1947

Performance study of mechanical loading machines in coal mining practice

Kor Uyetake

PERFORMANCE STUDY OF MECHANICAL LOADING MACHINES IN COAL MINING PRACTICE

BY

KOR UYETAKE

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A

THESIS

submitted to the faculty of the

SCHOOL OF MINES AND METALLURGY OF THE UNIVERSITY OF MISSOURI

in partial fulfillment of the work required for the

Degree of

MASTER OF SCIENCE IN MINING ENGINEERING

Rolla, Missouri

August 1947

Approved by J. D. Forrester

Professor of Mining Engineering

ACKNOWLEDGMENTS

This performance study of the mechanical loaders was made during the tenure of an appointment as Research Fellow in Mining Engineering with the State Mining Experiment Station, School of Mines and Metallurgy, University of Missouri. Grateful acknowledgment is made of aid thus provided.

The author wishes to express his appreciation for the counsel and the guiding interest of Dr. J. D. Forrester, Chairman, Department of Mining Engineering, Missouri School of Mines and Metallurgy. To Professor D. R. Schooler of the same department, the author is particularly indebted for the many helpful suggestions and untiring assistance rendered in the preparation of this study. The extraordinary generosity of the officials of various coal companies in Southern Illinois deserves specific mention. The mine superintendents and the engineers cooperated and made available much useful information. To them special acknowledgment is made.

Much useful information was provided by loading machine manufacturers.

PREFACE

This thesis is submitted to the Faculty of the School of Mines and Metallurgy of the University of Missouri in partial fulfillment of the work required for the degree of Master of Science in Mining Engineering.

The data included herein were obtained by making time-studies in the coal mines of six large companies in Southern Illinois. The time-studies were made on one coal loading crew for one complete shift.

The field investigations were made during the summer months of 1947.

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INTRODUCTION

In the transition from hand-loading methods in coal mining to mechanical loading methods various types of equipment have been developed to do the same job. Among the coal mining operators and among miners in the coal fields, various equipment preferences have developed. This produces a sharp difference of opinion. Emotional statements of such ideas based upon personal likings do not contribute materially to coal mining progress - it merely serves to confuse the issue. The author feels that the opinions on the loading equipment should be based upon some factual data rather than the preconceived idea. Often it is difficult to obtain such data that would give a clear-cut picture of certain equipment; and often it is not always easy to analyze facts after they are obtained so as to provide unquestionable correct conclusions.

Direct comparison of loading equipment cannot be made in operating mines because to do so the loading units must be working in the same territory and under identical conditions. A general comparison however, may be made by analyzing the performance study made by making time-studies of the operating units.

