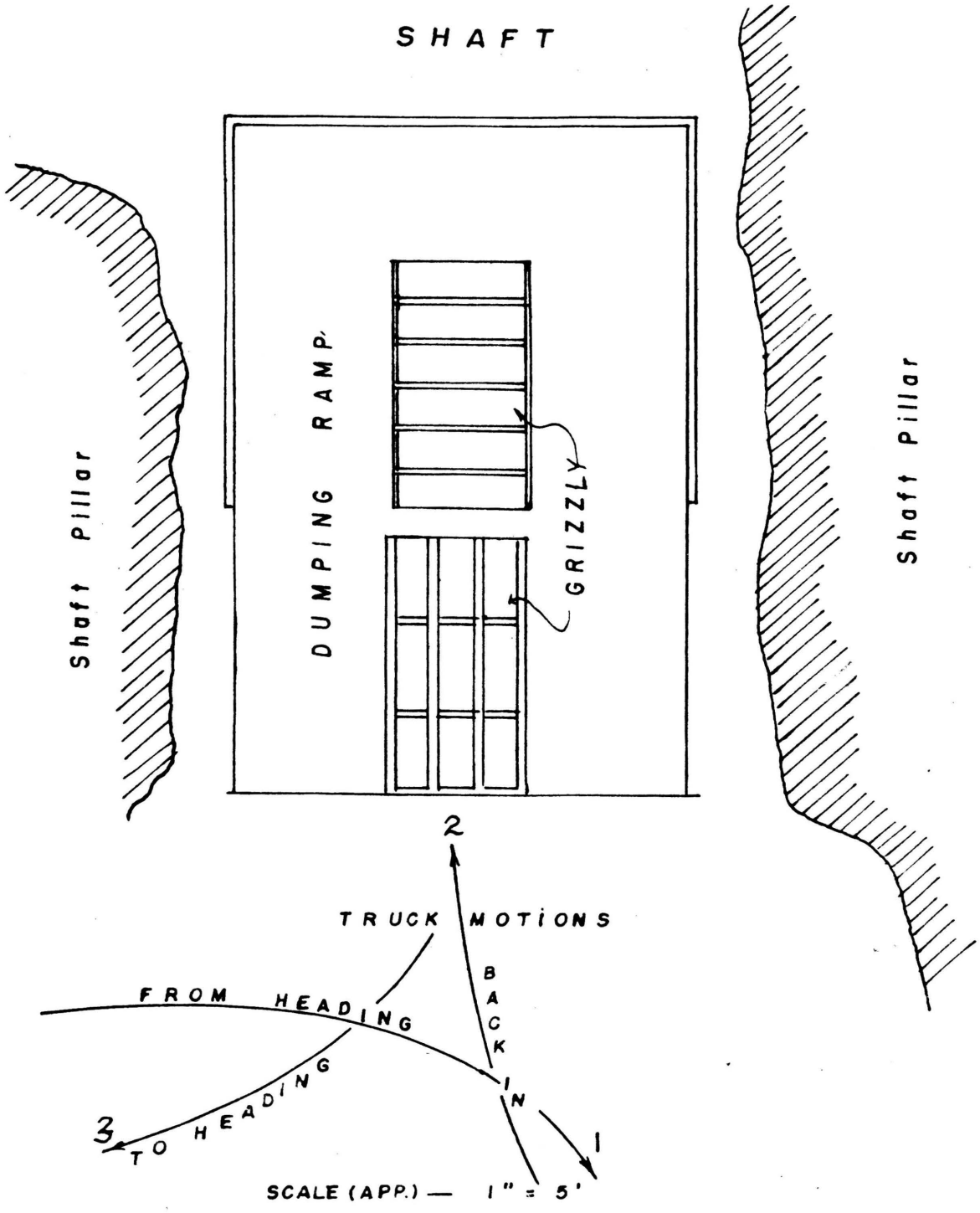
TIME RATIOS OF HAULAGE SYSTEM
Big John Mine

Table Number	Ton-Mileage	Productive / Nonproductive Time Ratio	Travel / Transpetration Time Ratio	Travel to Heading / Travel to Shaft / Loading Time Ratio
	T-Mlg	Pdt/Npdt	Trv/Trpt	TH/TS/Ld
18	3,800	1/0.56	1/0.49	0.69/1/0.75
19	2,840	1/0.63	1/0.56	0.76/1/0.85
20	480	1/1.55	1/0.78	1.43/1/1.93
21	398	1/2.06	1/0.87	1.41/1/2.00
22	1,730	1/0.81	1/0.68	0.81/1/1.18
23	2,840	1/0.49	1/1.07	1.10/1/1.94
24	2,740	1/0.70	1/0.78	0.92/1/0.20
25	1,680	1/0.59	1/1.60	1.36/1/3.60
26	126,000	1/0.82	1/0.83	0.93/1/1.50
Ideal		1/0.425	1/0.50	1.00/1/1.00

The truck-shift operations are presented in TABLES 18 through 25. The cumulative totals of the haulage operation are depicted in TABLE 26 and the results are represented graphically in FIGURE 20.

FIGURE 19

BACK-IN TYPE DUMPING STATION



BIG JOHN MINE

TABLE 18

TIME STUDY OBSERVATION
Truck no. 19 Type - Dart dump
Mine - Big John Date - August 22
Time in Minutes

Time Division	Heading 3	Heading 5	Heading 4	Total	%
I. PRODUCTIVE TIME					
A. Travel Time					
1. To Heading	19.0	54.0	10.0	73.0	
2. Maneuvering Allowance (Head)	4.5	5.5	1.5	11.5	
3. To Shaft	26.0	65.0	14.5	105.5	
4. Maneuvering Allowance (Shaft)	5.0	4.5	0.5	10.0	
Total	54.5	129.0	26.5	200.0	43.0
B. Transpetration Time					
1. Loading	28.5	33.5	17.5	79.5	
2. Dumping	5.0	9.5	3.5	18.0	
Total	33.5	43.0	21.0	97.5	21.0
Total Productive Time				297.5	64.0
II. NONPRODUCTIVE TIME					
A. Delays					
1. Truck Delays					
a. Breakdown					
b. Normal				17.0	
2. Loader Delays					
a. Breakdown					
b. Avoidable	15.5	17.0	32.5	65.0	
c. Other Load					
Total				82.0	17.6
3. Other Delays					
a. At Grizzly				5.5	
b. Nonoperating				80.0	
Total				85.5	18.4
Total Nonproductive Time				167.5	36.0
TOTAL TIME OBSERVED				465.0	100.0
Number Loads Transported	4	8	3	15	
Mileage Recorded	4.8	16.0	4.5	25.3	

TABLE 19

TIME STUDY OBSERVATION
Truck no. 19 Type - Dart dump
Mine - Big John Date - August 24
Time in Minutes

Time Division	Heading 3	Heading 6	Heading 4	Total	%
I. PRODUCTIVE TIME					
A. Travel Time					
1. To Heading	14.0	42.0	20.0	76.0	
2. Maneuvering Allowance (Head)	0.5	2.5	2.0	5.0	
3. To Shaft	16.5	58.5	24.5	99.5	
4. Maneuvering Allowance (Shaft)	1.0	2.0	1.0	4.0	
Total	32.0	105.0	45.5	184.5	39.7
B. Transpetration Time					
1. Loading	13.5	59.0	12.5	85.0	
2. Dumping	3.5	10.0	2.5	16.0	
Total	17.0	69.0	15.0	101.0	21.7
Total Productive Time				285.5	61.4
II. NONPRODUCTIVE TIME					
A. Delays					
1. Truck Delays					
a. Breakdown					
b. Normal				8.5	
2. Loader Delays					
a. Breakdown					
b. Avoidable	10.5	32.5	33.0	76.0	
c. Other Load	11.0			11.0	
Total				95.5	20.5
3. Other Delays					
a. At Grizzly				16.0	
b. Nonoperating				68.0	
Total				84.0	18.1
Total Nonproductive Time				179.5	38.6
TOTAL TIME OBSERVED				465.0	100.0
Number Loads Transported	3	9	3	15	
Mileage Recorded	3.6	10.8	4.5	18.9	

TABLE 20

TIME STUDY OBSERVATION
Truck no. 22 Type - Ford trailer
Mine - Big John Date - August 22
Time in Minutes

Time Division	Heading 1	Heading 3	Total	%
I. PRODUCTIVE TIME				
A. Travel Time				
1. To Heading	28.5	20.0	48.5	
2. Maneuvering Allowance (Head)	9.5	3.5	13.0	
3. To Shaft	9.5	25.0	34.5	
4. Maneuvering Allowance (Shaft)	2.5	2.5	5.0	
Total	40.5	60.5	101.0	21.7
B. Transpetration Time				
1. Loading	28.0	38.5	66.5	
2. Dumping	5.5	6.5	12.0	
Total	33.5	45.0	78.5	16.9
Total Productive Time			179.5	38.6
II. NONPRODUCTIVE TIME				
A. Delays				
1. Truck Delays				
a. Breakdown			46.0	
b. Normal			5.0	
2. Loader Delays				
a. Breakdown				
b. Avoidable				
c. Other Load				
Total			51.0	10.9
3. Other Delays				
a. At Grizzly				
b. Nonoperating			234.5	
Total			234.5	50.5
Total Nonproductive Time			285.5	61.4
TOTAL TIME OBSERVED			465.0	100.0
Number Loads Transported	4	4	8	
Mileage Recorded	1.2	4.8	6.0	

TABLE 21

TIME STUDY OBSERVATION
Truck no. 22 Type - Ford trailer
Mine - Big John Date - August 25
Time in Minutes

Time Division	Heading 1	Heading 3	Total	%
I. PRODUCTIVE TIME				
A. Travel Time				
1. To Heading	21.0	18.5	39.5	
2. Maneuvering Allowance (Head)		6.5	6.5	
3. To Shaft	7.5	20.5	28.0	
4. Maneuvering Allowance (Shaft)	3.5	3.5	7.0	
Total	32.0	49.0	81.0	17.4
B. Transpetration Time				
1. Loading	30.5	25.5	56.0	
2. Dumping	8.0	7.0	15.0	
Total	38.5	32.5	71.0	15.2
Total Productive Time			152.0	32.6
II. NONPRODUCTIVE TIME				
A. Delays				
1. Truck Delays				
a. Breakdown				
b. Normal			15.0	
2. Loader Delays				
a. Breakdown				
b. Avoidable				
c. Other Load			12.0	
Total			27.0	5.8
3. Other Delays				
a. At Grizzly				
b. Nonoperating			286.0	
Total			286.0	61.6
Total Nonproductive Time			313.0	67.4
TOTAL TIME OBSERVED			465.0	100.0
Number Loads Transported	3	4	7	
Mileage Recorded	0.9	4.8	5.7	

TABLE 22

TIME STUDY OBSERVATION
Truck no. 35 Type - Dart dump
Mine - Big John Date - August 21
Time in Minutes

Time Division	Heading 3	Heading 6	Total	%
I. PRODUCTIVE TIME				
A. Travel Time				
1. To Heading	26.0	35.0	61.0	
2. Maneuvering Allowance (Head)	2.5	5.5	8.0	
3. To Shaft	30.0	45.0	75.0	
4. Maneuvering Allowance (Shaft)	3.5	5.5	9.0	
Total	62.0	91.0	153.0	32.9
B. Transpetration Time				
1. Loading	25.0	63.0	88.0	
2. Dumping	5.5	10.0	15.5	
Total	30.5	73.0	103.5	22.3
Total Productive Time			256.5	55.2
II. NONPRODUCTIVE TIME				
A. Delays				
1. Truck Delays				
a. Breakdown			16.0	
b. Normal			5.5	
2. Loader Delays				
a. Breakdown	21.0		21.0	
b. Avoidable	48.0	24.0	72.0	
c. Other Load	3.5		3.5	
Total			118.0	25.4
3. Other Delays				
a. At Grizzly			20.0	
b. Nonoperating			70.5	
Total			90.5	19.4
Total Nonproductive Time			208.5	44.8
TOTAL TIME OBSERVED			465.0	100.0
Number Loads Transported	5	7	12	
Mileage Recorded	6.0	8.4	14.4	

TABLE 23

TIME STUDY OBSERVATION
Truck no. 35 Type - Dart dump
Mine - Big John Date - August 23
Time in Minutes

Time Division	Heading 6	1	2	3	Total	%
I. PRODUCTIVE TIME						
A. Travel Time						
1. To Heading	24.0	15.0	12.0	16.5	67.5	
2. Maneuvering Allowance (Head)	2.5	1.5	3.0	1.5	8.5	
3. To Shaft	29.0	8.0	11.5	18.5	67.0	
4. Maneuvering Allowance (Shaft)	2.0	1.5	3.5	1.5	8.0	
Total	57.5	26.0	20.0	38.0	151.0	32.5
B. Transpetration Time						
1. Loading	42.5	30.5	41.0	16.0	130.0	
2. Dumping	7.0	7.0	14.0	4.0	32.0	
Total	49.5	37.5	55.0	20.0	162.0	34.8
Total Productive Time					313.0	67.3
II. NONPRODUCTIVE TIME						
A. Delays						
1. Truck Delays						
a. Breakdown						
b. Normal					12.0	
2. Loader Delays						
a. Breakdown	18.0				18.0	
b. Avoidable	3.0		15.0	15.0	33.0	
c. Other Load	7.0	8.0	5.5	5.5	26.0	
Total					89.0	19.1
3. Other Delays						
a. At Grizzly					9.5	
b. Nonoperating					53.5	
Total					63.0	13.6
Total Nonproductive Time					152.0	32.7
TOTAL TIME OBSERVED					465.0	100.0
Number Loads Transported	5	5	9	3	22	
Mileage Recorded	6.0	1.5	1.8	3.6	12.9	

TABLE 24

TIME STUDY OBSERVATION
Truck no. 41 Type - Dart dump
Mine - Big John Date - August 21
Time in Minutes

Time Division	Heading 1	Heading 6	Total	%
I. PRODUCTIVE TIME				
A. Travel Time				
1. To Heading	14.5	45.5	60.0	
2. Maneuvering Allowance (Head)		3.5	3.5	
3. To Shaft	11.0	54.0	65.0	
4. Maneuvering Allowance (Shaft)	1.5	3.0	4.5	
Total	27.0	108.0	133.0	38.6
B. Transpetration Time				
1. Loading	39.0	75.5	114.5	
2. Dumping	13.0	13.0	26.0	
Total	52.0	88.5	140.5	30.2
Total Productive Time			273.5	58.8
II. NONPRODUCTIVE TIME				
A. Delays				
1. Truck Delays				
a. Breakdown				
b. Normal			25.0	
2. Loader Delays				
a. Breakdown		20.0	20.0	
b. Avoidable		59.5	59.5	
c. Other Load		7.0	7.0	
Total			111.5	24.0
3. Other Delays				
a. At Grizzly			10.0	
b. Nonoperating			70.0	
Total			80.0	17.2
Total Nonproductive Time			191.5	41.2
TOTAL TIME OBSERVED			465.0	100.0
Number Loads Transported	7	11	18	
Mileage Recorded	2.1	13.2	15.3	

TABLE 25

TIME STUDY OBSERVATION
Truck no. 41 Type - Dart dump
Mine - Big John Date - August 23
Time in Minutes

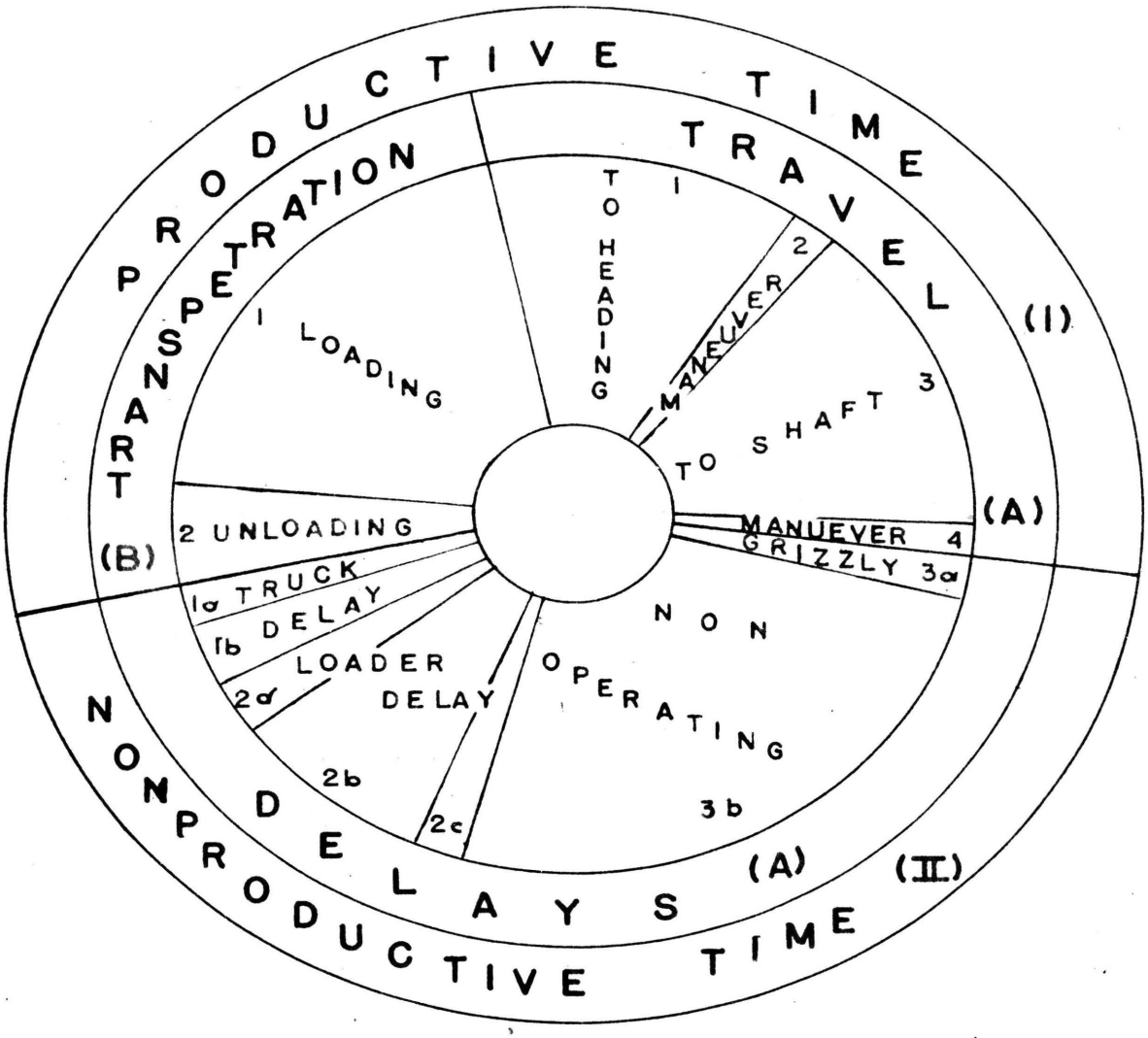
Time Division	Heading 1	Heading 5	Total	%
I. PRODUCTIVE TIME				
A. Travel Time				
1. To Heading	49.5	6.5	56.0	
2. Maneuvering Allowance (Head)	10.0		10.0	
3. To Shaft	34.0	7.0	41.0	
4. Maneuvering Allowance (Shaft)	5.0	0.5	5.5	
Total	98.5	14.0	112.5	24.2
B. Transpetration Time				
1. Loading	140.5	7.0	147.5	
2. Dumping	30.0	1.5	31.5	
Total	170.5	8.5	179.0	38.5
Total Productive Time			291.5	62.7
II. NONPRODUCTIVE TIME				
A. Delays				
1. Truck Delays				
a. Breakdown				
b. Normal			11.0	
2. Loader Delays				
a. Breakdown		24.0	24.0	
b. Avoidable	20.0	6.0	26.0	
c. Other Load	6.0		6.0	
Total			67.0	14.4
3. Other Delays				
a. At Grizzly			5.0	
b. Nonoperating			101.5	
Total			106.5	22.9
Total Nonproductive Time			173.5	37.3
TOTAL TIME OBSERVED			465.0	100.0
Number Loads Transported	20	1	21	
Mileage Recorded	6.0	2.0	8.0	

TABLE 26

TIME STUDY OBSERVATION
General Summary
Mine - Big John Date - August 21 to 25
Time in Minutes

Time Division	Heading Total	%
I. PRODUCTIVE TIME		
A. Travel Time		
1. To Heading	481.5	12.9
2. Maneuvering Allowance (Head)	66.0	1.8
3. To Shaft	515.5	13.9
4. Maneuvering Allowance (Shaft)	53.0	1.4
Total	1116.0	30.0
B. Transpetration Time		
1. Loading	767.0	20.5
2. Dumping	166.0	4.5
Total	933.0	25.0
Total Productive Time	2049.0	55.0
II. NONPRODUCTIVE TIME		
A. Delays		
1. Truck Delays		
a. Breakdown	62.0	1.7
b. Normal	99.0	2.7
2. Loader Delays		
a. Breakdown	83.0	2.2
b. Avoidable	331.5	8.9
c. Other Load	65.5	1.8
Total	641.0	17.3
3. Other Delays		
a. At Grizzly	66.0	1.8
b. Nonoperating	964.0	25.9
Total	1030.0	27.7
Total Nonproductive Time	1671.0	45.0
TOTAL TIME OBSERVED	3720.0	100.0
Number Loads Transported	118	
Mileage Recorded	106.5	

FIGURE 20



TIME DISTRIBUTION CHART

TRUCK HAULAGE

BIG JOHN MINE

TOTAL TIME 3,720 MIN LOADS 118

Nonproductive time represents a very large part of the total time in all recorded shifts. Truck 22 has an unsatisfactory record, spending over 50 per cent in nonoperating time. Delays attributed to loader are particularly noticeable in heading 6. As noted previously, there were too many haulage units available in that heading to be handled effectively by the dragline.

TABLE 26 shows that 17.3 per cent of the total time investigated was consumed by delays of haulage units. This situation should be improved.

Over one-quarter of the available time was not used in any operational work. This figure is twice the maximum calculated allowance.

Pdt/Npdt ratios are far below the expected value of 1/0.425, even though Trv/Trpt ratios show more favorable results.

Compendium

The efficiency of the haulage at Big John Mine should be improved.

At 0.9 truck capacity only 40 loads a shift are required to maintain the present mine output. At calculated possible capacity, 60 loads a day would be required. Three trucks can transport this quantity under a well managed plan.

One truck should be retired from active haulage and placed on a stand by reserve basis. The other trucks then should be dispatched to the various loading areas without overtaxing any single loader.

BLUE GOOSE 1 MINE

Location

The Blue Goose 1 Mine is in the NE$\frac{1}{4}$ of section 30, T. 29 N., R. 23 E., Ottawa County, Oklahoma.

Production

Approximately 670 cans are hoisted during a shift. This represents an average production of 520 tons a day.

Equipment

Three trucks are in operation, nos. 32, 33, and 34 Dart dump trucks (100 UG). Performance characteristics for these vehicles are for one month of operations and are listed in TABLE 27.

TABLE 27

TRUCK PERFORMANCE - BLUE GOOSE 1 MINE
(Courtesy of Eagle Picher Mn. & S. Co.)
June 1951

Truck Number	Fuel Consumed (gal.)	Number of Loads	Number of Shifts	Operating Costs
32	125	528	26	$406.
33	125	513	25	437.
34	95	493	26	391.

Loading is performed by three draglines and one shovel, no. 18 H D - 5. Cumulative operating data for the shovel are given in TABLE 28.

Hoisting

In the Blue Goose 1 Mine the ore is can hoisted 412 feet to the surface hopper. The average hoisting cycle expends 39 seconds. The

TABLE 28

SHOVEL PERFORMANCE - BLUE GOOSE 1 MINE
(Courtesy of Eagle Picher Mn. & S. Co.)
Cumulative data to June 1, 1951

Shovel Number	Total Tons Loaded	Total Shifts	Operating Labor Costs	Total Operating Costs	Unit Operating Cost ($/Ton)
18	120,923	396	$7,288.	$19,644.	$0.162

ore can is loaded and ready for hoisting in 19 seconds and the hooker waits 15 seconds for the return of the empty can.

As men and supplies are lowered through a different shaft, almost the entire working time can be utilized for ore hoisting. In 465 minutes, 715 cans could be hoisted. This computed output is comparable to present production.

Loading

Shovel no. 28 was studied when loading in high ground area. The results are summarized in TABLE 29.

TABLE 29

SHOVEL LOADING - BLUE GOOSE 1 MINE
(Time in seconds)

Motions	Average Time Cumulative	Average Time Individual
H D - 5 no. 28		
1. Move Back	5.6	5.6
2. Move Forward	12.0	6.4
3. Load Dipper	29.5	17.5
4. Move Back	37.5	8.0
5. Move Forward and Dump	46.0	8.5

An average of seven dipperfuls were required for a 10 ton load.

The average loading time was 5.4 minutes, which is poor shovel performance.

Of the three available draglines, only two were in operation during the visit to the mine. Average loading time for one dragline was slightly over 5 minutes which is considered excellent for this type of loader. The incompetency of the dragline operator in number 3 heading is evidenced by an average loading time of 12.5 minutes. This situation will be discussed later.

Haulage System

All loading areas in this mine are in high ground mining. Heading number 1 (Humba Lease) is located one-tenth mile from the dumping station. In this heading the loading is done entirely by dragline which moves from one face to another as required by mining operations. Although loading time was favorable, considerable time was wasted by the operator.

Two methods of loading are in use in headings number 2 and 3 (Blue Goose Lease), located three-tenths mile from the shaft. At one face the loading is performed by dragline. This operation is particularly unsuccessful. The operator seldom places the loader in a favorable position and is prone to waste time in unnecessary scraper movement. Shovel loading is carried on at other faces in the same stope with fair results.

Ore is mined in high ground on upper levels and slushed into raise-chutes to be loaded by dragline in heading number 4. No loading operations were being undertaken at this heading during the visit to the mine.

Heading 5 is located one mile from the shaft and provides only a small part of the mine production. Loading is done by the shovel in a restricted area.

The roads in most places are in good condition and loading areas are properly maintained.

A drive-over grizzly is used in Blue Goose 1 Mine. This type of dumping station, which is illustrated in FIGURE 21, is the best one in use underground. Because trucks are not required to back in, little time is consumed in the dumping operation and there is less fatigue on the driver than in the back-in type ramp. The grizzly is constructed to permit all but the largest boulders to pass directly into the hopper. The inclined position of the first screen permits the oversize material to roll onto the second screen where secondary breaking is performed. In this manner, the screen is not readily clogged up after a truck has unloaded. The hopper under the screens provides sufficient surge capacity for continuous operation.

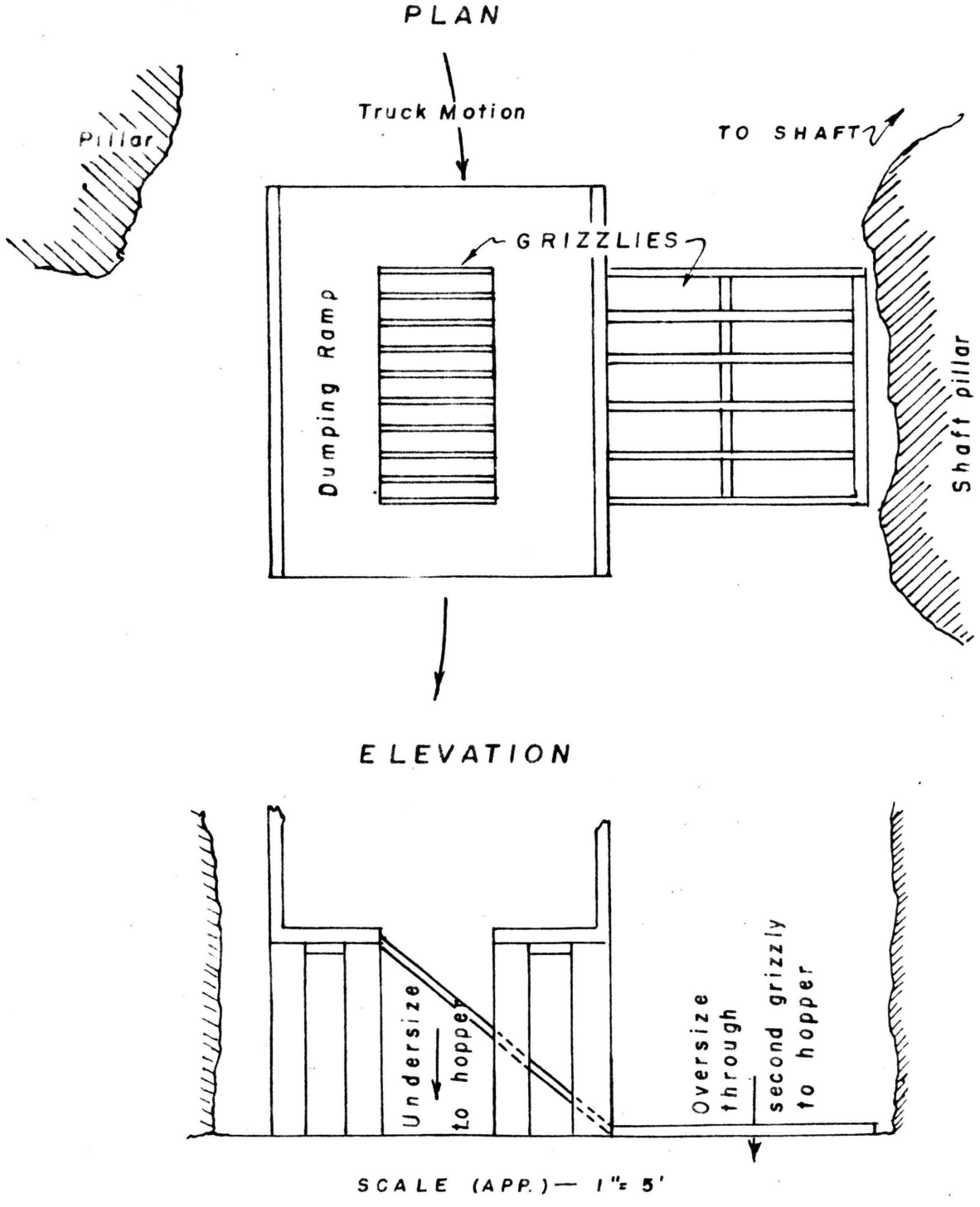
Time Study Results

Results of the time studies are summarized in TABLES 30 through 34. Graphical representation of the time distribution is given in FIGURE 22.

As shown in the General Summary (TABLE 34), there is too much time wasted in nonproductive operations. The Pdt/Npdt ratio of 1/0.79 indicates that too much nonproductive effort was expended during the shifts. The leading factor of this situation was the poor truck performance reported in TABLE 32. In this case the truck was dependent on shovel loading and no provision was made for the use of alternative equipment.

FIGURE 21

DRIVE OVER TYPE UNLOADING STATION



BLUE GOOSE I MINE

TABLE 30

TIME RATIOS OF HAULAGE SYSTEM
Blue Goose 1 Mine

Table Number	Ton-Mileage	Productive / Nonproductive Time Ratio	Travel / Transpetration Time Ratio	Travel to Heading / Travel to Shaft / Loading Time Ratio
	T- Mlg	Pdt/Npdt	Trv/Trpt	TH/TS/Ld
31	1950	1/0.37	1/3.18	0.80/1/5.65
	1950	1/0.45	1/2.46	0.74/1/4.15
32	735	1/1.40	1/3.68	0.79/1/6.10
	1015	1/2.18	1/1.14	0.63/1/1.41
33	900	1/0.91	1/2.13	0.97/1/4.41
	1125	1/4.10	1/7.24	1.24/1/18.2
34	47000	1/0.79	1/3.46	0.79/1/5.20
Ideal		1/0.425	1/0.50	1.00/1/1.00

The truck was forced to wait whenever repairs had to be made on the shovel.

Truck-shift studies of truck 32 (TABLE 31) shows that the Pdt/Npdt ratios are within the desired limits. The corresponding Trv/Trpt ratios, however, indicate the operation was not as efficient as disclosed by the Pdt/Npdt ratios. The loading periods were too great and are clearly illustrated by the TH/TS/Ld ratios. This situation has been discussed earlier.

Truck runs tabulated in TABLE 32 show that the same condition of extensive loading time exists as in TABLE 31. In this case, however, the haulage distances are so short that the ordinary comparison of ratios is not entirely justified. The most serious fault is delays that are attributable to the operator of the loading machine.

Compendium

The equipment available for ore transportation is not being used

TABLE 31

TIME STUDY OBSERVATION
Truck no. 32 Type - Dart dump
Mine - Blue Goose 1 Date - August 11, 15
Time in Minutes

Time Division	Heading 2	%	Heading 2	%
I. PRODUCTIVE TIME				
A. Travel Time				
1. To Heading	33.5		37.0	
2. Maneuvering Allowance (Head)	5.5		6.0	
3. To Shaft	42.0		50.0	
Total	81.0	17.4	93.0	20.0
B. Transpetration Time				
1. Loading	236.5		208.0	
2. Dumping	21.0		21.0	
Total	257.5	55.4	229.0	49.2
Total Productive Time	338.5	72.8	322.0	69.2
II. NONPRODUCTIVE TIME				
A. Delays				
1. Truck Delays				
a. Breakdown				
b. Normal	4.5		10.0	
2. Loader Delays				
a. Breakdown	39.0		24.5	
b. Avoidable				
c. Other Load	28.0		10.0	
Total	71.5	15.4	44.5	9.6
3. Other Delays				
a. At Grizzly	9.5		50.5	
b. Nonoperating	45.5		48.0	
Total	55.0	11.8	98.5	21.2
Total Nonproductive Time	126.5	27.2	143.0	30.8
TOTAL TIME OBSERVED	465.0	100.0	465.0	100.0
Number Loads Transported	18		18	
Mileage Recorded	10.8		10.8	

TABLE 32

TIME STUDY OBSERVATION
Truck no. 33 Type - Dart dump
Mine - Blue Goose 1 Date - August 13, 14
Time in Minutes

Time Division	Heading 3	Heading 2	Total	%	Heading 3	%
I. PRODUCTIVE TIME						
A. Travel Time						
1. To Heading	1.5	14.0	15.5		24.5	
2. Maneuvering Allowance (Head)		2.5	2.5		5.5	
3. To Shaft	1.5	18.0	19.5		38.5	
Total	3.0	34.5	37.5	8.0	68.5	14.7
B. Transpetration Time						
1. Loading	4.5	115.0	119.5		54.0	
2. Dumping	1.5	15.5	17.0		24.0	
Total	6.0	130.5	136.5	29.4	78.0	16.8
Total Productive Time			174.0	37.4	146.5	31.5
II. NONPRODUCTIVE TIME						
A. Delays						
1. Truck Delays						
a. Breakdown						
b. Normal			6.0		7.5	
2. Loader Delays						
a. Breakdown	125.5		125.5		224.0	
b. Avoidable		96.0	96.0			
c. Other Load	15.5		15.5		35.5	
Total			243.0	52.3	267.0	57.5
3. Other Delays						
a. At Grizzly			11.0		11.5	
b. Nonoperating			37.0		40.0	
Total			48.0	10.3	51.5	11.0
Total Nonproductive Time			291.0	62.6	318.5	68.5
TOTAL TIME OBSERVED			465.0	100.0	465.0	100.0
Number Loads Transported	1	10	11		13	
Mileage Recorded	0.7	6.0	6.7		7.8	

TABLE 33

TIME STUDY OBSERVATION
Truck no. 34 Type - Dart dump
Mine - Blue Goose 1 Date - August 11, 14
Time in Minutes

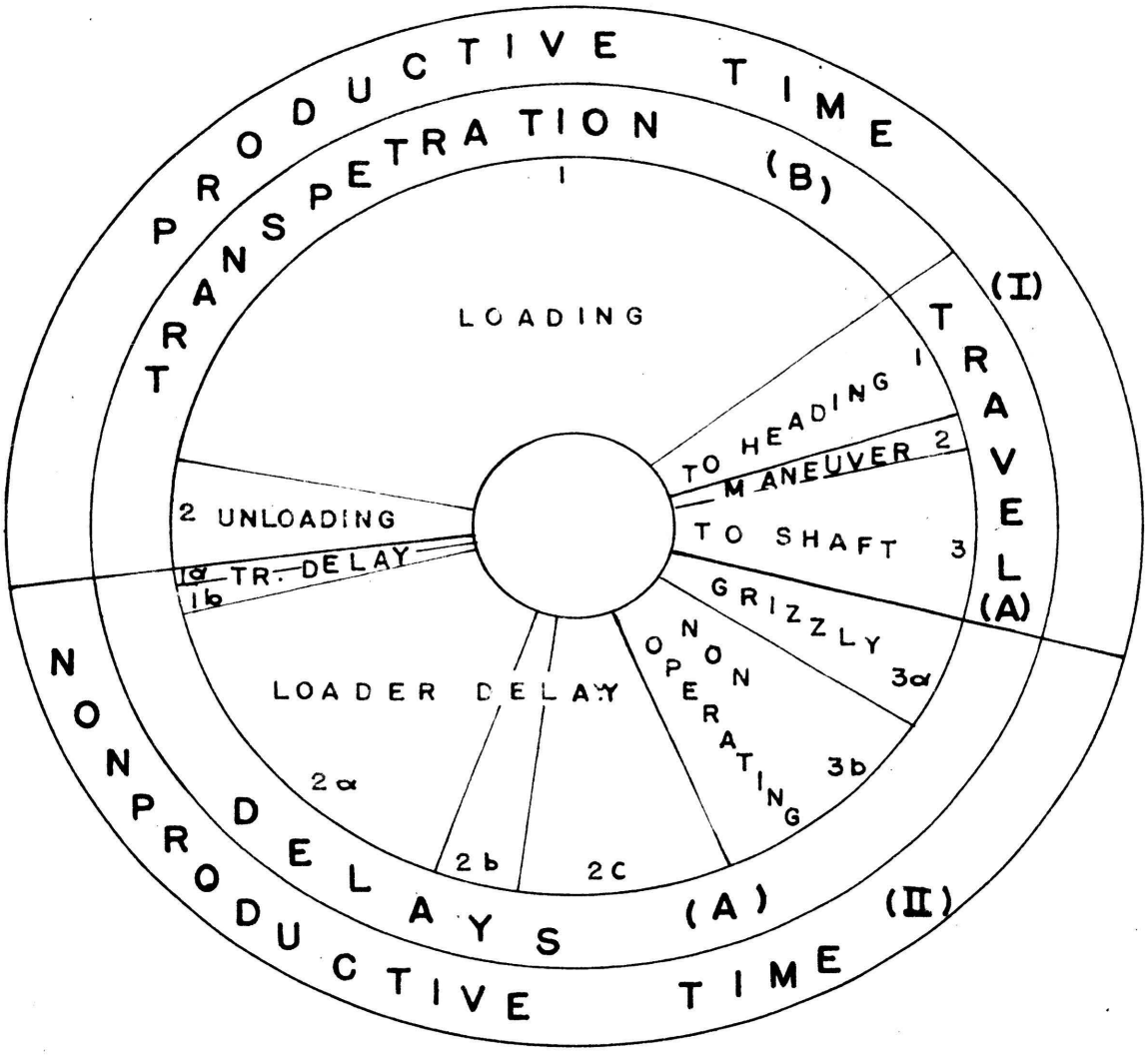
Time Division	Heading 1	Heading 4	Total	%	Heading	%
I. PRODUCTIVE TIME						
A. Travel Time						
1. To Heading	7.5	24.0	31.5		18.0	
2. Maneuvering Allowance (Head)	8.5	5.0	13.5		7.5	
3. To Shaft	7.0	25.5	32.5		14.5	
Total	23.0	54.5	77.5	16.7	40.0	8.6
B. Transpetration Time						
1. Loading	76.5	67.0	143.5		264.0	
2. Dumping	11.5	10.0	21.5		25.5	
Total	88.0	77.0	165.0	35.5	289.5	62.3
Total Production Time			242.5	52.2	329.5	70.9
II. NONPRODUCTION TIME						
A. Delays						
1. Truck Delays						
a. Breakdown			17.0			
b. Normal						
2. Loader Delays						
a. Breakdown			14.0		5.5	
b. Avoidable	14.0		14.0			
c. Other Load	90.0	10.5	100.5		54.0	
Total			145.5	31.3	59.5	12.8
3. Other Delays						
a. At Grizzly			40.0		10.0	
b. Nonoperating			37.0		66.0	
Total			77.0	16.5	76.0	16.3
Total Nonproductive Time			222.5	47.8	135.5	29.1
TOTAL TIME OBSERVED			465.0	100.0	465.0	100.0
Number Loads Transported	10	8	18		25	
Mileage Recorded	2.0	3.0	5.0		4.5	

TABLE 34

TIME STUDY OBSERVATION
General Summary
Mine - Blue Goose 1 Date - August 11 to 15
Time in Minutes

Time Division	Total	%
I. PRODUCTIVE TIME		
A. Travel Time		
1. To Heading	160.0	5.7
2. Maneuvering Allowance (Head)	40.5	1.5
3. To Shaft	197.0	7.1
Total	397.5	14.3
B. Transpetration Time		
1. Loading	1025.5	36.7
2. Dumping	130.0	4.7
Total	1155.5	41.4
Total Productive Time	1553.0	55.7
II. NONPRODUCTIVE TIME		
A. Delays		
1. Truck Delays		
a. Breakdown	17.0	0.6
b. Normal	28.0	1.0
2. Loader Delays		
a. Breakdown	432.5	15.5
b. Avoidable	96.0	3.5
c. Other Load	257.5	9.2
Total	831.0	29.8
3. Other Delays		
a. At Grizzly	132.5	4.7
b. Nonoperating	273.5	9.8
Total	406.0	14.5
Total Nonproductive Time	1237.0	44.3
TOTAL TIME OBSERVED	2790.0	100.0
Number Loads Transported	103	
Mileage Recorded	45.6	

FIGURE 22



TIME DISTRIBUTION CHART

TRUCK HAULAGE

BLUE GOOSE I MINE

TOTAL TIME 2,790 MIN LOADS 103

to the greatest advantage.

At the estimated capacity of 715 cans a day, approximately 62 truck loads a shift would be required. With three trucks in operation, the demand of 20 loads a shift can be met easily by each unit. Retirement of one truck would require a carefully planned distribution of equipment and elimination of all delays and therefore is not suggested at this time.

The dragline operating in heading number 2 should be retired from service. Under normal operating conditions, the shovel can load two trucks in both headings number 2 and 3 without difficulty. A planned cycle, with alternate loading in case of shovel breakdown, can be devised to provide at least 30 loads from the shovel. The other truck, loading from number 1 heading could provide the remaining necessary loads. This plan would require increased operational efficiency from the remaining draglines.

BLUE GOOSE 2 MINE

Location

The Blue Goose 2 Mine is in the S½ of section 30, T. 29 N., R. 23 E., Ottawa County, Oklahoma.

Production

An average production of 550 tons a day is realized at this mine.

Equipment

Haulage is performed by three diesel trucks and one battery truck. The diesel units are: no. 14 Dart truck-trailer (D-100 UG), no. 16 Mack truck-trailer, and no. 21 Ford truck-trailer. Performance data for these units are given in TABLE 35.

TABLE 35

TRUCK PERFORMANCE - BLUE GOOSE 2 MINE
(Courtesy of Eagle Picher Mn & S. Co.)
June 1951

Truck Number	Fuel Consumed (gal.)	Number of Loads	Number of Shifts	Operating Costs
14	100	374	23	$440.
16	117	502	27	456.
21	108	501	26	460.

Loading equipment includes three draglines and one shovel, H D -5 no. 1. Operating data for the shovel are given in TABLE 36.

Hoisting

Hoisting is done by a modern balanced hoisting system. Time study of hoisting shows that one skip is loaded, hoisted, and returned for loading in an average time of three minutes. The average hoisting

TABLE 36

SHOVEL PERFORMANCE - BLUE GOOSE 2 MINE
(Courtesy of Eagle Picher Mn. & S. Co.)
Cumulative data to June 1, 1951

Shovel Number	Total Tons Loaded	Total Shifts	Operating Labor Costs	Total Operating Costs	Unit Operating Cost ($/Ton)
1	171,259	895	$13,760.	$43,994.	$0.257

cycle is one and one-half minutes; therefore 285 skips could be hoisted each shift in the time allotted for hoisting. The represents a hoisting capacity of approximately 740 tons a day.

Loading

Shovel no. 1 is used exclusively for loading in a high ground stope. Time study results are summarized in TABLE 37. An average of 8 dipperfulls were required for one truck load. Total loading time was 5 minutes and is considered a fairly satisfactory result.

TABLE 37

SHOVEL LOADING - BLUE GOOSE 2 MINE
(Time in seconds)

Motion	Average Time Individual	Cumulative
H D - 5 no. 1		
1. Move Back	7.8	7.8
2. Move Forward	3.2	11.0
3. Load Dipper	13.0	24.0
4. Move Back	7.0	31.0
5. Move Forward and Dump	7.0	38.0

Most of the draglines were operating below standard performance. Average loading times were recorded as: no. 2, 7.0 minutes; no. 3, 7.5 minutes; and no. 4, 8.0 minutes. Improved performance should be ex-

pected from these machines with planned effort on the part of the operators.

Haulage System

All mining areas in the mine are located from four to six-tenths mile from the shaft and are reached by roads in good condition.

Number 1 heading (Blue Goose Lease), in a high ground area, is a narrow stope requiring difficult vehicle maneuvers. Loading is done entirely by shovel in this area.

The remaining headings are in sheet ground, most of which have a low back and poorly maintained approach roads. These include no. 2 (Blue Goose Lease), nos. 3 and 4 (Seesaw Lease), in which all loading is accomplished by draglines.

The dumping station is made up of two hoppers set on opposite sides of the shaft. This permits two trucks to dump simultaneously and avoids many delays. The grizzlies are located in the loading pocket under the hopper chutes, rather than over the hopper as in most mines. In this manner, the ore is dumped directly into the hopper and is fed, as required, through the hopper gate. The material falls onto the screen before going into the loading chute. FIGURE 23 A illustrates the grizzly arrangement, and FIGURE 23 B shows the skip in the loading pocket. The arrangement of these screens requires the skip-tenders to clear the grizzlies and break oversized material so that much of the actual loading time is expended in that work. If grizzlies were constructed at the dumping level, more loading time would be available at the pocket and the hopper chutes would not clog up as readily as they do at present. The two hoppers provide sufficient surge capacity under normal haulage conditions.

FIGURE 23 A

BLUE GOOSE 2 HOPPER GRIZZLY

The grizzly is located in the loading pocket, below the hopper gate.

FIGURE 23 B

SKIP HOISTING

A two ton skip is in the loading pocket prior to being hoisting.

Time Study Results

Haulage study results are summarized in TABLES 38 through 45.

TABLE 38

TIME RATIOS OF HAULAGE SYSTEM
Blue Goose 2 Mine

Table Number	Ton-Mileage	Productive / Nonproductive Time Ratio	Travel / Transpetration Time Ratio	Travel Heading / Travel Shaft Loading Time Ratio
	T-Mlg	Pdt/Npdt	Trv/Trpt	TH/TS/Ld
39	4050	1/0.42	1/0.80	1.05/1/1.60
40	2460	1/0.82	1/0.82	1.54/1/0.91
41	1450	1/1.61	1/0.59	0.75/1/1.05
42	3260	1/0.63	1/0.92	1.05/1/1.61
43	2510	1/0.60	1/0.68	1.03/1/1.29
44	3130	1/0.45	1/0.85	0.97/1/1.47
45	99400	1/0.68	1/0.78	0.97/1/1.38
Ideal		1/0.425	1/0.50	1.00/1/1.00

The cumulative totals of the haulage operations are presented in TABLE 45. The results are represented graphically in FIGURE 24.

As in other cases considered, nonproductive time is a very large portion of the total working time. Trv/Trpt ratios indicate that loading times represent longer periods than should be expected. This situation demands corrective measures in operational methods, especially in reference to loading practices. Truck breakdowns consume 13.5 per cent of the total time and should be reduced by more careful inspection and preventive maintenance.

The battery truck averaged five 10 ton loads a shift, and is a negligible contribution to the total output.

TABLE 39

TIME STUDY OBSERVATION
Truck no. 14 Type - Dart trailer
Mine - Blue Goose 2 Date - August 7
Time in Minutes

Time Division	Heading 1	Heading 3	Total	%
I. PRODUCTIVE TIME				
A. Travel Time				
1. To Heading	73.5	6.5	80.0	
2. Maneuvering Allowance (Head)	26.5		26.5	
3. To Shaft	69.0	7.5	76.5	
Total	169.0	14.0	183.0	39.3
B. Transpetration Time				
1. Loading	106.5	15.5	122.0	
2. Dumping	21.5	1.0	22.5	
Total	128.0	16.5	144.5	31.1
Total Productive Time			327.5	70.4
II. NONPRODUCTIVE TIME				
A. Delays				
1. Truck Delays				
a. Breakdown				
b. Normal			8.5	
2. Loader Delays				
a. Breakdown				
b. Avoidable	5.0		5.0	
c. Other Load	15.0		15.0	
Total			28.5	6.2
3. Other Delays				
a. At Grizzly			34.5	
b. Nonoperating			74.5	
Total			109.0	23.4
Total Nonproductive Time			137.5	29.6
TOTAL TIME OBSERVED			465.0	100.0
Number Loads Transported	20	2	22	
Mileage Recorded	16.0	2.4	18.4	

TABLE 40

TIME STUDY OBSERVATION
Truck no. 14 Type - Dart trailer
Mine - Blue Goose 2 Date - August 8
Time in Minutes

Time Division	Heading 1	Heading 4	Heading 2	Total	%
I. PRODUCTIVE TIME					
A. Travel Time					
1. To Heading	34.0	19.0	4.5	57.5	
2. Maneuvering Allowance (Head)	14.0		2.5	16.5	
3. To Shaft	33.5	24.5	5.0	63.0	
Total	81.5	43.5	12.0	137.0	29.5
B. Transpetration Time					
1. Loading	47.5	43.5	6.0	97.0	
2. Dumping	10.5	4.5	1.0	16.0	
Total	58.0	48.0	7.0	113.0	24.3
Total Productive Time				250.0	53.8
II. NONPRODUCTIVE TIME					
A. Delays					
1. Truck Delays					
a. Breakdown				128.5	
b. Normal				5.0	
2. Loader Delays					
a. Breakdown					
b. Avoidable	10.0			10.0	
c. Other Load	15.5			15.5	
Total				159.0	34.2
3. Other Delays					
a. At Grizzly				15.0	
b. Nonoperating				41.0	
Total				56.0	12.0
Total Nonproductive Time				215.0	46.2
TOTAL TIME OBSERVED				465.0	100.0
Number Loads Transported	10	5	1	16	
Mileage Recorded	8.0	6.0	1.4	15.4	

TABLE 41

TIME STUDY OBSERVATION
Truck no. 16 Type - Mack trailer
Mine - Blue Goose 2 Date - August 9
Time in Minutes

Time Division	Heading 4	%
I. PRODUCTIVE TIME		
A. Travel Time		
1. To Heading	40.5	
2. Maneuvering Allowance (Head)	17.5	
3. To Shaft	54.0	
Total	112.0	24.1
B. Transpetration Time		
1. Loading	56.5	
2. Dumping	9.5	
Total	66.0	14.2
Total Productive Time	178.0	38.3
II. NONPRODUCTIVE TIME		
A. Delays		
1. Truck Delays		
a. Breakdown	169.5	
b. Normal	5.5	
2. Loader Delays		
a. Breakdown		
b. Avoidable		
c. Other Load	13.0	
Total	188.0	40.4
3. Other Delays		
a. At Grizzly	38.0	
b. Nonoperating	61.0	
Total	99.0	21.3
Total Nonproductive Time	287.0	61.7
TOTAL TIME OBSERVED	465.0	100.0
Number Loads Transported	11	
Mileage Recorded	13.2	

TABLE 42

TIME STUDY OBSERVATION
Truck no. 16 Type - Mack trailer
Mine - Blue Goose 2 Date - August 8
Time in Minutes

Time Division	Heading 4	Heading 1	Heading 3	Total	%
I. PRODUCTIVE TIME					
A. Travel Time					
1. To Heading	24.5	27.0	25.5	77.0	
2. Maneuvering Allowance (Head)	1.0			1.0	
3. To Shaft	24.5	24.5	24.0	73.0	
Total	50.0	51.5	49.5	151.0	32.5
B. Transpetration Time					
1. Loading	43.0	28.5	46.0	117.5	
2. Dumping	5.0	6.0	6.0	17.0	
Total	48.0	34.5	52.0	134.5	28.9
Total Production Time				285.5	61.4
II. NONPRODUCTIVE TIME					
A. Delays					
1. Truck Delays					
a. Breakdown					
b. Normal				14.5	
2. Loader Delays					
a. Breakdown	11.0		6.5	17.5	
b. Avoidable	2.0		4.0	6.0	
c. Other Load	29.5			29.5	
Total				67.5	14.5
3. Other Delays					
a. At Grizzly					
b. Nonoperating				112.0	
Total				112.0	24.1
Total Nonproductive Time				179.5	38.6
TOTAL TIME OBSERVED				465.0	100.0
Number Loads Transported	5	6	6	17	
Mileage Recorded	6.0	4.8	8.4	19.2	

TABLE 43

TIME STUDY OBSERVATION
Truck no. 21 Type - Ford trailer
Mine - Blue Goose 2 Date - August 9
Time in Minutes

Time Division	Heading 4	Heading 1	Total	%
I. PRODUCTIVE TIME				
A. Travel Time				
1. To Heading	17.5	65.0	82.5	
2. Maneuvering Allowance (Head)	4.0	6.5	10.5	
3. To Shaft	16.5	63.5	80.0	
Total	38.0	135.0	173.0	37.2
B. Transpetration Time				
1. Loading	21.5	81.5	103.0	
2. Dumping	3.0	12.0	15.0	
Total	24.5	93.5	118.0	25.4
Total Productive Time			291.0	62.6
II. NONPRODUCTIVE TIME				
A. Delays				
1. Truck Delays				
a. Breakdown			9.0	
b. Normal			11.5	
2. Loader Delays				
a. Breakdown	5.5		5.5	
b. Avoidable	5.0	6.0	11.0	
c. Other Load	15.0	16.0	31.0	
Total			68.0	14.6
3. Other Delays				
a. At Grizzly				
b. Nonoperating			106.0	
Total			106.0	22.8
Total Nonproductive Time			174.0	37.4
TOTAL TIME OBSERVED			465.0	100.0
Number of Loads Transported	3	14	17	
Mileage Recorded	3.6	11.2	14.8	

TABLE 44

TIME STUDY OBSERVATION
Truck no. 21 Type - Ford trailer
Mine - Blue Goose 2 Date - August 10
Time in Minutes

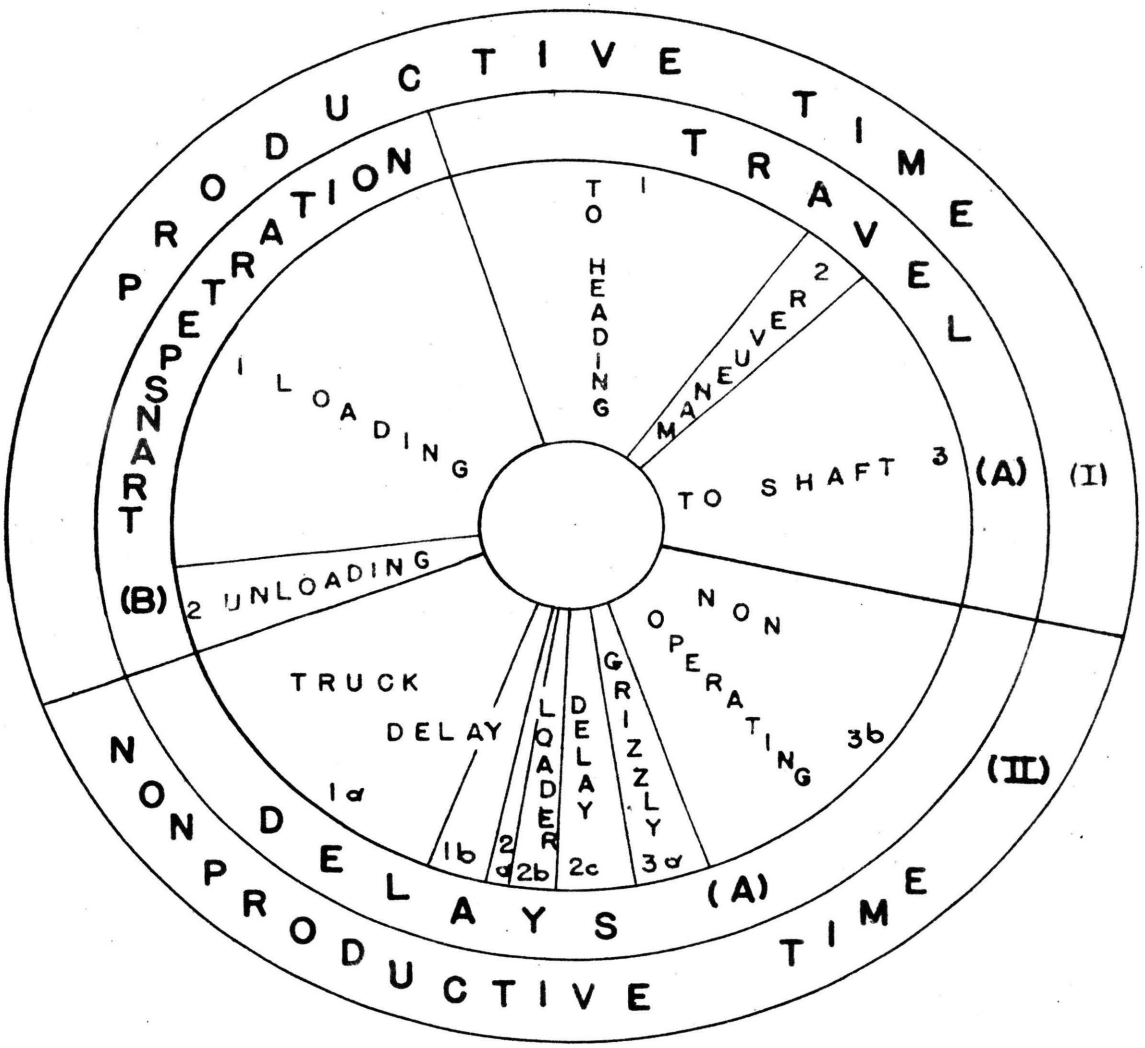
Time Division	Heading 3	Heading 2	Total	%
I. PRODUCTIVE TIME				
A. Travel Time				
1. To Heading	30.0	52.5	82.5	
2. Maneuvering Allowance (Head)		6.0	6.0	
3. To Shaft	29.5	55.5	85.0	
Total	59.5	114.0	173.5	37.3
B. Transpetration Time				
1. Loading	30.0	95.0	125.0	
2. Dumping	6.5	16.5	23.0	
Total	36.5	111.5	148.0	31.8
Total Productive Time			321.5	69.1
II. NONPRODUCTIVE TIME				
A. Delays				
1. Truck Delays				
a. Breakdown			70.0	
b. Normal			16.0	
2. Loader Delays				
a. Breakdown				
b. Avoidable		12.0	12.0	
c. Other Load				
Total			98.0	21.1
3. Other Delays				
a. At Grizzly				
b. Nonoperating			45.5	
Total			45.5	9.8
Total Nonproductive Time			143.5	30.9
TOTAL TIME OBSERVED			465.0	100.0
Number Loads Transported	5	13	18	
Mileage Recorded	7.0	10.4	17.4	

TABLE 45

TIME STUDY OBSERVATION
General Summary
Mine - Blue Goose 2 Date - August 7 to 10
Time in Minutes

Time Division	Total	%
I. PRODUCTIVE TIME		
A. Travel Time		
1. To Heading	420.0	15.0
2. Maneuvering Allowance (Head)	78.0	2.8
3. To Shaft	431.5	15.5
Total	929.5	33.3
B. Transpetration Time		
1. Loading	621.0	22.3
2. Dumping	103.0	3.7
Total	724.0	26.0
Total Productive Time	1653.5	59.3
II. NONPRODUCTIVE TIME		
A. Delays		
1. Truck Delays		
a. Breakdown	377.0	13.5
b. Normal	61.0	2.2
2. Loader Delays		
a. Breakdown	23.0	0.8
b. Avoidable	44.0	1.6
c. Other Load	104.0	3.7
Total	609.0	21.8
3. Other Delays		
a. At Grizzly	87.5	3.1
b. Nonoperating	440.0	15.7
Total	527.5	18.8
Total Nonproductive Time	1136.5	40.7
TOTAL TIME OBSERVED	2790.0	100.0
Number Loads Transported	101	
Mileage Recorded	98.4	

FIGURE 24



TIME DISTRIBUTION CHART

TRUCK HAULAGE

BLUE GOOSE 2 MINE

TOTAL TIME 2,790 MIN LOADS 101

Compendium

At the estimated maximum production of 720 tons a day 82 loads would be required, whereas at present average rate, 62 loads are produced. In either case, haulage demands could be met by the three diesel units now in operation. One truck usually is loaded from the shovel while the other two alternate between the three draglines as production demands. The individual requirement would be approximately 7,300 ton-miles (27 loads x 10 tons/load x 27 miles) which would have to be accomplished with greater operational efficiency than presently is realized. The battery truck could be retired from active service.

Because most of the nonproductive time represents improvable conditions, the supervisors can insure better equipment performance by closer observation of loading methods and unit distribution.

GOODWIN MINE

Location

Mining operation of the Goodwin Mine are in progress in the NE¼ and NW¼SW¼ of section 17, T. 29 N., R. 23 E., Ottawa County, Oklahoma.

Production

Average daily production is 400 tons, and is maintained by hoisting 510 cans a shift.

Equipment

Haulage units are: nos. 43 and 47 Dart dump-trucks (D-100 UG); nos. 46 and 56 Dart truck-trailers (D-100 UG); and no. 52 Autocar truck-trailer (AC-C-50-D-48). All these units are new and were acquired in 1951. Typical truck performances for one month are tabulated below.

TABLE 46

TRUCK PERFORMANCE - GOODWIN MINE
(Courtesy of Eagle Picher Mn. & S. Co.)
June 1951

Truck Number	Fuel Consumed (gal.)	Number of Loads	Number of Shifts	Operating Costs
43	90	155	15	$469.
46	85	301	23	347.
47	90	203	23	327.
52	20	173	17	274.
56	35	38	4	64.

Truck no. 56 is not in continuous use but is kept as a reserve unit.

All loading is performed by shovels: no. 28 Eimco 102; no. 27 A. C. H D - 5; no. 30 International Lodover (T D - 9); no. 33 A. C. H D - 9;

and a Hough Payloader. Cumulative operating characteristics for three of these units are shown in TABLE 47.

TABLE 47

SHOVEL PERFORMANCE - GOODWIN MINE
(Courtesy of Eagle Picher Mn. & S. Co.)
Cumulative data to June 1, 1951

Shovel Number	Total Tons Loaded	Total Shifts	Operating Labor Costs	Total Operating Costs	Unit Operating Cost ($/Ton)
27	8,920	51	$ 962.	$2,272.	$0.255
28	12,380	58	1,145.	1,475.	0.119
30	10,160	46	1,139.	2,033.	0.200

Hoisting

Hoisting is done by the can system. The average hoisting cycle is 34.2 seconds. This insures an average daily hoisting capacity of 735 cans, or 580 tons.

Loading

Time study of shovel loading is presented in TABLE 48.

The H D - 9 shovel, because of the large dipper capacity, is the fastest loader (average loading time of 3 minutes). The Lodover, with an average loading time of 3.8 minutes, is also an efficient unit. Because of traction difficulty, the Payloader was timed as one of the slower loading units and required 5.7 minutes to complete one truck load.

The Eimco and the H D - 5 were not being used for loading purposes while this study was made.

Although some of the loaders in the Goodwin Mine are on experi-

mental use only, the mine has the most equipment in the district.

TABLE 48

SHOVEL LOADING - GOODWIN MINE
(Time in seconds)

Motion	Average Time Individual	Cumulative
Hough Payloader		
1. Move Back	5.8	5.8
2. Move Forward	5.2	11.0
3. Load Dipper	9.0	20.0
4. Move Back	13.0	33.0
5. Move Forward and Dump	16.0	49.0
Average number of dippers for a 10 ton load - 7		
H D - 9 no. 33		
1. Move Back	6.5	6.5
2. Move Forward	8.0	14.5
3. Load Dipper	12.0	26.5
4. Move Back	10.0	36.5
5. Move Forward and Dump	13.5	50.0
Average number of dippers for a 10 ton load - 4		
International Lodover no. 30		
1. Move Forward	11.5	11.5
2. Load Dipper	11.0	22.5
3. Move Back	7.0	29.5
4. Dump	3.5	33.0
Average number of dippers for a 10 ton load - 7		

Haulage System

Three loading areas were being used during the visit to the mine. Heading number 1 (Otis White Lease) is in sheet ground area, eight-tenths mile from the shaft, and is on a higher elevation than the main haulage level. The stope is accessible only to dump trucks. The approach roads are in poor condition and requires very careful driving.

Loading was performed by the H D - 9 shovel, although the Lodover was used temporarily and uneffectively because of the low back.

Heading number 2 (Otis White Lease) is also in sheet ground, seven-tenths mile from the dumping station. The Payloader was used for loading in this area.

The Payloader was used also alternately with the Lodover in number 3 heading (La Salle Lease) located one and one-tenth mile from the shaft. This area is very constricted and much of the travel time of the truck is consumed in the actual approach roads of the stope. The loader operates in such a restricted area as to impair its effectiveness.

The dumping station is a drive-over type with the grizzly set at haulage level. Much of the grizzly delay time could be eliminated by the construction of a dual screen station, as there is sufficient space for two trucks to maneuver freely. FIGURE 25 shows a truck-trailer in the process of dumping at the station.

The roads in the mine are well maintained except in the immediate areas of loading.

Time Study Results

The truck-shift operations are presented in TABLES 50 through 54. The cumulative time totals are in TABLE 55 and are represented graphically in FIGURE 26.

The time study results show that the operations of the haulage system are below standard. Almost every type of delay exists and can be attributed to various causes. One excessive delay that is particularly noticeable is grizzly delay time. With a single dump ramp, some delay may be expected but it is evident that in this case the delays

FIGURE 25

TRUCK-TRAILER DUMPING AT SHAFT STATION

A diesel truck is in the process of dumping a 10 ton load over the dumping ramp grizzly.

are too large. There are actually too many trucks operating for the production obtained.

In most cases, the Trv/Trpt and TH/TS/Ld ratios are close to desired values (1/0.5 and 1.00/1/1.00 respectively) and indicate that the actual runs are normal and the loading times within desired limits.

Another evidence of excessive number of haulage units is the persistence of avoidable delays which are caused by one truck waiting for others to be loaded.

TABLE 49

TIME RATIOS OF HAULAGE SYSTEM
Goodwin Mine

Table Number	Ton-Mileage	Productive / Nonproductive Time Ratio	Travel / Transpetration Time Ratio	Travel Heading / Travel Shaft / Loading Time Ratio
	T-Mlg	Pdt/Npdt	Trv/Trpt	TH/TS/Ld
50	5410	1/0.52	1/0.41	0.90/1/0.53
	3940	1/1.08	1/0.63	0.91/1/0.92
51	4540	1/0.99	1/0.60	0.92/1/0.79
52	4330	1/0.67	1/0.47	0.96/1/0.79
53	2230	1/1.00	1/0.36	0.84/1/0.63
	2240	1/0.83	1/0.51	1.04/1/1.01
54	1930	1/0.89	1/0.67	0.92/1/1.29
	2300	1/0.65	1/0.56	0.84/1/1.07
55	201000	1/0.80	1/0.52	0.93/1/0.86
Ideal		1/0.425	1/0.50	1.00/1/1.00

TABLE 50

TIME STUDY OBSERVATION
Truck no. 43 Type - Dart dump
Mine - Goodwin Date - July 13, 14
Time in Minutes

Time Division	Heading 1	%	Heading 1	%
I. PRODUCTIVE TIME				
A. Travel Time				
1. To Heading	97.5		60.0	
2. Maneuvering Allowance (Head)	11.5		10.5	
3. To Shaft	108.0		66.0	
Total	217.0	46.6	136.5	29.4
B. Transpetration Time				
1. Loading	57.5		61.0	
2. Dumping	31.5		25.5	
Total	89.0	19.2	86.5	18.6
Total Productive Time	306.0	65.8	223.0	48.0
II. NONPRODUCTIVE TIME				
A. Delays				
1. Truck Delays				
a. Breakdown				
b. Normal			10.0	
2. Loader Delays				
a. Breakdown				
b. Avoidable	6.0		5.0	
c. Other Load	3.5		12.0	
Total	9.5	2.0	27.0	5.8
3. Other Delays				
a. At Grizzly	90.5		179.0	
b. Nonoperating	59.0		36.0	
Total	149.5	32.2	215.0	46.2
Total Nonproductive Time	159.0	34.2	242.0	52.0
TOTAL TIME OBSERVED	465.0	100.0	465.0	100.0
Number Loads Transported	19		14	
Mileage Recorded	28.5		21.0	

TABLE 51

TIME STUDY OBSERVATION
Truck no. 46 Type - Dart trailer
Mine - Goodwin Date - July 18
Time in Minutes

Time Division	Heading 1	Heading 2	Total	%
I. PRODUCTIVE TIME				
A. Travel Time				
1. To Heading	6.5	59.5	66.0	
2. Maneuvering Allowance (Head)	3.0	5.0	8.0	
3. To Shaft	11.5	60.5	72.0	
Total	21.0	125.0	146.0	31.4
B. Transpetration Time				
1. Loading	19.0	38.0	57.0	
2. Dumping	9.0	21.5	30.5	
Total	28.0	59.5	87.5	18.8
Total Productive Time			233.5	50.2
II. NONPRODUCTIVE TIME				
A. Delays				
1. Truck Delays				
a. Breakdown			6.5	
b. Normal			10.0	
2. Loader Delays				
a. Breakdown		6.5	6.5	
b. Avoidable	25.5	37.0	62.5	
c. Other Load		45.0	45.0	
Total			130.5	28.1
3. Other Delays				
a. At Grizzly			51.5	
b. Nonoperating			49.5	
Total			101.0	21.7
Total Nonproductive Time			231.5	49.8
TOTAL TIME OBSERVED			465.0	100.0
Number Loads Transported	5	12	17	
Mileage Recorded	7.5	19.2	26.7	

TABLE 52

TIME STUDY OBSERVATION
Truck no. 46 Type - Dart trailer
Mine - Goodwin Date - July 17
Time in Minutes

Time Division	Heading 1	%
I. PRODUCTIVE TIME		
A. Travel Time		
1. To Heading	95.0	
2. Maneuvering Allowance (Head)	6.5	
3. To Shaft	88.5	
Total	190.0	40.9
B. Transpetration Time		
1. Loading	70.0	
2. Dumping	19.0	
Total	89.0	19.1
Total Productive Time	279.0	60.0
II. NONPRODUCTIVE TIME		
A. Delays		
1. Truck Delays		
a. Breakdown	8.5	
b. Normal	7.0	
2. Loader Delays		
a. Breakdown	33.0	
b. Avoidable	17.0	
c. Other Load	21.5	
Total	87.0	18.7
3. Other Delays		
a. At Grizzly	51.5	
b. Nonoperating	47.5	
Total	99.0	21.3
Total Nonproductive Time	186.0	40.0
TOTAL TIME OBSERVED	465.0	100.0
Number Loads Transported	17	
Mileage Recorded	25.5	

TABLE 53

TIME STUDY OBSERVATION
Truck no. 47 Type - Dart dump
Mine - Goodwin Date - July 16, 17
Time in Minutes

Time Division	Heading 3	%	3	2	Total	%
I. PRODUCTION TIME						
A. Travel Time						
1. To Heading	67.5		35.5	42.0	77.5	
2. Maneuvering Allowance (Head)	23.0		4.5	12.0	16.5	
3. To Shaft	80.5		33.0	41.5	74.5	
Total	171.0	36.8	73.0	95.5	168.5	36.2
B. Transpetration Time						
1. Loading	50.5		13.0	62.0	75.0	
2. Dumping	11.0		3.5	8.0	11.5	
Total	61.5	13.2	16.5	70.0	86.5	18.6
Total Productive Time	232.5	50.0			255.0	54.8
II. NONPRODUCTIVE TIME						
A. Delays						
1. Truck Delays						
a. Breakdown	4.0				19.5	
b. Normal					7.5	
2. Loader Delays						
a. Breakdown			20.0		20.0	
b. Avoidable	9.5			39.0	39.0	
c. Other Load	54.0		10.0	25.5	35.5	
Total	67.5	14.5			121.5	26.2
3. Other Delays						
a. At Grizzly	114.5				36.5	
b. Nonoperating	50.5				52.0	
Total	165.0	35.5			88.5	19.0
Total Nonproductive Time	232.5	50.0			210.0	45.2
TOTAL TIME OBSERVED	465.0	100.0			465.0	100.0
Number Loads Transported	10		4	7	11	
Mileage Recorded	22.3		9.2	11.2	20.4	

TABLE 54

TIME STUDY OBSERVATION
Truck no. 52 Type - Autocar trailer
Mine - Goodwin Date - July 16, 17
Time in Minutes

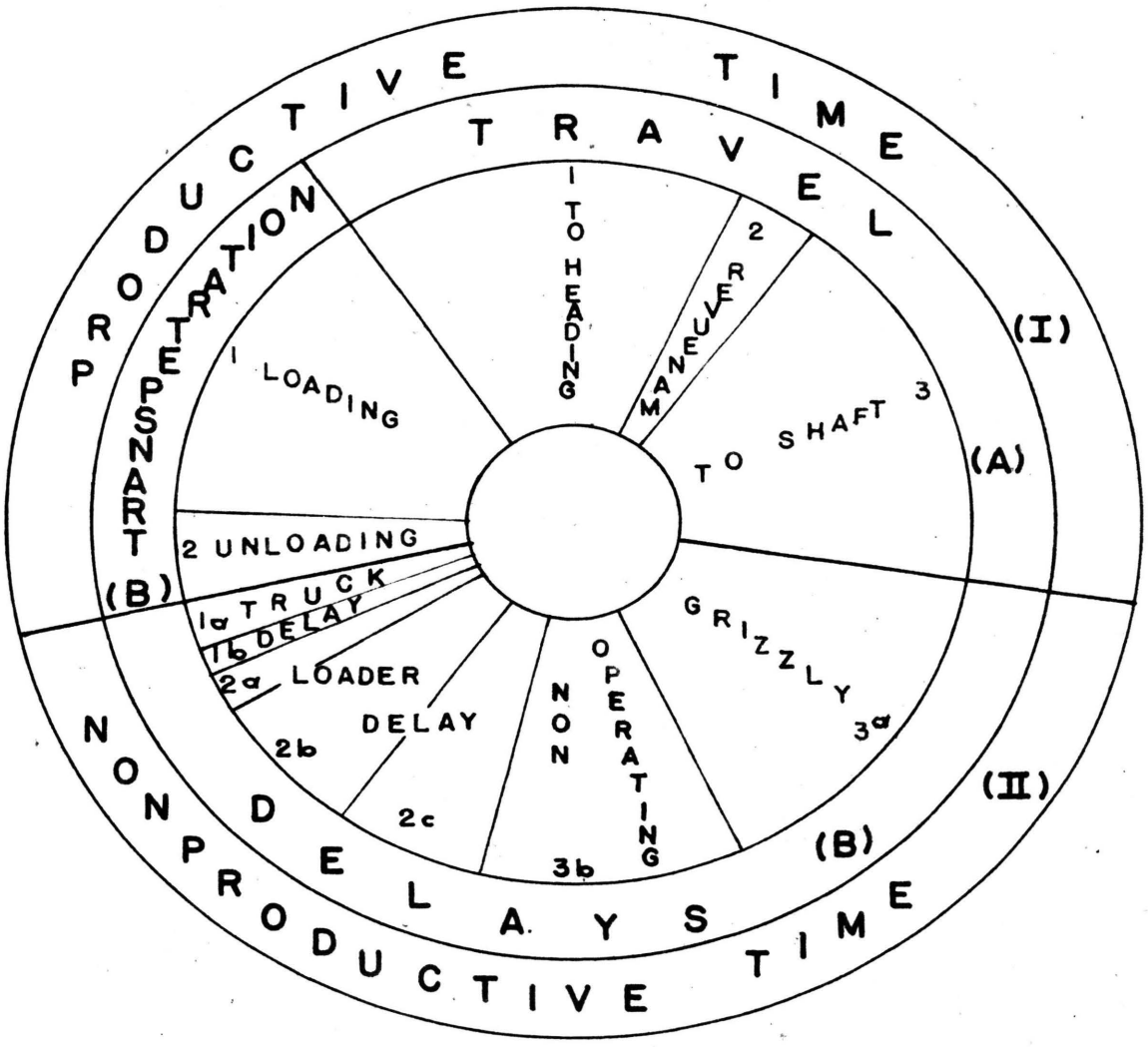
Time Division	Heading 2	%	Heading 2	%
I. PRODUCTIVE TIME				
A. Travel Time				
1. To Heading	64.0		75.5	
2. Maneuvering Allowance (Head)	13.5		24.0	
3. To Shaft	69.5		90.5	
Total	147.0	31.6	190.0	40.8
B. Transpetration Time				
1. Loading	89.5		97.0	
2. Dumping	9.5		9.0	
Total	99.0	21.3	106.0	22.8
Total Productive Time	246.0	52.9	296.0	63.6
II. NONPRODUCTIVE TIME				
A. Delays				
1. Truck Delays				
a. Breakdown	27.5		6.5	
b. Normal	5.5		5.5	
2. Loader Delays				
a. Breakdown				
b. Avoidable	90.0		32.0	
c. Other Load			53.0	
Total	123.0	26.4	97.0	20.8
3. Other Delays				
a. At Grizzly	40.5		24.0	
b. Nonoperating	55.5		48.0	
Total	96.0	20.7	72.0	15.6
Total Nonproductive Time	219.0	47.1	169.0	36.4
TOTAL TIME OBSERVED	465.0	100.0	465.0	100.0
Total Loads Transported	11		12	
Mileage Recorded	17.6		19.2	

TABLE 55

TIME STUDY OBSERVATION
General Summary
Mine - Goodwin Date - July 13 to 18
Time in Minutes

Time Division	Total	%
I. PRODUCTIVE TIME		
A. Travel Time		
1. To Heading	603.0	16.2
2. Maneuvering Allowance (Head)	113.5	3.0
3. To Shaft	649.5	17.5
Total	1366.0	36.7
B. Transpetration Time		
1. Loading	557.5	15.0
2. Dumping	147.5	3.9
Total	705.0	18.9
Total Productive Time	2071.0	55.6
II. NONPRODUCTIVE TIME		
A. Delays		
1. Truck Delays		
a. Breakdown	72.5	2.0
b. Normal	45.5	1.2
2. Loader Delays		
a. Breakdown	59.5	1.6
b. Avoidable	261.0	7.0
c. Other Load	224.5	6.0
Total	663.0	17.8
3. Other Delays		
a. At Grizzly	588.0	15.9
b. Nonoperating	398.0	10.7
Total	986.0	26.6
Total Nonproductive Time	1649.0	44.4
TOTAL TIME OBSERVED	3720.0	100.0
Number Loads Transported	111	
Mileage Recorded	181.2	

FIGURE 26



TIME DISTRIBUTION CHART

TRUCK HAULAGE

GOODWIN MINE

TOTAL TIME 3,720 MIN LOADS 111

Compendium

At the estimated production of 580 tons a day, approximately 65 truck loads a shift would be required. If three trucks were in operation, only 22 loads would have to be handled by each unit. There are enough loaders to permit each truck to be loaded by an individual shovel. This would tend to eliminate all avoidable, other load, and grizzly delays. One truck could be kept as a reserve unit if desired and the fifth truck should be released to another mine.

Three loaders could handle effectively all loading. When necessary two trucks could be loaded by one shovel without imparing production, as loading time cycles consume less time than travel time cycles in all cases studied.

When there is more potential capacity in use in any haulage system than is actually required, the effectiveness of each unit is decreased considerably. This condition exists at the Goodwin Mine and can be corrected by planning a transportation system whose capacity is comparable to actual production.

HUMBAHWATTAH MINE

Location

The Humbahwattah Mine is located in the NE¼ and the E½NW¼ of section 30, T. 29 N., R. 23 E., Ottawa County, Oklahoma.

Production

The average daily production of ore is approximately 400 tons.

Equipment

Three haulage units are in operation: no. 24 Autocar dump-truck; nos. 27 and 37 Dart dump-trucks. Operational data for these units are given in TABLE 56.

TABLE 56

TRUCK PERFORMANCE - HUMBAHWATTAH MINE
(Courtesy of Eagle Picher Mn. & S. Co.)
June 1951

Truck Number	Fuel Consumed (gal.)	Number of Loads	Number of Shifts	Operating Costs
24	160	480	26	$601.
27	170	535	26	416.
37	170	529	26	487.

The trucks have been in operation from one to two years and are in good condition.

Loading equipment includes: three draglines; no. 14 H D - 5 shovel; and no. 23 H T - 4 Traxcavator shovel. Cumulative operating data for the two shovels are given in TABLE 57.

Hoisting

At this property the ore is hoisted in cans, although the shaft

TABLE 57

SHOVEL PERFORMANCE - HUMBAHWATTAH MINE
(Courtesy of Eagle Picher Mn. & S. Co.)
Cumulative data to June 1, 1951

Shovel Number	Total Tons Loaded	Total Shifts	Operating Labor Costs	Total Operating Costs	Unit Operating Cost ($/Ton)
14	69,211	487	$7,121.	$25,657.	$0.371
23	30,709	229	4,196.	10,932.	0.356

station is arranged in a different manner from other mines. The grizzly hopper underground is located some distance from the shaft so that the cans are not loaded and transported on a bumper car. Cans are loaded at the hopper on individual track-cars and pulled in groups of 16 cans by a main and back tail rope system. The hooker moves the train each time a can is hoisted to place the next car under the hoisting center. The train is motivated by compressed air hoists.

The hoisting time cycle in the 307 feet shaft is approximately 40 seconds. During one shift about 640 cans may be hoisted and thus a maximum mine production of 500 tons may be obtained. During the time study period a new hoistman was working at the mine and had not acquired proficiency in operating the hoist. Therefore, the hoisting cycle may be of shorter duration and the actual capacity larger than indicated here.

Loading

Results of time studies of shovel loading are presented in TABLE 58.

The average loading time for the H D - 5 shovel was 4.4 minutes, and for the Traxcavator 5.6 minutes. Although the shovels are used

TABLE 58

SHOVEL LOADING - HUMBAHWATTAH MINE
(Time in seconds)

Motion	Average Time Individual	Cumulative
H D - 5 no. 14		
1. Move Back	4.4	4.4
2. Move Forward	6.6	11.0
3. Load Dipper	13.0	24.0
4. Move Back	8.0	32.0
5. Move Forward and Dump	6.0	38.0
Average number of dippers for a 10 ton load - 7		
Traxcavator no. 23		
1. Move Back	5.5	5.5
2. Move Forward	9.0	14.5
3. Load Dipper	18.0	32.5
4. Move Back	8.5	41.0
5. Move Forward and Dump	7.0	48.0
Average number of dippers for a 10 ton load - 7		

alternately in the same headings, the difference in time cycles can be attributed to the difference in ability and competence of the operators.

FIGURE 27 shows a Traxcavator shovel dumping a dipperfull into a waiting truck.

Dragline loading time varies from 5 to 10 minutes. The operator in heading 4 was slow while the one in heading 1 completed loading in much better manner.

Haulage System

Although there are many producing areas in the mine, only four were being operated during this investigation. Heading 1 (Humbahwattah Lease), located three-tenths of a mile from the dumping station, is in an extensive sheet ground area. Loading is performed by dragline and a high degree of efficiency is maintained.

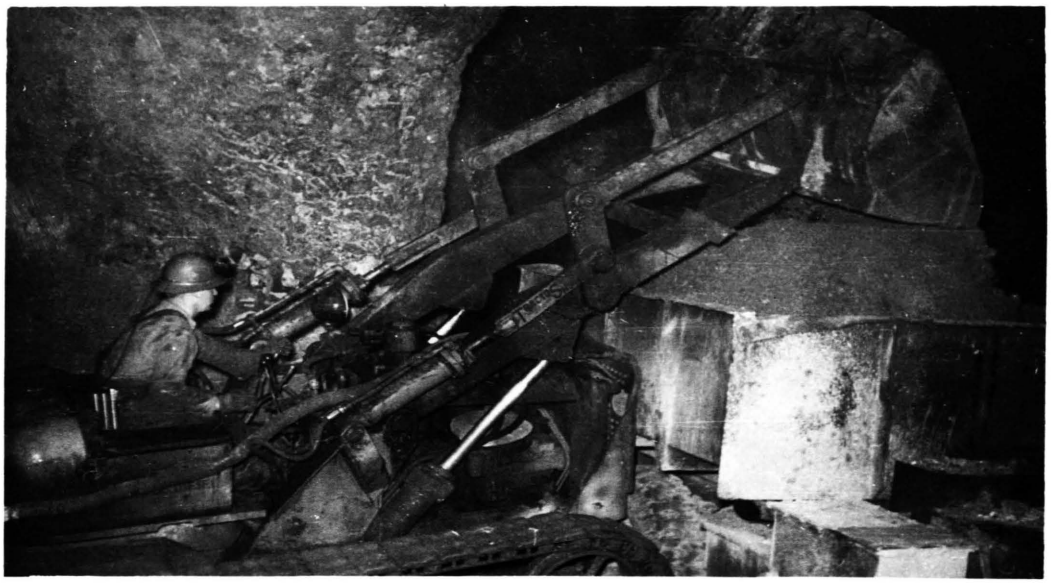


FIGURE 27

SHOVEL LOADING

A Traxcavator shovel is in the process of dumping a dipperfull of ore into a diesel truck.

Heading 2 (Woodchuck Lease) is a high ground stope which is located four-tenths mile from the shaft.

Another high ground stope, heading 3 (Humbahwattah Lease), is located five-tenths mile from the shaft. Mining proceeds in a restricted area and shovel loading is difficult.

In Lucky Bill Lease there are two headings: number 4 in high ground area, where loading is accomplished by dragline; number 4 A in sheet ground area, where shovels perform the loading. The distance from the shaft to these headings is nearly one mile.

The roads in the mine are in fair condition, although in the actual loading areas maneuverability is hampered by the restricted area and uneven floor.

The dumping station is of the back-in type and uses a single screen. The approach is constructed in such a manner as to require the trucks to back in straight, and operator visibility is difficult. In most mines, the truck can move back through an arc, permitting greater range of vision for the driver.

Time Study Results

Tabulated results of truck-shift studies are in TABLES 60 through 65. Total summarized values are presented in TABLE 66 and illustrated in FIGURE 28.

Because of excessive grizzly delays, productive time in the truck-shift studies are unfavorable. Pdt/Npdt ratios (TABLE 59) show clearly that the haulage operations are not proceeding efficiently. Truck and shovel delays are not excessive, except for other load delays.

Due to hoist equipment breakdown and the inexperience of the oper-

ator, the hoisting output was less than the capacity of the haulage system. For this reason the underground hopper was kept full a greater part of the shift. A large proportion of the grizzly delays resulted from this situation.

TABLE 59

TIME RATIOS OF HAULAGE SYSTEM
Humbahwattah Mine

Table Number	Ton-Mileage	Production / Nonproduction Time Ratio	Travel / Transpetration Time Ratio	Travel Heading / Travel Shaft Loading Time Ratio
	T-Mlg	Pdt/Npdt	Trv/Trpt	TH/TS/Ld
60	2450	1/0.79	1/0.70	0.83/1/1.24
61	2130	1/1.77	1/1.30	1.12/1/2.40
62	1870	1/1.40	1/0.68	0.91/1/1.20
63	2130	1/2.00	1/0.87	0.80/1/1.43
64	1150	1/2.14	1/0.83	0.95/1/1.34
65	2510	1/0.83	1/1.35	0.95/1/2.75
66	73600	1/1.18	1/0.91	0.91/1/1.64
Ideal		1/0.425	1/0.50	1.00/1/1.00

Trv/Trpt and TH/TS/Ld ratios indicate that loading cycles need improvement. Slow dragline operations and one slow shovel (no. 23) should receive special attention from supervisors.

Compendium

At estimated maximum production approximately 60 truck loads would be necessary in one shift. This demand could not be met very readily by two trucks while three would provide ample capacity. At the most, 8,000 ton-miles could be recorded by any one truck (20 loads x 10 tons x 40 miles), which is a reasonable value.

As there are two independent shovels, operating more efficiently

TABLE 60

TIME STUDY OBSERVATION
Truck no. 24 Type - Autocar dump
Mine - Humbahwattah Date - August 2
Time in Minutes

Time Division	Heading 4	Heading 3	Heading 1	Total	%
I. PRODUCTIVE TIME					
A. Travel Time					
1. To Heading	11.5	45.5	5.0	62.0	
2. Maneuvering Allowance (Head)	1.5	10.0	1.0	12.5	
3. To Shaft	11.5	59.5	3.0	74.0	
4. Maneuvering Allowance (Shaft)	1.0	3.0	0.5	4.5	
Total	25.5	118.0	9.5	153.0	32.9
B. Transpetration Time					
1. Loading	15.5	71.5	5.0	92.0	
2. Dumping	2.0	11.5	1.0	14.5	
Total	17.5	83.0	6.0	106.5	22.9
Total Productive Time				259.5	55.8
II. NONPRODUCTIVE TIME					
A. Delays					
1. Truck Delays					
a. Breakdown					
b. Normal				5.0	
2. Loader Delays					
a. Breakdown					
b. Avoidable	10.0	11.0		21.0	
c. Other Load	8.0			8.0	
Total				34.0	7.3
3. Other Delays					
a. At Grizzly				123.5	
b. Nonoperating				48.0	
Total				171.5	36.9
Total Nonproductive Time				205.5	44.2
TOTAL TIME OBSERVED				465.0	100.0
Number Loads Transported	2	15	1	18	
Mileage Recorded	3.6	9.0	1.0	13.6	

TABLE 61

TIME STUDY OBSERVATION
Truck no. 24 Type - Autocar dump
Mine - Humbahwattah Date - August 4
Time in Minutes

Time Division	Heading 4	Heading 2	Heading 1	Total	%
I. PRODUCTIVE TIME					
A. Travel Time					
1. To Heading	5.0	3.5	25.0	33.5	
2. Maneuvering Allowance (Head)	0.5			0.5	
3. To Shaft	4.0	3.0	21.0	30.0	
4. Maneuvering Allowance (Shaft)			1.0	1.0	
Total	10.5	6.5	46.0	65.0	13.9
B. Transpetration Time					
1. Loading	7.0	7.0	58.0	72.0	
2. Dumping	1.0	0.5	10.0	11.5	
Total	8.0	7.5	68.0	83.5	18.0
Total Productive Time				148.5	31.9
II. NONPRODUCTIVE TIME					
A. Delays					
1. Truck Delays					
a. Breakdown					
b. Normal				6.0	
2. Loader Delays					
a. Breakdown					
b. Avoidable					
c. Other Load	12.0		36.0	48.0	
Total				54.0	11.6
3. Other Delays					
a. At Grizzly				122.0	
b. Nonoperating				140.5	
Total				262.5	56.5
Total Nonproductive Time				316.5	68.1
TOTAL TIME OBSERVED				465.0	100.0
Number Loads Transported	1	1	11	13	
Mileage Recorded	1.8	0.8	6.6	16.4	

TABLE 62

TIME STUDY OBSERVATION
Truck no. 27 Type - Dart dump
Mine - Humbahwattah Date - August 4
Time in Minutes

Time Division	Heading 4	4-A	2	Total	%
I. PRODUCTIVE TIME					
A. Travel Time					
1. To Heading	14.5	7.5	27.5	49.5	
2. Maneuvering Allowance (Head)	2.0	0.5	4.5	7.0	
3. To Shaft	16.0	7.5	31.0	54.5	
4. Maneuvering Allowance (Shaft)	1.0	0.5	3.0	4.5	
Total	33.5	16.0	66.0	115.5	24.8
B. Transpetration Time					
1. Loading	23.5	8.0	34.0	65.5	
2. Dumping	4.0	2.0	7.0	13.0	
Total	27.5	10.0	41.0	78.5	16.8
Total Productive Time				194.0	41.6
II. NONPRODUCTIVE TIME					
A. Delays					
1. Truck Delays					
a. Breakdown				9.0	
b. Normal				5.5	
2. Loader Delays					
a. Breakdown			7.5	7.5	
b. Avoidable					
c. Other Load	7.0		8.0	15.0	
Total				37.0	8.0
3. Other Delays					
a. At Grizzly				180.0	
b. Nonoperating				54.0	
Total				234.0	50.4
Total Nonproductive Time				271.0	58.4
TOTAL TIME OBSERVED				465.0	100.0
Number of Loads Transported	4	2	6	12	
Mileage Recorded	7.2	3.6	4.8	15.6	

TABLE 63

TIME STUDY OBSERVATION
Truck no. 27 Type - Dart dump
Mine - Humbahwattah Date - August 3
Time in Minutes

Time Division	Heading 2	Heading 4	Total	%
I. PRODUCTIVE TIME				
A. Travel Time				
1. To Heading	22.5	14.5	37.0	
2. Maneuvering Allowance (Head)	4.5	1.5	6.0	
3. To Shaft	31.5	15.0	46.5	
4. Maneuvering Allowance (Shaft)	1.0	0.5	1.5	
Total	69.5	31.5	91.0	19.6
B. Transpetration Time				
1. Loading	45.5	21.0	66.5	
2. Dumping	9.0	4.0	13.0	
Total	54.5	25.0	79.5	17.1
Total Productive Time			170.5	36.7
II. NONPRODUCTIVE TIME				
A. Delays				
1. Truck Delays				
a. Breakdown				
b. Normal			7.0	
2. Loader Delays				
a. Breakdown				
b. Avoidable	4.5		4.5	
c. Other Load	17.0	4.0	21.0	
Total			32.5	7.0
3. Other Delays				
a. At Grizzly			224.0	
b. Nonoperating			38.0	
Total			262.0	56.3
Total Nonproductive Time			294.5	63.3
TOTAL TIME OBSERVED			465.0	100.0
Number Loads Transported	10	4	14	
Mileage Recorded	8.0	7.2	15.2	

TABLE 64

TIME STUDY OBSERVATION
Truck no. 37 Type - Dart dump
Mine - Humbahwattah Date - August 3
Time in Minutes

Time Division	Heading 2	%
I. PRODUCTIVE TIME		
A. Travel Time		
1. To Heading	38.0	
2. Maneuvering Allowance (Head)	2.0	
3. To Shaft	40.0	
4. Maneuvering Allowance (Shaft)	0.5	
Total	80.5	17.4
B. Transpetration Time		
1. Loading	53.5	
2. Dumping	13.5	
Total	67.0	14.4
Total Productive Time	147.5	31.8
II. NONPRODUCTIVE TIME		
A. Delays		
1. Truck Delays		
a. Breakdown	31.0	
b. Normal	15.0	
2. Loader Delays		
a. Breakdown		
b. Avoidable	4.5	
c. Other Load	1.5	
Total	52.0	11.1
3. Other Delays		
a. At Grizzly	218.0	
b. Nonoperating	47.5	
Total	265.5	57.1
Total Nonproductive Time	317.5	68.2
TOTAL TIME OBSERVED	465.0	100.0
Number Loads Transported	12	
Mileage Recorded	9.6	

TABLE 65

TIME STUDY OBSERVATION
Truck no. 37 Type - Dart dump
Mine - Humbahwattah Date - August 2
Time in Minutes

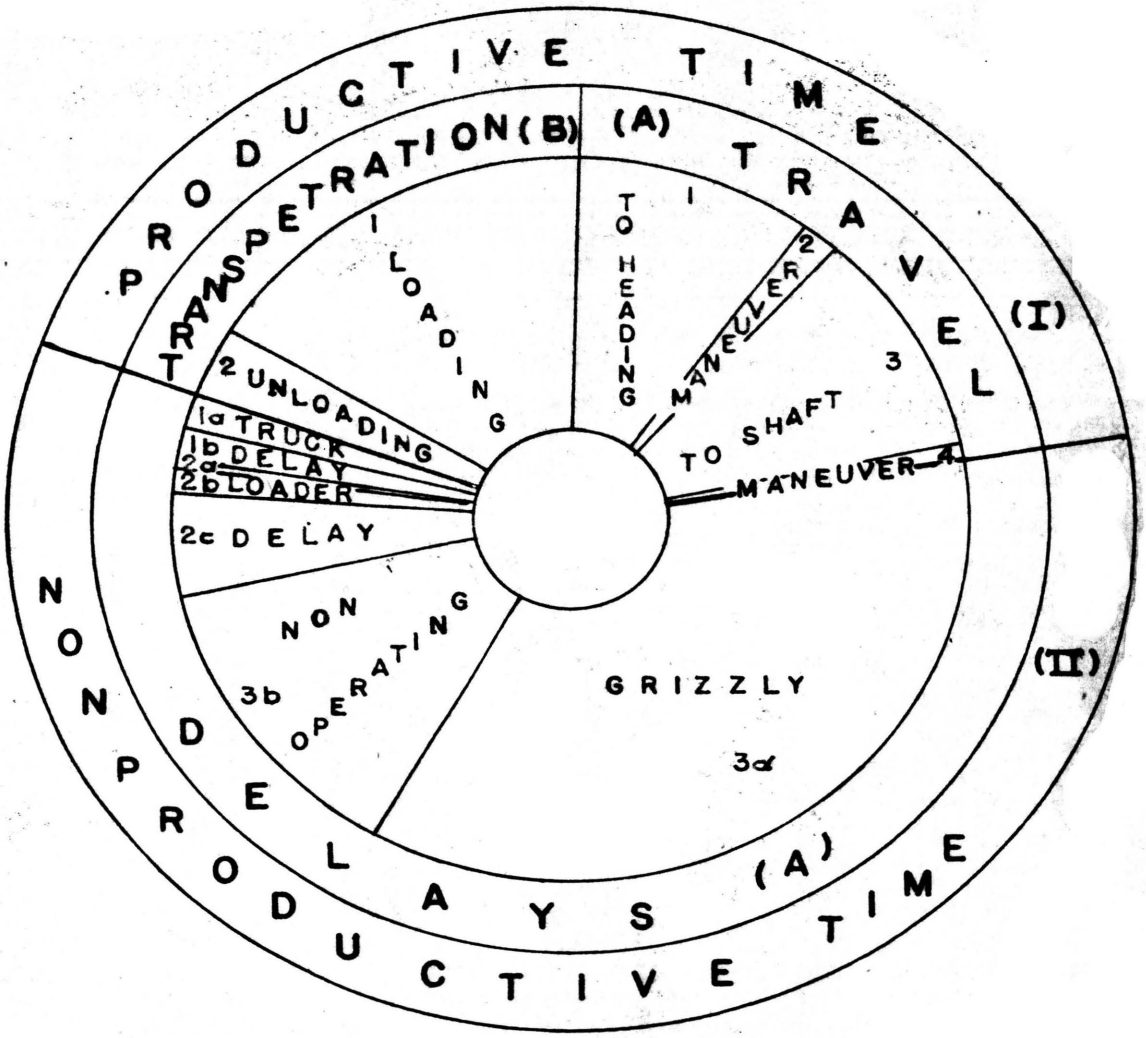
Time Division	Heading 3	Heading 1	Heading 2	Total	%
I. PRODUCTIVE TIME					
A. Travel Time					
1. To Heading	8.5	24.0	12.0	44.5	
2. Maneuvering Allowance (Head)	0.5	6.0	5.0	11.5	
3. To Shaft	8.5	24.5	15.0	47.0	
4. Maneuvering Allowance (Shaft)	1.0	4.0		5.0	
Total	18.5	58.5	32.0	108.0	23.3
B. Transpetration Time					
1. Loading	7.0	89.0	33.0	129.0	
2. Dumping	2.0	11.0	3.0	16.0	
Total	9.0	100.0	36.0	145.0	31.2
Total Productive Time				253.0	54.5
II. NONPRODUCTIVE TIME					
A. Delays					
1. Truck Delays					
a. Breakdown					
b. Normal				5.0	
2. Loader Delays					
a. Breakdown	4.0			4.0	
b. Avoidable					
c. Other Load	10.0	3.0	10.0	23.0	
Total				32.0	6.8
3. Other Delays					
a. At Grizzly				135.0	
b. Nonoperating				45.0	
Total				180.0	38.7
Total Nonproductive Time				212.0	45.5
TOTAL TIME OBSERVED				465.0	100.0
Number Loads Transported	2	12	5	19	
Mileage Recorded	2.0	7.2	4.0	13.2	

TABLE 66

TIME STUDY OBSERVATION
General Summary
Mine - Humbahwattah Date - August 2 to 5
Time in Minutes

Time Division	Total	%
I. PRODUCTIVE TIME		
A. Travel Time		
1. To Heading	264.5	9.5
2. Maneuvering Allowance (Head)	39.5	1.5
3. To Shaft	292.0	10.4
4. Maneuvering Allowance (Shaft)	17.0	0.6
Total	613.0	22.0
B. Transpetration Time		
1. Loading	478.5	17.0
2. Dumping	81.5	3.0
Total	560.0	20.0
Total Productive Time	1173.0	42.0
II. NONPRODUCTIVE TIME		
A. Delays		
1. Truck Delays		
a. Breakdown	40.0	1.4
b. Normal	43.5	1.5
2. Loader Delays		
a. Breakdown	11.5	0.4
b. Avoidable	30.0	1.1
c. Other Load	116.5	4.2
Total	241.5	8.6
3. Other Delays		
a. At Grizzly	1002.5	36.0
b. Nonoperating	373.0	13.4
Total	1375.5	49.4
Total Nonproductive Time	1617.0	58.0
TOTAL TIME OBSERVED	2790.0	100.0
Number Loads Transported	88	
Mileage Recorded	83.6	

FIGURE 28



TIME DISTRIBUTION CHART

TRUCK HAULAGE

HUMBAHWATTAH MINE

TOTAL TIME 2,790 MIN LOADS 65

than draglines, only the loader now operating in heading number 1 should be maintained. Shovel mobility permits any loading area to be used promptly. Cycles in all cases except in number 1 heading indicate that one shovel could effectively load two trucks if this became necessary.

KENOYER MINE

Location

The Kenoyer Mine is in the S½NW¼, N½SW¼, and SW¼SW¼ of section 20, T. 29 N., R. 23 E., Ottawa County, Oklahoma.

Production

The average daily production of ore is approximately 630 tons. This represents a hoisting rate of 820 cans through two shafts.

Equipment

Five trucks are used in underground haulage: nos. 9, 10, 11, 20, and 42 Dart dump-trucks. Most trucks are three years old and in fair condition, although no. 42 has been in operation one year and is in excellent condition. Typical truck performance for one month is given in TABLE 67.

TABLE 67

TRUCK PERFORMANCE - KENOYER MINE
(Courtesy of Eagle Picher Mn. & S. Co.)
June 1951

Truck Number	Fuel Consumed (gal.)	Number of Loads	Number of Shifts	Operating Costs
9	185	522	26	$681.
10	175	464	26	487.
11	70	369	20	744.
20	110	370	26	414.
42	70	587	26	445.

Trucks are loaded by: upper ground chute; two draglines; nos. 4 and 11 A. C. H D - 5 shovels; no. 20 Eimco 104 shovel. Cumulative cost records of shovel operations are given in TABLE 68.

TABLE 68

SHOVEL PERFORMANCE - KENOYER MINE
(Courtesy of Eagle Picher Mn. & S. Co.)
(Cumulative data to June 1, 1951)

Shovel Number	Total Tons Loaded	Total Shifts	Operating Labor Costs	Total Operating Costs	Unit Operating Cost ($/Ton)
4	95,338	427	$8,171.	$27,817.	$0.292
11	116,356	461	7,634.	26,491.	0.228
20	117,200	324	6,618.	14,426.	0.123

Hoisting

The ore is hoisted through two shafts of equal capacity. Time studies conducted at each shaft indicate that the hoisting cycles are approximately 36 seconds. Supplies are lowered through a third shaft so that hoisting is not interrupted during the working period. The combined hoisting capacity is 1450 cans a shift or 1,100 tons. This is based on 425 minutes operating time. As more time is actually available, because no time is consumed in hoisting supplies, the capacity may be greater than estimated.

Loading

Time studies of shovel operations are summarized in TABLE 69. These figures represent average values of loading operations in several areas. Shovel no. 4 was retired for repairs during the period of the investigation.

Average loading times were 3.1 minutes for the Eimco and 4.8 minutes for the H D - 5. These periods are considered efficient for each type of loader, although the H D - 5 can be operated faster.

TABLE 69

SHOVEL LOADING - KENOYER MINE
(Time in seconds)

Motion	Average Time Individual	Cumulative
H D - 5 no. 11		
1. Move Back	7.5	7.5
2. Move Forward	5.5	13.0
3. Load Dipper	11.0	24.0
4. Move Back	8.0	32.0
5. Move Forward and Dump	9.0	41.0
Average number of dippers for a 10 ton load - 7		
Eimco no. 20		
1. Move Forward	7.0	7.0
2. Load Dipper	8.0	15.0
3. Move Back	6.0	21.0
4. Dump	2.0	23.0
Average number of dippers for a 10 ton load - 8		

Dragline loading in heading 5 averaged 7.5 minutes and in heading 1, 8.8 minutes. Results in this range indicate lack of proficiency of the operators.

Haulage System

Ore hoisted through each shaft comes from certain areas, although trucks may be re-routed occasionally to the more distant shaft.

Ore hoisted through number 1 shaft is transported from two areas. Heading number 4, only two-tenths mile from the shaft, is in sheet ground area. Loading is performed by shovel in several small room headings. As these headings are very small, the H D - 5 shovel is most effective in this area.

Heading number 2 is a single high ground stope, eight-tenths mile from shaft 1. The Eimco operates effectively in this area and is gener-

ally used as the loading unit.

Number 5 heading is a small producing room in sheet ground area located between the two shafts. It is used primarily as an alternate loading area when a shovel breaks down or difficulties are encountered in other zones.

Ore to be raised through the second shaft is obtained from two principal areas. High ground heading number 3, the largest producer, is located three-tenths mile from the dumping point. The stope area is large and any of the shovels can load effectively.

Heading number 1 is a high ground stope also and is located one mile from shaft number 2. The floor, which is very rough and poorly maintained, increases the difficulty of truck maneuverability. Loading is done with dragline in an average time of 8.9 minutes. This is very slow loading time. The dragline operator in this area is particularly inept and uncooperative.

One chute, refered to as heading number 6, loads ore from an upper ground raise. The type of chute designed for truck loading is illustrated in FIGURE 2 9. It generally takes 2 minutes or less to load a 10 ton truck with a chute. This loading point is not used on a regular basis.

Most of the roads are in good condition. Stope approaches and roads in the headings are in poor shape in many areas. This situation is common to many mines and deserves more attention. Time spent in clean-up operations would be well rewarded by improved loading performance and truck travel time.

The dumping stations are of the back-in type. FIGURE 30 shows a diesel truck unloading over the dumping ramp grizzly.

FIGURE 29

UNDERGROUND LOADING CHUTE

Ore from upper levels is gravity fed to the chute to be loaded on trucks.

FIGURE 30

TRUCK UNLOADING AT DUMPING STATION

A 10 ton dump-truck is unloading ore over a hopper grizzly.

Time Study Results

The time study results are presented in TABLES 70 through 79. TABLE 79 represents cumulative totals of all truck-shifts. The time distribution is represented graphically in FIGURE 31.

TABLE 70

TIME RATIOS OF HAULAGE SYSTEM
Kenoyer Mine

Table Number	Ton-Mileage	Productive / Nonproductive Time Ratio	Travel / Transpetration Time Ratio	Travel Heading / Travel Shaft / Loading Time Ratio
	T-Mlg	Pdt/Npdt	Trv/Trpt	TH/TS/Ld
71	3610	1/0.54	1/1.35	1.15/1/2.72
72	3650	1/0.90	1/0.96	1.01/1/1.46
73	1500	1/1.11	1/1.16	1.65/1/1.98
74	3180	1/0.91	1/1.23	1.03/1/2.31
75	1000	1/1.12	1/0.85	1.02/1/1.30
	780	1/0.76	1/0.85	0.98/1/1.34
76	2000	1/0.63	1/0.61	1.01/1/1.06
	2750	1/0.62	1/1.27	0.90/1/2.44
77	7000	1/0.56	1/0.85	1.01/1/1.28
78	4020	1/0.97	1/1.35	0.83/1/2.24
79	276000	1/0.76	1/1.00	1.03/1/1.70
Ideal		1/0.425	1/0.50	1.00/1/1.00

Trucks no. 11 and 40 dump at number 1 shaft. Nonproductive time for these units represents a very large proportion of total operating time. This shows up more clearly in the time ratios of TABLE 70. Grizzly and other load delays contribute greatly to the general ineffectiveness of the haulage system. Planned distribution of equipment can do much to reduce these delays.

Trucks no. 9, 10, and 20 unload at no. 2 shaft. It may be noticed that delays attributed to loaders represents a large proportion of the total time. Because loaders are considered subservient to the haulage

units, the proper distribution of shovels is important.

Compendium

The Kenoyer Mine has a high hoisting capacity, widely dispersed mining zones, and a large number of haulage units. These combined factors render effective equipment distribution a vital necessity. As many variations of equipment and zone combination are possible, it is necessary to maintain close supervision and a careful check on production and equipment performance.

The equipment presently available does not have haulage capacity equal to possible mine capacity. If the units are used to a desired production of 8,000 ton-miles a shift, the present production can be increased greatly. At present only 56.7 per cent of the available time (TABLE 79) is used in actual productive effort. FIGURE 31 shows that, to a large extent, time is consumed in various undesirable activities.

Trucks should be permitted to unload at either shaft as conditions warrant. When more than one truck is to be loaded from a particular zone, the fastest loader should be used. The dumping station should be determined by the relation of total travel time cycle and the transpetration time cycle so that delays at the shovel and grizzly are not introduced.

A production of 900 to 1,000 tons could be obtained with an average of 6,000 ton-miles a shift for each truck. As discussed earlier, this would be a reasonable accomplishment.

TABLE 71

TIME STUDY OBSERVATION
Truck no. 9 Type - Dart dump
Mine - Kenoyer Date - July 6
Time in Minutes

Time Division	Heading 1	2	3	Total	%
I. PRODUCTIVE TIME					
A. Travel Time					
1. To Heading	13.0	17.0	25.0	55.0	
2. Maneuvering Allowance (Head)	2.0	4.5	5.0	11.5	
3. To Shaft	12.5	12.0	23.5	48.0	
4. Maneuvering Allowance (Shaft)	1.5	4.0	8.5	14.0	
Total	19.0	37.5	62.0	128.5	27.6
B. Transpetration Time					
1. Loading	36.5	38.0	56.0	130.5	
2. Dumping	3.5	9.0	30.5	43.0	
Total	40.0	47.0	86.5	173.5	37.5
Total Productive Time				302.0	65.1
II. NONPRODUCTIVE TIME					
A. Delays					
1. Truck Delays					
a. Breakdown				14.0	
b. Normal				5.0	
2. Loader Delays					
a. Breakdown					
b. Avoidable	8.0		24.0	32.0	
c. Other Load			12.0	12.0	
Total				63.0	13.5
3. Other Delays					
a. At Grizzly				48.0	
b. Nonoperating				52.0	
Total				100.0	21.4
Total Nonproductive Time				163.0	39.9
TOTAL TIME OBSERVED				465.0	100.0
Number Loads Transported	4	5	12	21	
Mileage Recorded	8.0	2.0	7.2	17.2	

TABLE 72

TIME STUDY OBSERVATION
Truck no. 9 Type - Dart dump
Mine - Kenoyer Date - July 7
Time in Minutes

Time Division	Heading 2	Heading 3	Total	%
I. PRODUCTIVE TIME				
A. Travel Time				
1. To Heading	4.5	46.5	51.0	
2. Maneuvering Allowance (Head)	2.0	14.5	16.5	
3. To Shaft	4.0	46.5	50.5	
4. Maneuvering Allowance (Shaft)	1.0	6.0	7.0	
Total	11.5	113.5	125.0	26.9
B. Transpetration Time				
1. Loading	9.0	65.0	74.0	
2. Dumping	2.0	44.5	46.5	
Total	11.0	109.5	120.5	25.9
Total Productive Time			245.5	52.8
II. NONPRODUCTIVE TIME				
A. Delays				
1. Truck Delays				
a. Breakdown			49.0	
b. Normal			6.5	
2. Loader Delays				
a. Breakdown		21.0	21.0	
b. Avoidable	6.0	25.0	31.0	
c. Other Load	10.0		10.0	
Total			117.5	25.3
3. Other Delays				
a. At Grizzly			30.5	
b. Nonoperating			71.5	
Total			102.0	21.9
Total Nonproductive Time			219.5	47.2
TOTAL TIME OBSERVED			465.0	100.0
Number Loads Transported	2	23	25	
Mileage Recorded	0.8	13.8	14.6	

TABLE 73

TIME STUDY OBSERVATION
Truck no. 10 Type - Dart dump
Mine - Kenoyer Date - July 5
Time in Minutes

Time Division	Heading 2	Heading 5	Total	%
I. PRODUCTIVE TIME				
A. Travel Time				
1. To Heading	48.5	2.5	51.0	
2. Maneuvering Allowance (Head)	12.0		12.0	
3. To Shaft	30.0	1.0	31.0	
4. Maneuvering Allowance (Shaft)	8.0		8.0	
Total	98.5	3.5	102.0	21.9
B. Transpetration Time				
1. Loading	54.0	7.5	61.5	
2. Dumping	55.5	1.0	56.5	
Total	109.5	8.5	118.0	25.5
Total Productive Time			220.0	47.4
II. NONPRODUCTIVE TIME				
A. Delays				
1. Truck Delays				
a. Breakdown			11.5	
b. Normal			6.0	
2. Loader Delays				
a. Breakdown				
b. Avoidable				
c. Other Load	25.0	4.5	29.5	
Total			47.0	10.1
3. Other Delays				
a. At Grizzly			151.5	
b. Nonoperating			46.5	
Total			198.0	42.5
Total Nonproductive Time			245.5	52.6
TOTAL TIME OBSERVED			465.0	100.0
Number Loads Transported	18	1	19	
Mileage Recorded	7.2	0.7	7.9	

TABLE 74

TIME STUDY OBSERVATION
Truck no. 10 Type - Dart dump
Mine - Kenoyer Date - July 6
Time in Minutes

Time Division	Heading 1	2	3	5	Total	%
I. PRODUCTIVE TIME						
A. Travel Time						
1. To Heading	18.0	2.5	26.0	2.0	48.5	
2. Maneuvering Allowance (Head)	1.5	2.5	3.5	0.5	8.0	
3. To Shaft	17.5	2.5	26.0	1.0	47.0	
4. Maneuvering Allowance (Shaft)	2.0		3.0	0.5	5.5	
Total	39.0	5.0	61.0	4.0	109.0	23.4
B. Transpetration Time						
1. Loading	35.0	7.5	58.0	8.0	108.5	
2. Dumping	4.5	1.0	19.0	1.0	25.5	
Total	39.5	8.5	77.0	9.0	134.0	28.8
Total Productive Time					243.0	52.2
II. NONPRODUCTIVE TIME						
A. Delays						
1. Truck Delays						
a. Breakdown					10.0	
b. Normal					12.5	
2. Loader Delays						
a. Breakdown						
b. Avoidable	10.0	12.5	30.0		52.5	
c. Other Load	6.0		34.0		40.0	
Total					115.0	24.8
3. Other Delays						
a. At Grizzly					47.0	
b. Nonoperating					60.0	
Total					107.0	23.0
Total Nonproductive Time					222.0	47.8
TOTAL TIME OBSERVED					465.0	100.0
Number Loads Transported	4	1	13	1	19	
Mileage Recorded	8.0	0.4	7.8	0.5	16.7	

TABLE 75

TIME STUDY OBSERVATION
Truck no. 11 Type - Dart dump
Mine - Kenoyer Date - July 7, 8
Time in Minutes

Time Division	Heading 3	%	Heading 4	%
I. PRODUCTIVE TIME				
A. Travel Time				
1. To Heading	54.0		62.5	
2. Maneuvering Allowance (Head)	5.0		8.5	
3. To Shaft	53.0		64.0	
4. Maneuvering Allowance (Shaft)	6.5		8.0	
Total	118.5	25.5	143.0	30.8
B. Transpetration Time				
1. Loading	69.0		86.0	
2. Dumping	32.0		35.5	
Total	101.0	21.7	121.5	26.1
Total Productive Time	219.5	47.2	264.5	56.9
II. NONPRODUCTIVE TIME				
A. Delays				
1. Truck Delays				
a. Breakdown	61.5		30.0	
b. Normal	5.0		4.5	
2. Loader Delays				
a. Breakdown	23.0			
b. Avoidable	4.5		10.5	
c. Other Load	12.5		30.0	
Total	106.5	22.9	75.0	16.1
3. Other Delays				
a. At Grizzly	74.5		65.5	
b. Nonoperating	64.5		60.0	
Total	139.0	29.9	125.5	27.0
Total Nonproductive Time	245.5	52.8	200.5	43.1
TOTAL TIME OBSERVED	465.0	100.0	465.0	100.0
Number Loads Transported	10		13	
Mileage Recorded	10.0		6.0	

TABLE 76

TIME STUDY OBSERVATION
Truck no. 20 Type - Dart dump
Mine - Kenoyer Date - July 3, 5
Time in Minutes

Time Division	Heading 2	%	Heading 4	6	Total	%
I. PRODUCTIVE TIME						
A. Travel Time						
1. To Heading	87.0		41.5	3.0	44.5	
2. Maneuvering Allowance (Head)	15.0		13.5	1.0	14.5	
3. To Shaft	86.5		46.0	3.5	49.5	
4. Maneuvering Allowance (Shaft)	10.5		20.0	0.5	20.5	
Total	199.0	42.8	121.0	8.0	129.0	27.7
B. Transpetration Time						
1. Loading	91.5		119.0	2.0	121.0	
2. Dumping	31.0		37.0	1.0	38.0	
Total	122.5	26.3	156.0	3.0	159.0	34.2
Total Productive Time	321.5	69.1			288.0	61.9
II. NONPRODUCTIVE TIME						
A. Delays						
1. Truck Delays						
a. Breakdown	18.0				20.0	
b. Normal	7.0				9.0	
2. Loader Delays						
a. Breakdown						
b. Avoidable	19.5		13.5		13.5	
c. Other Load	19.0		53.5		53.5	
Total	63.5	13.7	67.0		96.0	20.6
3. Other Delays						
a. At Grizzly	19.0				12.0	
b. Nonoperating	61.0				69.0	
Total	80.0	17.2			81.0	17.5
Total Nonproductive Time	143.5	30.9			177.0	38.1
TOTAL TIME OBSERVED	465.0	100.0			465.0	100.0
Number Loads Transported	20		21	1	22	
Mileage Recorded	10.0		10.5	1.5	12.0	

TABLE 77

TIME STUDY OBSERVATION
Truck no. 42 Type - Dart dump
Mine - Kenoyer Date - July 3
Time in Minutes

Time Division	Heading 2	%
I. PRODUCTIVE TIME		
A. Travel Time		
1. To Heading	73.5	
2. Maneuvering Allowance (Head)	9.5	
3. To Shaft	73.0	
4. Maneuvering Allowance (Shaft)	4.5	
Total	160.5	34.5
B. Transpetration Time		
1. Loading	93.5	
2. Dumping	43.5	
Total	137.0	29.5
Total Productive Time	297.5	64.0
II. NONPRODUCTIVE TIME		
A. Delays		
1. Truck Delays		
a. Breakdown	23.5	
b. Normal	6.5	
2. Loader Delays		
a. Breakdown		
b. Avoidable	11.0	
c. Other Load	31.0	
Total	72.0	15.5
3. Other Delays		
a. At Grizzly	27.0	
b. Nonoperating	68.5	
Total	95.5	20.5
Total Nonproductive Time	167.5	36.0
TOTAL TIME OBSERVED	465.0	100.0
Number Loads Transported	22	
Mileage Recorded	31	

TABLE 78

TIME STUDY OBSERVATION
Truck no. 42 Type - Dart dump
Mine - Kenoyer Date - July 5
Time in Minutes

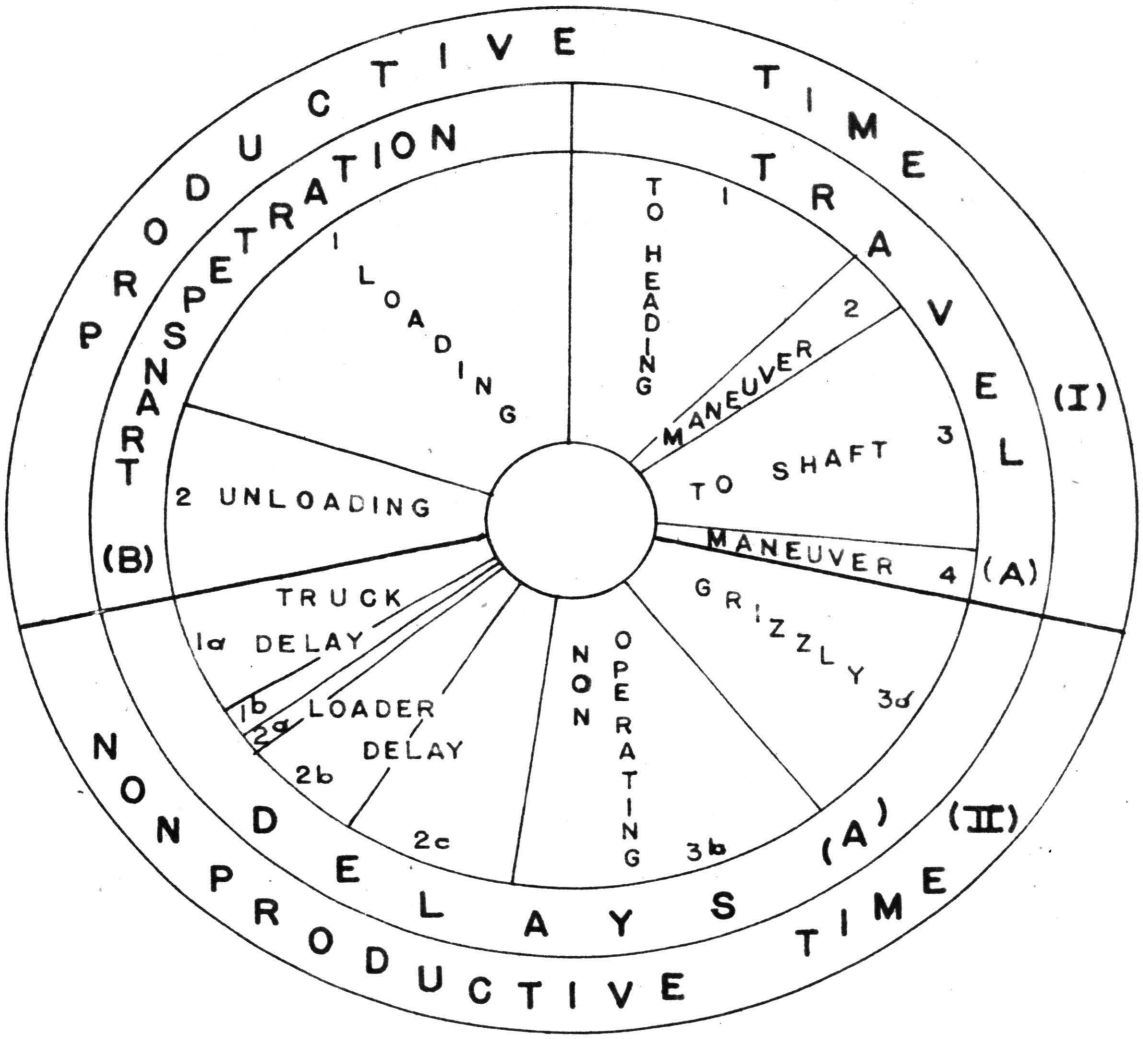
Time Division	Heading 6	Heading 2	Heading 4	Total	%
I. PRODUCTIVE TIME					
A. Travel Time					
1. To Heading	8.0	8.5	21.0	37.5	
2. Maneuvering Allowance (Head)	1.5	1.5	9.0	12.0	
3. To Shaft	8.0	9.0	28.0	45.0	
4. Maneuvering Allowance (Shaft)	1.0	0.5	5.0	6.5	
Total	18.5	19.5	63.0	101.0	21.7
B. Transpetration Time					
1. Loading	7.0	20.0	74.0	101.0	
2. Dumping	4.0	3.5	27.0	34.5	
Total	11.0	23.5	101.0	135.5	29.2
Total Productive Time				236.5	50.9
II. NONPRODUCTIVE TIME					
A. Delays					
1. Truck Delays					
a. Breakdown				9.0	
b. Normal				6.5	
2. Loader Delays					
a. Breakdown					
b. Avoidable		10.0	39.0	49.0	
c. Other Load		9.0	75.0	84.0	
Total				148.5	32.0
3. Other Delays					
a. At Grizzly				35.0	
b. Nonoperating				45.0	
Total				80.0	17.1
Total Nonproductive Time				228.5	49.1
TOTAL TIME OBSERVED				465.0	100.0
Number Loads Transported	3	3	17	23	
Mileage Recorded	4.5	4.5	8.5	17.5	

TABLE 79

TIME STUDY OBSERVATION
General Summary
Mine - Kenoyer Date - July 3 to 8
Time in Minutes

Time Division	Total	%
I. PRODUCTIVE TIME		
A. Travel Time		
1. To Heading	564.5	12.1
2. Maneuvering Allowance (Head)	112.5	2.4
3. To Shaft	547.5	11.8
4. Maneuvering Allowance (Shaft)	91.0	2.0
Total	1315.5	28.3
B. Transpetration Time		
1. Loading	936.5	20.1
2. Dumping	386.0	8.3
Total	1322.5	28.4
Total Productive Time	2638.0	56.7
II. NONPRODUCTIVE TIME		
A. Delays		
1. Truck Delays		
a. Breakdown	246.5	5.4
b. Normal	68.5	1.5
2. Shovel Delays		
a. Breakdown	44.0	0.9
b. Avoidable	223.5	4.8
c. Other Load	321.5	6.9
Total	904.0	19.5
3. Other Delays		
a. At Grizzly	510.0	11.0
b. Nonoperating	598.0	12.8
Total	1108.0	23.8
Total Nonproductive Time	2012.0	43.3
TOTAL TIME OBSERVED	4650.0	100.0
Number Loads Transported	194	
Mileage Recorded	142.9	

FIGURE 31



TIME DISTRIBUTION CHART

TRUCK HAULAGE

KENOYER MINE

TOTAL TIME 4,650 MIN LOADS 194

NETTA MINE

Location

The Netta Mine is located in the NE¼NE¼, section 20; the SW¼SE¼, section 17; and the SE¼SE¼, section 16, Ottawa County, Oklahoma.

Production

The average daily ore production is 450 tons. This is obtained by hoisting approximately 600 cans a shift.

Equipment

Haulage units include: nos. 2, 4, and 6 Dart truck-trailers; no. 15 Dart dump-truck. These are some of the oldest diesel units in the Eagle Picher mines and are only in fair shape. Operational data for one month are given in TABLE 80.

TABLE 80

TRUCK PERFORMANCE - NETTA MINE
(Courtesy of Eagle Picher Mn. & S. Co.)
June 1951

Truck Number	Fuel Consumed (gal.)	Number of Loads	Number of shifts	Operating Costs
2	145	477	26	$632.
4	150	132	26	411.
6	115	484	26	391.
15	100	284	26	425

Three methods of loading are used in the mine: chute, dragline, and shovel. Shovel equipment includes: no. 13 A. C. H D - 5; no. 25 Eimco 104; no. 26 H T - 4 Traxcavator. Operational characteristics for these shovels are shown in TABLE 81.

TABLE 81

SHOVEL PERFORMANCE - NETTA MINE
(Courtesy of Eagle Picher Mn. & S. Co.)
Cumulative data to June 1, 1951

Shovel Number	Total Tons Loaded	Total Shifts	Operating Labor Costs	Total Operating Costs	Unit Operating Cost ($/Ton)
13	19,308	204	$3,876.	$13,142.	$0.681
25	28,800	192	3,021.	8,854.	0.307
26	14,828	124	2,275.	4,815.	0.325

Hoisting

The average hoisting time cycle in the 327 feet Netta shaft is 36 seconds. Hoisting capacity in the estimated available time (425 minutes in a shift) would be 710 cans.

Loading

The only dragline in use as a loading unit is located in number 4 heading and has a 10 ton loading cycle of approximately 9.5 minutes. As discussed later, one truck normally hauls from this area. Because the travel cycle is great, there is sufficient time for the operator to prepare the broken rock for the next load. If actual effort were expended in such preparation, the loading time could be reduced.

Time study results of shovel loading are presented in TABLE 82.

The Eimco is the fastest loading machine. A 10 ton load is completed in an average time of 3.1 minutes. Maneuvers of the rocker type shovel are shown in FIGURES 32 and 33. This shovel is used only in one stope at the Netta Mine because others have low roofs or are too restricted.

The H D - 5 has an average loading time of 6.6 minutes and the

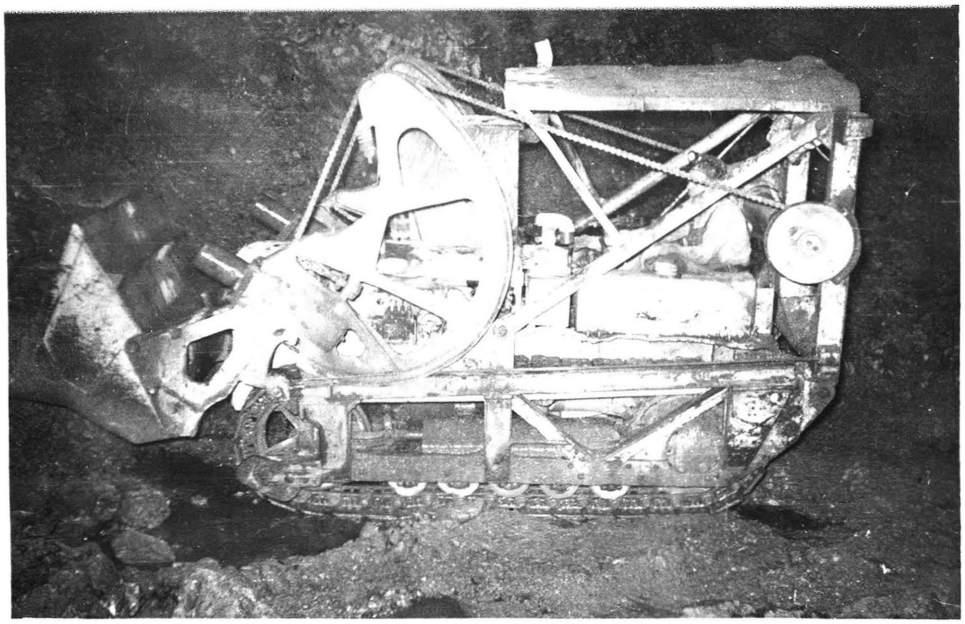


FIGURE 32

EIMCO SHOVEL IN OPERATION

An Eimco 104 is in the process of loading a dipperfull of ore in a high ground stope.

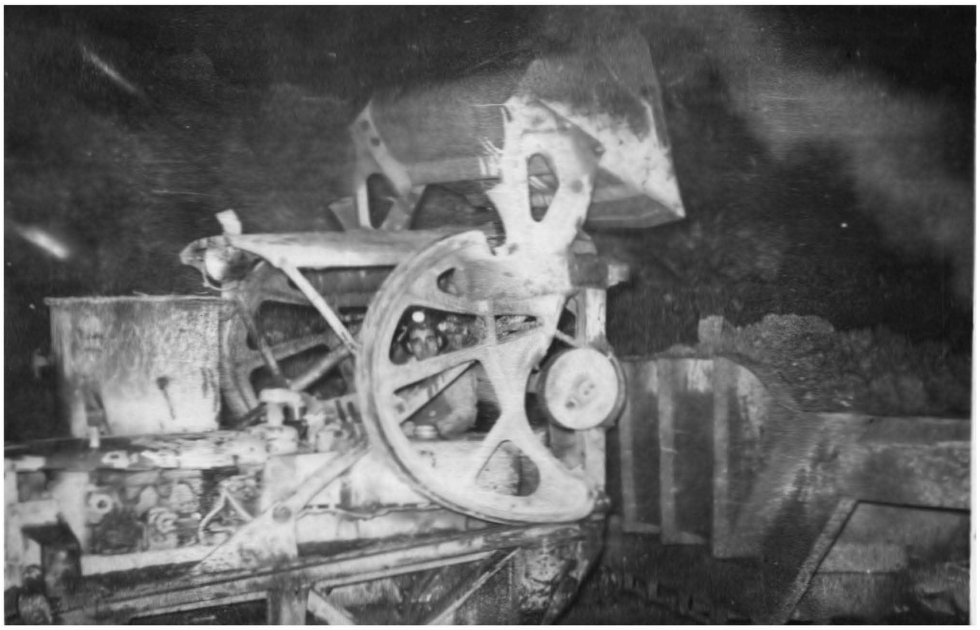


FIGURE 33

EIMCO SHOVEL LOADING

An Eimco 104 is dumping a dipperfull of ore into a waiting truck-trailer.

Traxcavator's average cycle is 5.2 minutes. Both figures are high indicating lack of dexterity on the part of the operators.

TABLE 82

SHOVEL LOADING - NETTA MINE
(Time in seconds)

Motion	Average Time Individual	Cumulative
H D - 5 no. 13		
1. Move Back	8.5	8.5
2. Move Forward	12.5	21.0
3. Load Dipper	12.0	33.0
4. Move Back	13.0	46.0
5. Move Forward and Dump	7.0	53.0
Average number of dippers for a 10 ton load - 7		
Traxcavator no. 26		
1. Move Back	7.5	7.5
2. Move Forward	8.5	16.0
3. Load Dipper	9.0	25.0
4. Move Back	11.0	36.0
5. Move Forward and Dump	9.0	45.0
Average number of dippers for a 10 ton load - 7		
Eimco no. 25		
1. Move Forward and Load Dipper	10.0	10.0
2. Move Back and Dump	7.0	17.0
Average number of dippers for a 10 ton load - 11		

Haulage System

Trucks and shovels usually are dispatched to the same areas each shift. In Netta White Lease (Heading number 1), four-tenths of a mile from the shaft, the ore is mined in an upper level and slushed through a raise to the haulage level. The H D - 5 shovel loads truck no. 15 which is the only unit capable of negotiating the steep grade to the

loading zone.

Heading number 2 (Netta East 40 Lease) is located three-tenths of a mile from the dumping station in sheet ground area. The Traxcavator is used to load truck no. 6.

Two chutes are used in heading 3 to load ore from upper ground mining. The ore is slushed into raises and fed into the chutes. The approach areas to the chutes are not well maintained generally, and this causes some difficulty in maneuvering the trucks into the loading position.

The Eimco is used to load ore in heading 5 (Vantage Lease). This zone is in high ground stoping area, five-tenths of a mile from the shaft. The floor is very uneven and the stope full of boulders so that truck motion is restricted.

The longest run of all mines is made to heading number 4 (Consolidated Number 2 Lease) a round trip distance of five miles. A dragline loads truck number 4 from a high ground stope. A cable slusher has to be used to help the truck at one grade close to the heading.

The roads are not well maintained and some approach roads to loading areas are very poorly conditioned.

The dumping station has a drive over ramp with grizzly set at haulage level (FIGURE 15 illustrates this ramp). The grizzly hopper does not have very large surge capacity.

Time Study Results

Results of time studies in the Netta Mine are summarized in TABLES 83 through 90. TABLE 90 presents the total time of all truck-shifts; the time distribution in this table is represented graphically in

FIGURE 34.

TABLE 83

TIME RATIOS OF HAULAGE SYSTEM
Netta Mine

Table Number	Ton-Mileage	Productive / Nonproductive Time Ratio	Travel / Transpetration Time Ratio	Travel Heading / Travel Shaft Loading Time Ratio
	T-Mlg	Pdt/Npdt	Trv/Trpt	TH/TS/Ld
84	2685	1/1.13	1/1.04	1.05/1/2.32
85	1420	1/1.54	1/0.99	1.18/1/2.00
86	1800	1/0.70	1/0.32	0.90/1/0.53
	2450	1/0.29	1/0.30	1.06/1/0.57
87	1630	1/1.23	1/1.22	0.88/1/2.22
	865	1/1.18	1/1.75	0.94/1/3.36
88	1015	1/0.82	1/0.85	0.97/1/1.45
89	1055	1/1.50	1/1.79	1.05/1/1.45
90	122000	1/0.99	1/0.73	1.00/1/1.34
Ideal		1/0.425	1/0.50	1.00/1/1.00

Most truck-shifts indicate unfavorable time disposition. The Pdt/Npdt ratios show only one run within the estimated efficient range of 1/0.425 to 1/0.25. Truck no. 4, due to its extensive travel cycle, has a high Trv/Trpt ratio. All others have large loading time proportions.

Delays at the grizzly are noticeable in every truck-shift. There is more wasted time at the dumping station of this mine than at any other mine within the scope of this investigation.

Compendium

A study of TABLE 90 is sufficient to show that the haulage system is inefficient. Almost as much time is expended in nonproductive activity as in productive effort. There are many delays attributed to various causes the most serious of which is grizzly delay.

TABLE 84

TIME STUDY OBSERVATION
Truck no. 2 Type - Dart trailer
Mine - Netta Date - June 12
Time in Minutes

Time Division	Heading 5	Heading 3	Total	%
I. PRODUCTIVE TIME				
A. Travel Time				
1. To Heading	38.0	5.0	43.0	
2. Maneuvering Allowance (Head)	18.5	4.5	23.0	
3. To Shaft	35.0	6.0	41.0	
Total	91.5	15.5	107.0	23.0
B. Transpetration Time				
1. Loading	90.0	5.0	95.0	
2. Dumping	13.0	3.5	16.5	
Total	103.0	8.5	111.5	24.0
Total Productive Time			218.5	47.0
II. NONPRODUCTIVE TIME				
A. Delays				
1. Truck Delays				
a. Breakdown				
b. Normal			6.5	
2. Loader Delays				
a. Breakdown				
b. Avoidable	3.0		3.0	
c. Other Load	38.0		38.0	
Total			47.5	10.2
3. Other Delays				
a. At Grizzly			161.5	
b. Nonoperating			37.5	
Total			199.0	42.8
Total Nonproductive Time			246.5	53.0
TOTAL TIME OBSERVED			465.0	100.0
Number Loads Transported	13	3	16	
Mileage Recorded	15.6	1.2	16.8	

TABLE 85

TIME STUDY OBSERVATION
Truck no. 2 Type - Dart trailer
Mine - Netta Date - June 14
Time in Minutes

Time Division	Heading 2	1	5	Total	%
I. PRODUCTIVE TIME					
A. Travel Time					
1. To Heading	9.0	3.0	28.0	40.0	
2. Maneuvering Allowance (Head)	4.0	2.0	6.0	12.0	
3. To Shaft	8.0	2.0	24.0	34.0	
Total	21.0	7.0	58.0	86.0	18.5
B. Transpetration Time					
1. Loading	27.0	2.0	39.0	68.0	
2. Dumping	6.0	2.0	9.0	17.0	
Total	33.0	4.0	48.0	85.0	18.3
Total Productive Time				171.0	36.8
II. NONPRODUCTIVE TIME					
A. Delays					
1. Truck Delays					
a. Breakdown					
b. Normal				14.0	
2. Loader Delays					
a. Breakdown					
b. Avoidable	12.0			12.0	
c. Other Load	6.0			6.0	
Total				32.0	6.9
3. Other Delays					
a. At Grizzly				209.0	
b. Nonoperating				53.0	
Total				262.0	56.3
Total Productive Time				294.0	63.2
TOTAL TIME OBSERVED				465.0	100.0
Number Loads Transported	3	1	8	12	
Mileage Recorded	1.8	0.4	9.6	11.8	

TABLE 86

TIME STUDY OBSERVATION
Truck no. 4 Type - Dart trailer
Mine - Netta Date - June 13, 16
Time in Minutes

Time Division	Heading 4	%	Heading 4	%
I. PRODUCTIVE TIME				
A. Travel Time				
1. To Heading	93.0		129.0	
2. Maneuvering Allowance (Head)	11.0		16.0	
3. To Shaft	103.5		121.0	
Total	207.5	44.6	266.0	57.2
B. Transpetration Time				
1. Loading	55.0		69.0	
2. Dumping	12.0		11.0	
Total	67.0	14.4	80.0	17.2
Total Productive Time	274.5	59.0	346.0	74.4
II. NONPRODUCTIVE TIME				
A. Delays				
1. Truck Delays				
a. Breakdown	67.5			
b. Normal	9.5		6.0	
2. Loader Delays				
a. Breakdown	8.0			
b. Avoidable			8.0	
c. Other Load	32.0		3.5	
Total	117.0	25.2	17.5	3.8
3. Other Delays				
a. At Grizzly	13.5		47.0	
b. Nonoperating	60.0		54.5	
Total	73.5	15.8	101.5	21.8
Total Nonproductive Time	190.5	41.0	119.0	25.6
TOTAL TIME OBSERVED	465.0	100.0	465.0	100.0
Number Loads Transported	6		7	
Mileage Recorded	30		35	

TABLE 87

TIME STUDY OBSERVATION
Truck no. 6 Type - Dart trailer
Mine - Netta Date - June 9, 13
Time in Minutes

Time Division	Heading 2	Heading 3	Total	%	Heading 2	%
I. PRODUCTIVE TIME						
A. Travel Time						
1. To Heading	31.5	7.0	38.5		32.0	
2. Maneuvering Allowance (Head)	8.5	2.5	11.0		12.0	
3. To Shaft	38.0	6.0	44.0		34.0	
Total	78.0	15.5	93.5	20.2	78.0	16.7
B. Transpetration Time						
1. Loading	92.5	5.0	97.5		114.0	
2. Dumping	13.5	3.5	17.0		22.0	
Total	106.0	8.5	114.5	24.6	136.0	29.3
Total Productive Time			208.0	44.8	214.0	46.0
II. NONPRODUCTIVE TIME						
A. Delays						
1. Truck Delays						
a. Breakdown			35.5			
b. Normal			5.0		9.0	
2. Loader Delays						
a. Breakdown	23.0		23.0			
b. Avoidable	18.0		18.0		79.0	
c. Other Load	18.5		18.5		25.0	
Total			100.0	21.5	113.0	24.3
3. Other Delays						
a. At Grizzly			118.0		104.0	
b. Nonoperating			39.0		34.0	
Total			157.0	33.7	138.0	29.7
Total Nonproductive Time			257.0	55.2	251.0	54.0
TOTAL TIME OBSERVED			465.0	100.0	465.0	100.0
Number Loads Transported	14	3	17		12	
Mileage Recorded	8.4	1.2	9.6		7.2	

TABLE 88

TIME STUDY OBSERVATION
Truck no. 15 Type - Dart dump
Mine - Netta Date - June 16
Time in Minutes

Time Division	Heading 5	%
I. PRODUCTIVE TIME		
A. Travel Time		
1. To Heading	65.0	
2. Maneuvering Allowance (Head)	6.5	
3. To Shaft	67.0	
Total	138.5	29.7
B. Transpetration Time		
1. Loading	97.5	
2. Dumping	20.0	
Total	117.5	25.3
Total Productive Time	256.0	55.0
II. NONPRODUCTIVE TIME		
A. Delays		
1. Truck Delays		
a. Breakdown		
b. Normal	6.0	
2. Loader Delays		
a. Breakdown	16.0	
b. Avoidable	16.5	
c. Other Load	22.5	
Total	61.0	13.2
3. Other Delays		
a. At Grizzly	117.0	
b. Nonoperating	31.0	
Total	148.0	31.8
Total Nonproductive Time	209.0	45.0
TOTAL TIME OBSERVED	465.0	100.0
Number of Loads Transported	13	
Mileage Recorded	7.8	

TABLE 89

TIME STUDY OBSERVATION
Truck no. 15 Type - Dart dump
Mine - Netta Date - June 11
Time in Minutes

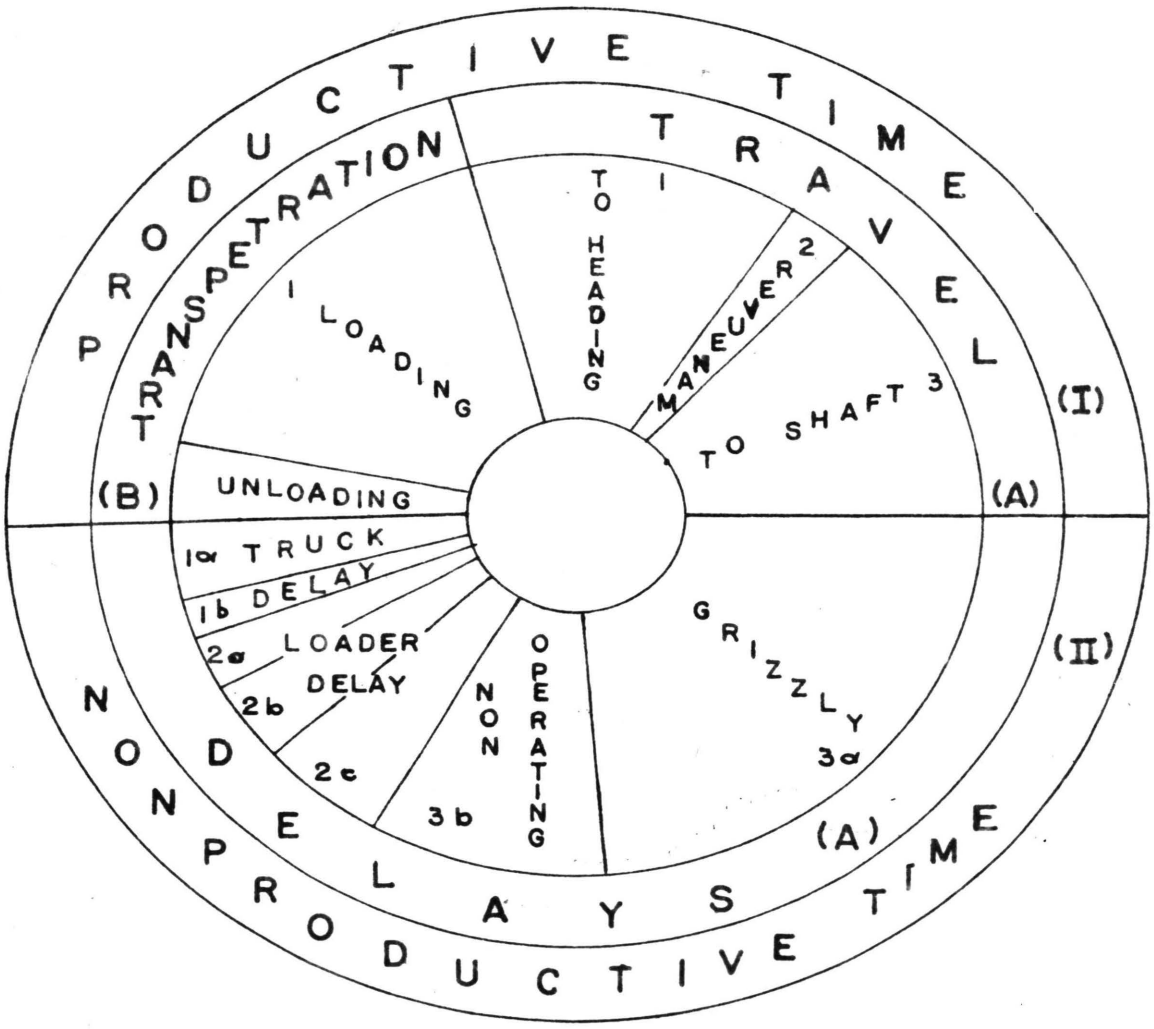
Time Division	Heading 2	3	4	Total	%
I. PRODUCTIVE TIME					
A. Travel Time					
1. To Heading	13.0	11.5	25.0	49.5	
2. Maneuvering Allowance	4.5	1.5	1.5	7.5	
3. To Shaft	14.5	8.5	24.0	47.0	
Total	32.0	21.5	50.5	104.0	22.4
B. Transpetration Time					
1. Loading	50.0	9.5	8.5	68.0	
2. Dumping	8.5	4.5	1.0	14.0	
Total	58.5	14.0	9.5	82.0	17.6
Total Productive Time				186.0	40.0
II. NONPRODUCTIVE TIME					
A. Delays					
1. Truck Delays					
a. Breakdown				24.5	
b. Normal				6.5	
2. Loader Delays					
a. Breakdown	49.5			49.5	
b. Avoidable	7.5			7.5	
c. Other Load	14.5		19.5	34.0	
Total				122.0	26.2
3. Other Delays					
a. At Grizzly				111.5	
b. Nonoperating				45.5	
Total				157.0	33.8
Total Nonproductive Time				279.0	60.0
TOTAL TIME OBSERVED				465.0	100.0
Number Loads Transported	6	4	1	11	
Mileage Recorded	3.0	1.6	5.0	9.6	

TABLE 90

TIME STUDY OBSERVATION
General Summary
Mine - Netta Date - June 9 to 17
Time in Minutes

Time Division	Total	%
I. PRODUCTIVE TIME		
A. Travel Time		
1. To Heading	490.0	13.2
2. Maneuvering Allowance (Head)	99.0	2.7
3. To Shaft	491.5	13.3
Total	1080.5	29.2
B. Transpetration Time		
1. Loading	664.0	17.7
2. Dumping	129.5	3.5
Total	793.5	21.2
Total Productive Time	1874.0	50.4
II. NONPRODUCTIVE TIME		
A. Delays		
1. Truck Delays		
a. Breakdown	127.5	3.4
b. Normal	62.5	1.7
2. Loader Delays		
a. Breakdown	104.5	2.8
b. Avoidable	136.0	3.7
c. Other Load	179.5	4.8
Total	610.0	16.4
3. Other Delays		
a. At Grizzly	881.5	23.7
b. Nonoperating	354.5	9.5
Total	1236.0	33.2
Total Nonproductive Time	1846.0	49.6
TOTAL TIME OBSERVED	3720.0	100.0
Number Loads Transported	94	
Mileage Covered	129.8	

FIGURE 34



TIME DISTRIBUTION CHART

TRUCK HAULAGE

NETTA MINE

TOTAL TIME 3,720 MIN LOADS 94

To obtain the estimated capacity, 60 truck loads a shift would be required. If production is to be maintained in number 4 heading, one truck would be required for that area alone. Operating with improved loading times and less nonoperating time, this truck could provide ten loads a shift since the travel distance is great. The fifty remaining loads could be collected from four headings of relative short haul distances.

Time lost because of truck breakdowns could be eliminated by retiring one truck and maintaining it as a stand by or reserve unit. With one unit withdrawn, the delays due to conjestion at one heading and at the grizzly would be reduced materially. With the omission of a haulage unit one shovel could also be removed from active work. This would leave two trucks and two shovels to be distributed as desired to transport 50 loads a day. The average requirement would be 5,000 ton-miles (25 loads x 10 tons/load x 25 miles) for each haulage unit. The trucks could be dispatched with shovels to the headings according to production demands. Between travel cycles the shovels could prepare the muck pile for the next load without pressure from another waiting unit. While the shovels are moving to other headings, the trucks can load from the chutes and thus avoid delays on loading units.

As haulage distances are short, each truck with its independent loading unit could meet production demands without difficulty.

PIOKEE MINE

Location

The Piokee Mine is located in the N½SE¼ and SE¼SW¼ of section 17, T. 29 N., R. 23 E., Ottawa County, Oklahoma.

Production

The average daily production of ore is 600 tons.

Equipment

Three trucks are used in ore haulage: nos. 12 and 40 Dart dump trucks; and no. 18 Autocar dump truck. Although two of these units have been in operation over three years, they are in good condition. Production data for one month of operation are given in TABLE 91.

TABLE 91

TRUCK PERFORMANCE - PIOKEE MINE
(Courtesy of Eagle Picher Mn. & S. Co.)
June 1951

Truck Number	Fuel Consumed (gal.)	Number of Loads	Number of Shifts	Operating Costs
12	155	669	26	$505.
18	115	711	26	407.
40	155	731	26	776.

Loading is performed entirely by draglines although one shovel is available at the mine. This unit is used for cleaning loading zones, maintaining roads, and helping the draglines work the broken rock.

Hoisting

Can hoisting at this mine has a short average cycle of 30 seconds. The shaft capacity, in the estimated available time of 425 minutes, is

850 cans. This represents a daily production rate of approximately 650 tons.

Loading

Because loading is done with draglines, no individual time studies were conducted on loading cycles. Average loading time varies considerably from one heading to another. The upper ground dragline averaged less than 5 minutes for a 10 ton load which is an excellent time cycle. Loading in number 1 heading was approximately 8 minutes. This is a comparatively high time cycle. The dragline is set up in such a manner as to require a large travel distance for the scraper. This accounts in part for the greater loading time. Other loading times are favorable and vary from 4 to 7 minutes.

Haulage System

There are four dragline loading zones, all within a three-tenths mile radius of the shaft.

Heading number 1 is a very wide sheet ground area. For maximum coverage the dragline is set up an excessively great distance from the face. The scraper has a very long average run so that loading cycles are very slow.

Another sheet ground area is heading number 3, located in an upper level. The dragline is generally operated with a high degree of efficiency. It is set up close to the muck, and the competent operator loads at a fast rate of 2 or more tons a minute.

Headings 2 and 4 are high ground stopes.

The dumping station is a drive over type that can be approached from either side with equal ease. The haulage cycles are very uniform

so that the hopper is generally full, although it does not provide a large surge capacity.

Time Study Results

Truck-shift time studies are summarized in TABLES 93 through 97. The total of these studies is presented in TABLE 98 and the time distribution in this table is represented graphically in FIGURE 35.

TABLE 92

TIME RATIOS OF HAULAGE SYSTEM
Pickee Mine

Table Number	Ton-Mileage T-Mlg	Productive / Nonproductive Time Ratio Pdt/Npdt	Travel / Transpetration Time Ratio Trv/Trpt	Travel Heading / Travel Shaft / Loading Time Ratio TH/TS/Ld
93	1940	1/1.18	1/0.93	1.14/1/1.68
93	5400	1/0.30	1/1.09	0.98/1/1.91
94	2710	1/0.58	1/1.70	1.00/1/4.50
95	2500	1/0.56	1/1.84	0.80/1/4.00
96	2500	1/0.23	1/2.54	0.73/1/3.45
97	5180	1/0.40	1/1.71	0.89/1/3.40
98	118000	1/0.49	1/1.59	0.93/1/3.20
Ideal		1/0.425	1/0.50	1.00/1/1.00

Results in TABLE 92 show that Pdt/Npdt ratios are very close to desired values. Nonproductive time is held to a minimum in this mine. Travel/Transpetration ratios are lower than the recommended values but partially justifiable in this case. This is true as the truck runs are very short so that travel time cycles are held to a minimum, while average loading time cycles are longer because loading is done by draglines. However, these ratios could be higher with improved loading performance.

TABLE 93

TIME STUDY OBSERVATION
Truck no. 12 Type - Dart dump
Mine - Pickee Date - July 27, 28
Time in Minutes

Time Division	Heading 3	%	Heading 3	%
I. PRODUCTIVE TIME				
A. Travel Time				
1. To Heading	56.5		78.5	
2. Maneuvering Allowance (Head)	4.5		13.5	
3. To Shaft	49.5		80.0	
Total	110.5	23.8	172.0	37.0
B. Transpetration Time				
1. Loading	83.5		153.0	
2. Dumping	19.5		33.5	
Total	103.0	22.1	186.5	40.1
Total Productive Time	213.5	45.9	358.5	77.1
II. NONPRODUCTIVE TIME				
A. Delays				
1. Truck Delays				
a. Breakdown				
b. Normal	12.5		9.5	
2. Loader Delays				
a. Breakdown	112.5			
b. Avoidable				
c. Other Load	56.0		34.0	
Total	181.0	38.9	43.5	9.3
3. Other Delays				
a. At Grizzly	14.0		32.0	
b. Nonoperating	56.5		31.0	
Total	70.5	15.2	63.0	13.6
Total Nonproductive Time	251.5	54.1	106.5	22.9
TOTAL TIME OBSERVED	465.0	100.0	465.0	100.0
Number Loads Transported	18		30	
Mileage Recorded	10.8		18.0	

TABLE 94

TIME STUDY OBSERVATION
Truck no. 18 Type - A.C. dump
Mine - Piokee Date - July 26
Time in Minutes

Time Division	Heading 1	Heading 2	Total	%
I. PRODUCTIVE TIME				
A. Travel Time				
1. To Heading	15.0	21.0	36.0	
2. Maneuvering Allowance (Head)	18.0	18.5	36.5	
3. To Shaft	16.0	20.5	36.5	
Total	49.0	60.0	109.0	23.4
B. Transpetration Time				
1. Loading	81.0	81.0	162.0	
2. Dumping	9.5	13.5	23.0	
Total	90.5	94.5	185.0	39.7
Total Productive Time			294.0	63.1
II. NONPRODUCTIVE TIME				
A. Delays				
1. Truck Delays				
a. Breakdown			85.0	
b. Normal			15.5	
2. Loader Delays				
a. Breakdown				
b. Avoidable			4.0	
c. Other Load			2.0	
Total			106.5	23.0
3. Other Delays				
a. At Grizzly			20.5	
b. Nonoperating			44.0	
Total			64.5	13.9
Total Nonproductive Time			171.0	36.9
TOTAL TIME OBSERVED			465.0	100.0
Number Loads Transported	11	15	26	
Mileage Recorded	4.4	6.0	10.4	

TABLE 95

TIME STUDY OBSERVATION
Truck no. 18 Type - A. C. dump
Mine - Pickee Date - July 27
Time in Minutes

Time Division	Heading 1	Heading 2	Total	%
I. PRODUCTIVE TIME				
A. Travel Time				
1. To Heading	17.5	15.0	32.5	
2. Maneuvering Allowance (Head)	17.5	14.5	32.0	
3. To Shaft	22.5	18.0	40.5	
Total	57.5	47.5	105.0	22.6
B. Transpetration Time				
1. Loading	108.0	54.0	162.0	
2. Dumping	17.5	13.5	31.0	
Total	125.5	67.5	193.0	41.5
Total Productive Time			298.0	64.1
II. NONPRODUCTIVE TIME				
A. Delays				
1. Truck Delays				
a. Breakdown				
b. Normal			10.5	
2. Loader Delays				
a. Breakdown	25.0	20.0	45.0	
b. Avoidable				
c. Other Load	20.0	15.0	35.0	
Total			90.5	19.5
3. Other Delays				
a. At Grizzly			40.0	
b. Nonoperating			36.5	
Total			76.5	16.4
Total Nonproductive Time			167.0	35.9
TOTAL TIME OBSERVED			465.0	100.0
Number Loads Transported	12	13	25	
Mileage Recorded	4.8	5.2	10.0	

TABLE 96

TIME STUDY OBSERVATION
Truck no. 40 Type - Dart dump
Mine - Piokee Date - July 26
Time in Minutes

Time Division	Heading 4	Heading 2	Total	%
I. PRODUCTIVE TIME				
A. Travel Time				
1. To Heading	29.0	5.0	34.0	
2. Maneuvering Allowance (Head)	19.0	5.5	24.5	
3. To Shaft	41.0	6.0	47.0	
Total	89.0	16.5	105.5	22.7
B. Transpetration Time				
1. Loading	218.5	28.0	246.5	
2. Dumping	22.0	5.0	27.0	
Total	240.5	33.0	273.5	58.8
Total Productive Time			379.0	81.5
II. NONPRODUCTIVE TIME				
A. Delays				
1. Truck Delays				
a. Breakdown				
b. Normal	3.5		3.5	
2. Loader Delays				
a. Breakdown	6.0		6.0	
b. Avoidable	8.0		8.0	
c. Other Load	25.0		25.0	
Total			42.5	9.1
3. Other Delays				
a. At Grizzly			9.5	
b. Nonoperating			34.0	
Total			43.5	9.4
Total Nonproductive Time			86.0	18.5
TOTAL TIME OBSERVED			465.0	100.0
Number Loads Transported	21	4	25	
Mileage Recorded	8.4	1.6	10.0	

TABLE 97

TIME STUDY OBSERVATION
Truck no. 40 Type - Dart dump
Mine - Pickee Date - July 28
Time in Minutes

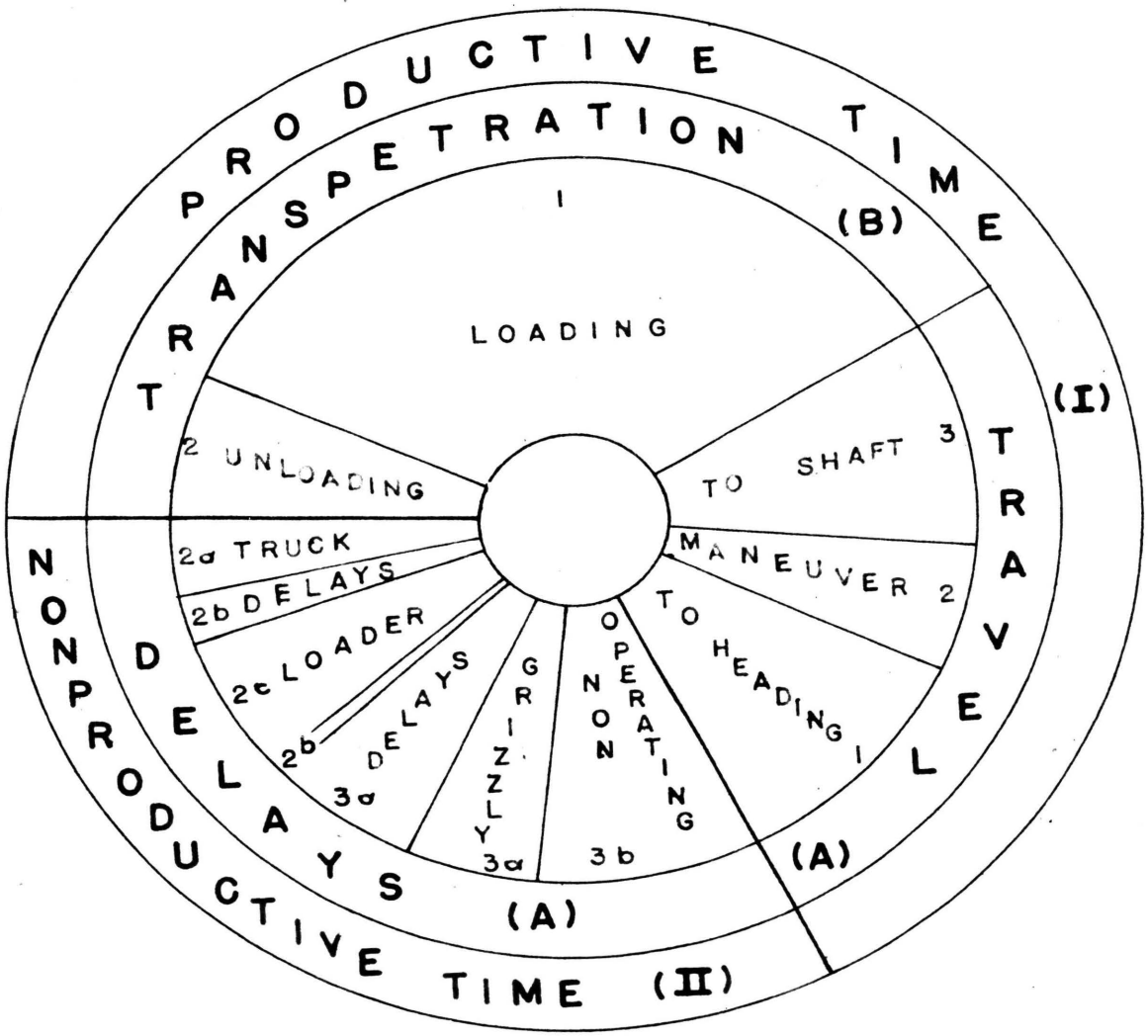
Time Division	Heading 4	Heading 2	Total	%
I. PRODUCTIVE TIME				
A. Travel Time				
1. To Heading	3.0	41.0	44.0	
2. Maneuvering Allowance (Head)	3.0	25.5	28.5	
3. To Shaft	5.0	45.0	50.0	
Total	11.0	111.5	122.5	26.4
B. Transpetration Time				
1. Loading	33.0	137.0	170.0	
2. Dumping	4.0	37.0	41.0	
Total	37.0	174.0	211.0	45.2
Total Productive Time			333.5	71.6
II. NONPRODUCTIVE TIME				
A. Delays				
1. Truck Delays				
a. Breakdown				
b. Normal			3.5	
2. Loader Delays				
a. Breakdown	17.5		17.5	
b. Avoidable	3.5		3.5	
c. Other Load	33.0		33.0	
Total			57.5	12.4
3. Other Delays				
a. At Grizzly			36.0	
b. Nonoperating			38.0	
Total			74.0	16.0
Total Nonproductive Time			131.5	28.4
TOTAL TIME OBSERVED			465.0	100.0
Number Loads Transported	3	33	36	
Mileage Recorded	1.4	13.0	14.4	

TABLE 98

TIME STUDY OBSERVATION
General Summary
Mine - Piokee Date - July 26 to 29
Time in Minutes

Time Division	Total	%
I. PRODUCTIVE TIME		
A. Travel Time		
1. To Heading	281.5	10.1
2. Maneuvering Allowance (Head)	139.5	5.0
3. To Shaft	303.5	10.9
Total	724.5	26.0
B. Transpetration Time		
1. Loading	977.0	35.0
2. Dumping	175.0	6.2
Total	1152.0	41.2
Total Productive Time	1876.5	67.2
II. NONPRODUCTIVE TIME		
A. Delays		
1. Truck Delays		
a. Breakdown	85.0	3.1
b. Normal	55.0	1.9
2. Loader Delays		
a. Breakdown	181.0	6.5
b. Avoidable	15.5	0.5
c. Other Load	185.0	6.7
Total	521.5	18.7
3. Other Delays		
a. At Grizzly	152.0	5.5
b. Nonoperating	240.0	8.6
Total	392.0	14.1
Total Nonproductive Time	913.5	32.8
TOTAL TIME OBSERVED	2790.0	100.0
Number Loads Transported	160	
Mileage Recorded	73.6	

FIGURE 35



TIME DISTRIBUTION CHART

TRUCK HAULAGE

PIOKEE MINE

TOTAL TIME 2,790 MIN LOADS 160

Compendium

From the standpoint of time distribution and production capacity the Pickee Mine has one of the most efficient haulage systems in the District. The actual mine output might be increased slightly by attention to delay causes. Loader delays could be reduced with more careful inspection, maintenance of equipment, and better allocation of haulage units. Although equipment allocation is effective and well managed, more attention to alternate routes would help to reduce other load delays.

With observance of these factors each unit could transport 25 loads a shift and bring mine output to a maximum.

WESTSIDE MINE

Location

Westside mining operations are confined to the SE½, section 7, T. 35 S., R. 24 E., Cherokee County, Kansas.

Production

The average daily production of ore from the mine is 800 tons.

Equipment

The Westside Mine uses four haulage units: nos. 3 and 5 Dart truck-trailers; no. 13 Dart dump-truck; and no. 78 Koehring Dumptor, which is illustrated in FIGURE 36. Typical monthly production data for these trucks are given in TABLE 99.

TABLE 99

TRUCK PERFORMANCE - WESTSIDE MINE
(Courtesy of Eagle Picher Mn. & S. Co.)
June 1951

Truck Number	Fuel Consumed (gal.)	Number of Loads	Number of Shifts	Operating Costs
3	156	561	26	$443.
5	156	623	26	471.
13	156	558	26	637.
78	156	622	26	423.

Loading equipment includes: three draglines; no. 16 H T - 4 Traxcavator shovel; and no. 17 Eimco 104 shovel. Performance data for the shovels are given in TABLE 100.

Hoisting

Hoisting is done by a two skip balanced system, in a two compartment shaft which is approximately 500 feet deep.

FIGURE 36

KOEHRING DUMPTOR

A six ton capacity unit

used in underground ore haulage.

TABLE 100

SHOVEL PERFORMANCE - WESTSIDE MINE
(Courtesy of Eagle Picher Mn. & S. Co.)
Cumulative data to June 1, 1951

Shovel Number	Total Tons Loaded	Total Shifts	Operating Labor Costs	Total Operating Costs	Unit Operating Cost ($/Ton)
16	211,900	497	$8,126.	$26,074	$0.123
17	197,200	413	7,432.	27,901	0.141

The average hoisting cycle for one skip is 2.2 minutes; this includes loading, hoisting, dumping and lowering the skip. As hoisting is a continuous operation throughout the shift, the hoisting time is approximately 465 minutes. The mine has a hoisting capacity of 900 tons a day.

Haulage System

There are three main loading zones in use. Heading number 1 is a high ground stope five-tenths of a mile from the shaft. The Eimco performs all the loading. The average loading time was 3.4 minutes, a favorable accomplishment for the loader.

Heading number 3, five-tenths of a mile from the shaft, is also a high ground stope. Loading is done by Eimco shovel number 17.

The third high ground stope, heading number 2, is three-tenths of a mile from the dumping station. This is a very large stope in which various areas are mined. The Traxcavator shovel is used for loading. The average loading cycle is 6 minutes, which is a high figure for this type of loader. The operator is inexperienced, however, and should, in time, improve his ability.

The draglines are distributed in various parts of the mine. They

are not used ordinarily, but are reserve units, to be used only when necessary.

The roads are maintained in excellent condition. Travel times are kept to a minimum since trucks are capable of travelling at high speeds.

The unloading station has two grizzlies of the back in type. One screen is constructed so that drive-over dumping is possible. The general layout of this station is shown in FIGURE 37.

Time Study Results

The results of time studies are summarized in TABLES 101 through 106. The general summary for the mine is presented in TABLE 106; the time distribution in this table is represented graphically in FIGURE 38.

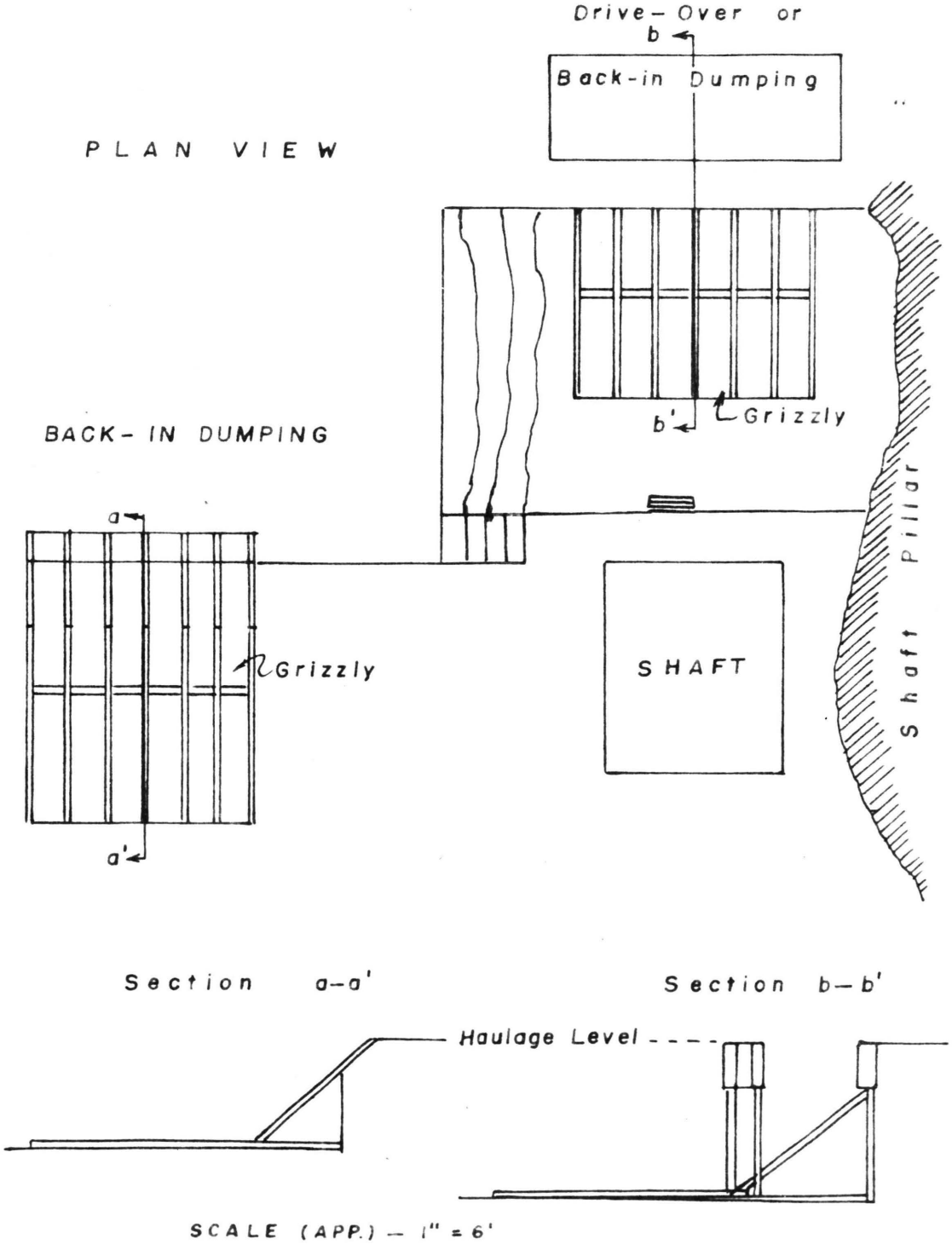
TABLE 101

TIME RATIOS OF HAULAGE SYSTEM
Westside Mine

Table Number	Ton-Mileage	Productive / Nonproductive Time Ratio	Travel / Transpetration Time Ratio	Travel Heading / Travel Shaft Loading Time Ratio
	T-Mlg	Pdt/Npdt	Trv/Trpt	TH/TS/Ld
102	3090	1/0.60	1/1.23	0.82/1/2.34
	2800	1/0.81	1/1.13	0.68/1/1.74
103	5650	1/0.57	1/0.70	0.70/1/1.06
	8400	1/0.31	1/0.44	0.80/1/0.77
104	3080	1/0.68	1/1.56	0.56/1/2.11
	1620	1/2.64	1/1.10	0.67/1/1.76
105	3450	1/0.51	1/0.48	0.73/1/0.83
	4800	1/0.37	1/0.50	0.80/1/0.89
106	281000	1/0.65	1/0.76	0.74/1/1.25
Ideal		1/0.425	1/0.50	1.00/1/1.00

The actual output of the haulage system is the largest of the mines investigated, 281,000 ton-miles, or 3,500 ton-miles average in

FIGURE 37
DOUBLE GRIZZLY UNLOADING STATION



SCALE (APP.) — 1" = 6'

WESTSIDE MINE

each shift. From the standpoint of time distribution, however, improvements should be made. With the two screen dumping station, the grizzly delays should be held to a minimum. The drivers seem to prefer to wait at the larger screen rather than dump at the smaller one. Combined use of the screens would essentially eliminate the 9.2 per cent time delay. Avoidable shovel delays are excessive also (9.6 per cent).

Compendium

The excellent haulage conditions at the Westside Mine permits a properly operated truck to deliver at least 30 loads in one shift.

It is proposed that the Koehring Dumptor be retired from active service. The truck should be kept as a stand by reserve unit, contributing toward the elimination of truck breakdown delays. Less congestion at the dumping station would also result in time saving. The Eimco shovel should be used to load two trucks, while the Traxcavator would only have to load one truck. As the Eimco is a much faster unit the travel time cycles would coincide more closely with loading time cycles, and thus avoid other load delays.

With careful planning, three trucks could maintain production more effectively than the four presently used.

TABLE 102

TIME STUDY OBSERVATION
Truck no. 3 Type - Dart trailer
Mine - Westside Date - June 21, 23
Time in Minutes

Time Division	Heading 2	%	Heading 2	%
I. PRODUCTIVE TIME				
A. Travel Time				
1. To Heading	49.5		44.0	
2. Maneuvering Allowance (Head)	13.0		6.0	
3. To Shaft	60.5		65.0	
4. Maneuvering Allowance (Shaft)	7.0		5.0	
Total	130.0	28.0	120.0	25.8
B. Transpetration Time				
1. Loading	140.5		113.0	
2. Dumping	20.0		23.0	
Total	160.5	34.5	136.0	29.3
Total Productive Time	290.5	62.5	256.0	55.1
II. NONPRODUCTIVE TIME				
A. Delays				
1. Truck Delays				
a. Breakdown				
b. Normal	6.0		12.0	
2. Loader Delays				
a. Breakdown	17.0			
b. Avoidable	38.0		73.0	
c. Other Load	41.0		10.0	
Total	102.0	21.9	95.0	20.4
3. Other Delays				
a. At Grizzly	41.5		40.0	
b. Nonoperating	31.0		74.0	
Total	72.5	15.6	114.0	24.5
Total Nonproductive Time	174.5	37.5	209.0	44.9
TOTAL TIME OBSERVED	465.0	100.0	465.0	100.0
Number Loads Transported	21		20	
Mileage Recorded	14.7		14.0	

TABLE 103

TIME STUDY OBSERVATION
Truck no. 5 Type - Dart trailer
Mine - Westside Date - June 23, 25
Time in Minutes

Time Division	Heading 1	Heading 2	Total	%	Heading 1	%
I. PRODUCTIVE TIME						
A. Travel Time						
1. To Heading	46.0	17.0	63.0		97.0	
2. Maneuvering Allowance (Head)	9.0	4.0	13.0		18.0	
3. To Shaft	68.0	22.0	90.0		122.0	
4. Maneuvering Allowance (Shaft)	6.0	2.5	8.5		9.0	
Total	129.0	45.5	174.5	37.5	246.0	52.9
B. Transpetration Time						
1. Loading	52.0	43.5	95.5		94.0	
2. Dumping	18.0	8.0	26.0		14.5	
Total	70.0	51.5	121.5	26.1	108.5	23.3
Total Productive Time			296.0	63.6	354.5	76.2
II. NONPRODUCTIVE TIME						
A. Delays						
1. Truck Delays						
a. Breakdown						
b. Normal			10.0		13.0	
2. Loader Delays						
a. Breakdown	14.5		14.5			
b. Avoidable	5.0	27.0	32.0		8.0	
c. Other Load	7.5		7.5			
Total			64.0	13.8	21.0	4.5
3. Other Delays						
a. At Grizzly			69.0		52.5	
b. Nonoperating			36.0		37.0	
Total			105.0	22.6	89.5	19.3
Total Nonproductive Time			169.0	36.4	110.5	23.8
TOTAL TIME OBSERVED			465.0	100.0	465.0	100.0
Number Loads Transported	17	8	25		29	
Mileage Recorded	17.0	5.6	22.6		29	

TABLE 104

TIME STUDY OBSERVATION
Truck no. 13 Type - Dart dump
Mine - Westside Date - June 21, 22
Time in Minutes

Time Division	Heading 2	%	Heading 3	%
I. PRODUCTIVE TIME				
A. Travel Time				
1. To Heading	36.0		22.0	
2. Maneuvering Allowance (Head)	7.0		4.0	
3. To Shaft	62.0		33.0	
4. Maneuvering Allowance (Shaft)	3.0		2.0	
Total	108.0	23.2	61.0	13.1
B. Transpetration Time				
1. Loading	131.0		58.0	
2. Dumping	38.0		9.0	
Total	169.0	36.3	67.0	14.4
Total Productive Time	277.0	59.5	128.0	27.5
II. NONPRODUCTIVE TIME				
A. Delays				
1. Truck Delays				
a. Breakdown				
b. Normal	12.0		13.0	
2. Loader Delays				
a. Breakdown	13.0		92.0	
b. Avoidable	72.0		83.0	
c. Other Load				
Total	97.0	20.8	188.0	40.5
3. Other Delays				
a. At Grizzly	34.0		12.0	
b. Nonoperating	57.0		137.0	
Total	91.0	19.7	149.0	32.0
Total Nonproductive Time	188.0	40.5	337.0	72.5
TOTAL TIME OBSERVED	465.0	100.0	465.0	100.0
Number Loads Transported	21		10	
Mileage Recorded	14.7		11.0	

TABLE 105

TIME STUDY OBSERVATION
Truck no. 78 Type - Dumptor
Mine - Westside Date - June 25, 26
Time in Minutes

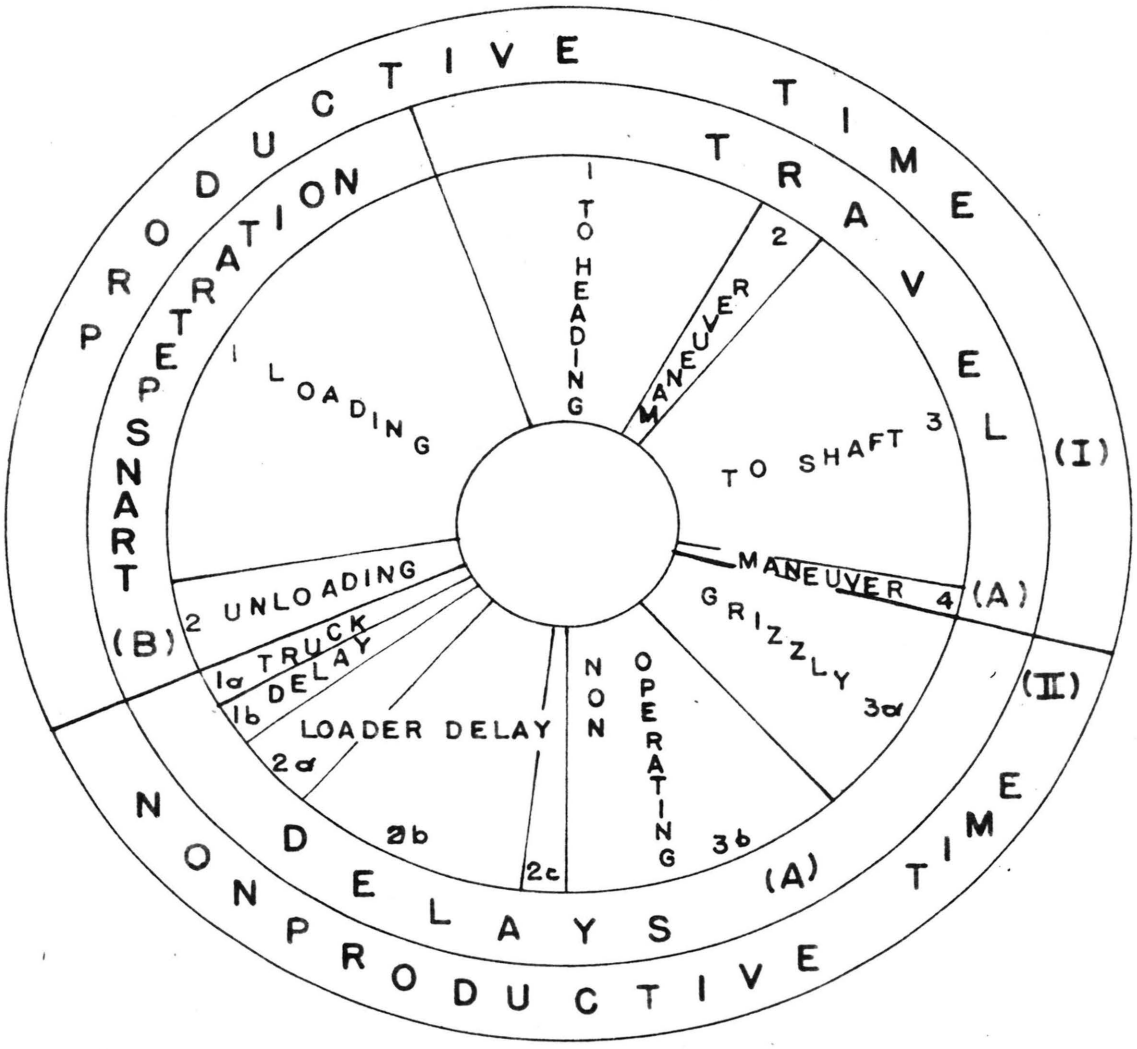
Time Division	Heading 1	%	Heading 1	%
I. PRODUCTIVE TIME				
A. Travel Time				
1. To Heading	82.0		93.0	
2. Maneuvering Allowance (Head)	14.0		16.0	
3. To Shaft	112.0		116.5	
4. Maneuvering Allowance (Shaft)	1.0		0.5	
Total	209.0	45.0	226.0	48.6
B. Transpetration Time				
1. Loading	93.5		103.0	
2. Dumping	6.0		10.0	
Total	99.5	21.4	113.0	24.3
Total Productive Time	308.5	66.4	339.0	72.9
II. NONPRODUCTIVE TIME				
A. Delays				
1. Truck Delays				
a. Breakdown	52.0			
b. Normal				
2. Loader Delays				
a. Breakdown			23.0	
b. Avoidable	28.5		25.0	
c. Other Load				
Total	80.5	17.3	48.0	10.3
3. Other Delays				
a. At Grizzly	43.0		52.0	
b. Nonoperating	33.0		26.0	
Total	76.0	16.3	78.0	16.8
Total Nonproductive Time	156.5	33.6	126.0	27.1
TOTAL TIME OBSERVED	465.0	100.0	465.0	100.0
Number Loads Transported	24		28	
Mileage Recorded	24		28	

TABLE 106

TIME STUDY OBSERVATION
General Summary
Mine - Westside Date - June 21 to 27
Time in Minutes

Time Division	Total	%
I. PRODUCTIVE TIME		
A. Travel Time		
1. To Heading	486.5	13.1
2. Maneuvering Allowance (Head)	91.0	2.5
3. To Shaft	661.0	17.7
4. Maneuvering Allowance (Shaft)	36.0	1.0
Total	1274.5	34.3
B. Transpetration Time		
1. Loading	828.5	22.1
2. Dumping	146.5	4.0
Total	975.0	26.1
Total Productive Time	2249.5	60.4
II. NONPRODUCTIVE TIME		
A. Delays		
1. Truck Delays		
a. Breakdown	52.0	1.4
b. Normal	66.0	1.8
2. Loader Delays		
a. Breakdown	159.5	4.3
b. Avoidable	359.5	9.6
c. Other Load	58.5	1.6
Total	695.5	18.7
3. Other Delays		
a. At Grizzly	344.0	9.2
b. Nonoperating	431.0	11.7
Total	775.0	20.9
Total Nonproductive Time	1470.5	39.6
TOTAL TIME OBSERVED	3720.0	100.0
Number Loads Transported	178	
Mileage Recorded	158	

FIGURE 38



TIME DISTRIBUTION CHART

TRUCK HAULAGE

WESTSIDE MINE

TOTAL TIME 3,720 MIN LOADS 178

SUMMARY AND CONCLUSIONS

A time study investigation discloses the overall inefficiency of any system. The results of this study in the Tri-State District reveal the traffic congestion of the main haulage and the causes of delays. Supplementary studies of individual unit performance divulges the operational effectiveness of the unit.

Time divisions are defined so that all operations which can be construed to represent productive effort are included in productive time classification. All nonproductive time should be held to a minimum. This factor should not be greater than 30 per cent, as discussed in the first part of this paper.

The total time during which the haulage system was investigated represents 74 shifts. The time distribution for all mines is summarized in TABLE 107. The division of time can be visualized more clearly by referring to FIGURE 39.

Nonproductive time represents 44 per cent of the total working time. The controlling elements in nonproductive effort are reviewed subsequently.

Delays due to truck breakdowns consumed 4.2 per cent of the time. If the proposed retirement of the haulage units is accomplished, this cause of delay can be reduced to a minimum. This can be achieved by keeping the retired units on a reserve or stand by basis, to be used whenever operating trucks develop mechanical trouble. A more thorough and comprehensive system of inspection and preventive maintenance should be planned and executed to reduce this factor.

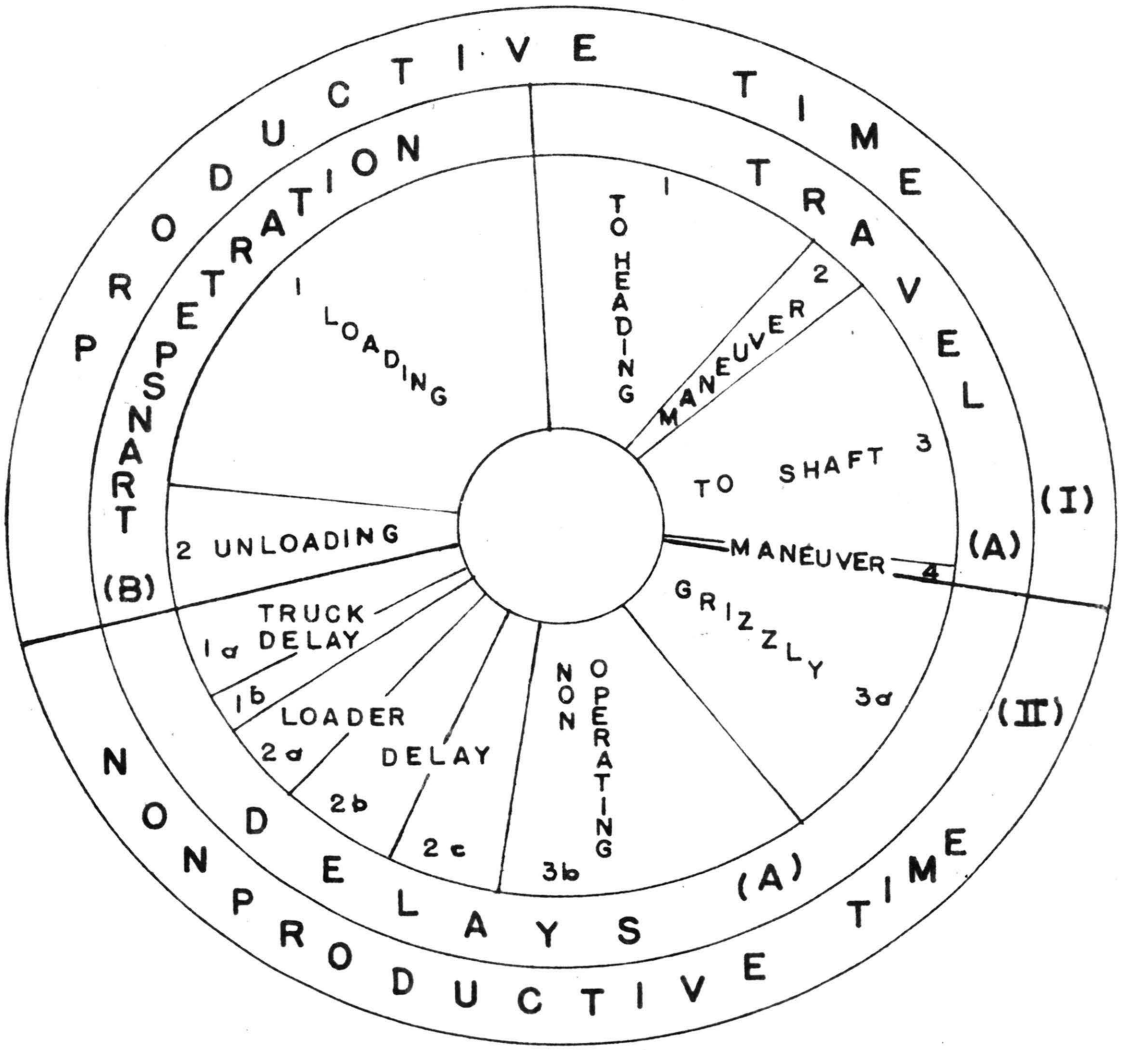
The normal truck delays fall well within the estimated allowable

TABLE 107

TIME STUDY OBSERVATION
General Summary
Mines: Big Chief, Big John, Blue Goose 1 & 2, Goodwin, Humbahwattah, Kenoyer, Netta, Piokee, and Westside.
Time in Minutes

Time Division	Total	%
I. PRODUCTIVE TIME		
A. Travel Time		
1. To Heading	4,166.5	12.1
2. Maneuvering Allowance (Heading)	867.0	2.5
3. To Shaft	4,547.5	13.2
4. Maneuvering Allowance (Shaft)	197.0	0.6
Total	9,778.0	28.4
B. Transpetration Time		
1. Loading	7,707.5	22.4
2. Dumping	1,772.0	5.2
Total	9,479.5	27.6
Total Productive Time	19,257.5	56.0
II. NONPRODUCTIVE TIME		
A. Delays		
1. Truck Delays		
a. Breakdown	1,433.0	4.2
b. Normal	583.0	1.7
2. Loader Delays		
a. Breakdown	1,228.0	3.5
b. Avoidable	1,648.5	4.8
c. Other Load	1,645.5	4.8
Total	6,538.0	19.0
3. Other Delays		
a. At Grizzly	4,110.5	12.0
b. Nonoperating	4,504.0	13.0
Total	8,614.5	25.0
Total Nonproductive Time	15,152.5	44.0
TOTAL TIME OBSERVED	34,410.0	100.0
Number Loads Transported	1273	
Mileage Recorded	1184.8	

FIGURE 39



TIME DISTRIBUTION CHART

TRUCK HAULAGE

GENERAL SUMMARY

MINES — BIG CHIEF, BIG JOHN, BLUE GOOSE 182, GOODWIN, HUMBAHWATTAH, KENOYER, NETTA, PIOKEE, WESTSIDE.

TOTAL TIME = 34,410 MIN — TOTAL LOADS = 1,273

time, for the system as a whole, and are justified.

Shovel breakdown delays could be reduced also by an intensified inspection program. Provision for alternate truck routes after a shovel breaks down would aid further in reducing delays.

Avoidable shovel delays are attributed generally to the operator. This represents an unnecessarily large proportion of the shift time. Better operator training and cooperation can be secured if the supervisory personnel will attempt to improve each individual's performance.

Delays due to other loads, which represents 4.8 per cent of the available time, can be reduced materially. Better planning of routes and distribution of equipment are the most important necessary improvements. In many mines the haulage capacity is far greater than the available loading ability. Whenever this situation exists, this type of delay will result. In some operations the retirement of one haulage unit will partially solve the problem.

Grizzly delay is a major problem and is an important component in all mines as evidenced by the total time consumption of 12 per cent. Poorly designed dumping ramps and small surge capacity grizzly-hoppers contribute also to this situation. Whenever possible, drive-over ramps should be constructed with provision for easy screen clearing. An example of good ramp design is to be found in the Blue Goose 1 Mine (see FIGURE 21). The use of more haulage units than is warranted by production demands will also help to aggravate the delay problem.

Nonoperating time for the combined mines falls within the expected or predicted maximum allowance. Although many mines maintain a lower figure than this, it may be expected that other mines can reduce nonoperating time consumption.

Within the productive time classification, the time distribution should be modified for greater efficiency. The travel time/transpetration time ratio is 1/0.97 for the general average. For such a general average this ratio is very low. As studied, most travel cycles permit the realization of a 1/0.50 ratio. In the case of the travel heading/travel shaft/loading time proportion, the average result was 0.92/1/1.70, whereas the expected norm is 1.00/1/1.00. These results disclose, as has been pointed out throughout this paper, that loading machines are not operating at their fullest capabilities. This can be attributed not only to lack of training, incompetency and general unwillingness of the operators, but also to improper allocation and distribution of equipment. Some loaders are more adaptable to certain loading zones than others. This is overlooked often in distributing shovels to heading assignments. In distributing loaders not only the loading zone conditions should be considered, but also the haulage capacity to be assigned to the loader, and the haulage distance.

The results of the investigation show that the haulage system, as presently practiced, is inefficient. This is true no only because a large proportion of the average shift time is nonproductive, but also because haulage capacity available is far greater than delivered production. Each mine has its own problems and haulage congestions so that each one should be studied separately before presenting specific recommendations for changes. There are, however, several general considerations that should be noted.

A. Loaders

1. Shovels are used often in places where their effectiveness is hampered.

a. Eimco shovels operate best in large production stopes, which have high roofs and fairly smooth floors. Loading rate should be approximately 3 tons a minute.

b. Other shovels can operate in sheet ground areas and restricted areas. Loading speed should be more than 2 tons a minute. To increase effectiveness, proper operator training is necessary to observe such factors as: correct angle spotting of trucks for minimum shovel movement; keeping approach area clean to simplify truck maneuverability; and working muck pile between loading cycles.

2. Draglines operate most effectively in low stopes with wide mining faces. A competent operator should load at a rate of 1.5 tons a minute or better.

3. Breakdown delays can be minimized by more rigid inspections and early replacement of worn parts.

4. If it is feasible, the faster loader should be used in the shorter runs. The travel time cycles in short runs will coincide more closely with loading time cycles of these shovels, and thus delay will be avoided on other loads. In addition, the loader operator will have time to prepare for the next load.

B. Trucks

1. Where runs do not exceed one mile, a truck should be expected to have an output of 6,500 ton-miles, or at least 25 loads in any single shift.

2. At any time there should be no more haulage units than is necessary to maintain the desired mine production. Excessive numbers of trucks only serve to congest loading zones and dumping ramps, which

effectively slows down the entire system.

3. If enough units are present to provide overcapacity, one or more units should be retired and properly maintained as reserve equipment.

C. Distribution

An essential factor in the proper operation of a haulage system is proper apportionment of equipment. The supervisory personnel should consider all factors, i.e., loading capacity, available tonnage, and travel time cycles, in dispatching equipment to the various parts of the mine. Trucks should be given routes to follow with alternate possibilities in case of breakdowns or other contingencies.

The proper coordination of loading and haulage cycles is dependent on selective planning by the supervisory staff. With close attention to these factors, effective and efficient production can be attained.

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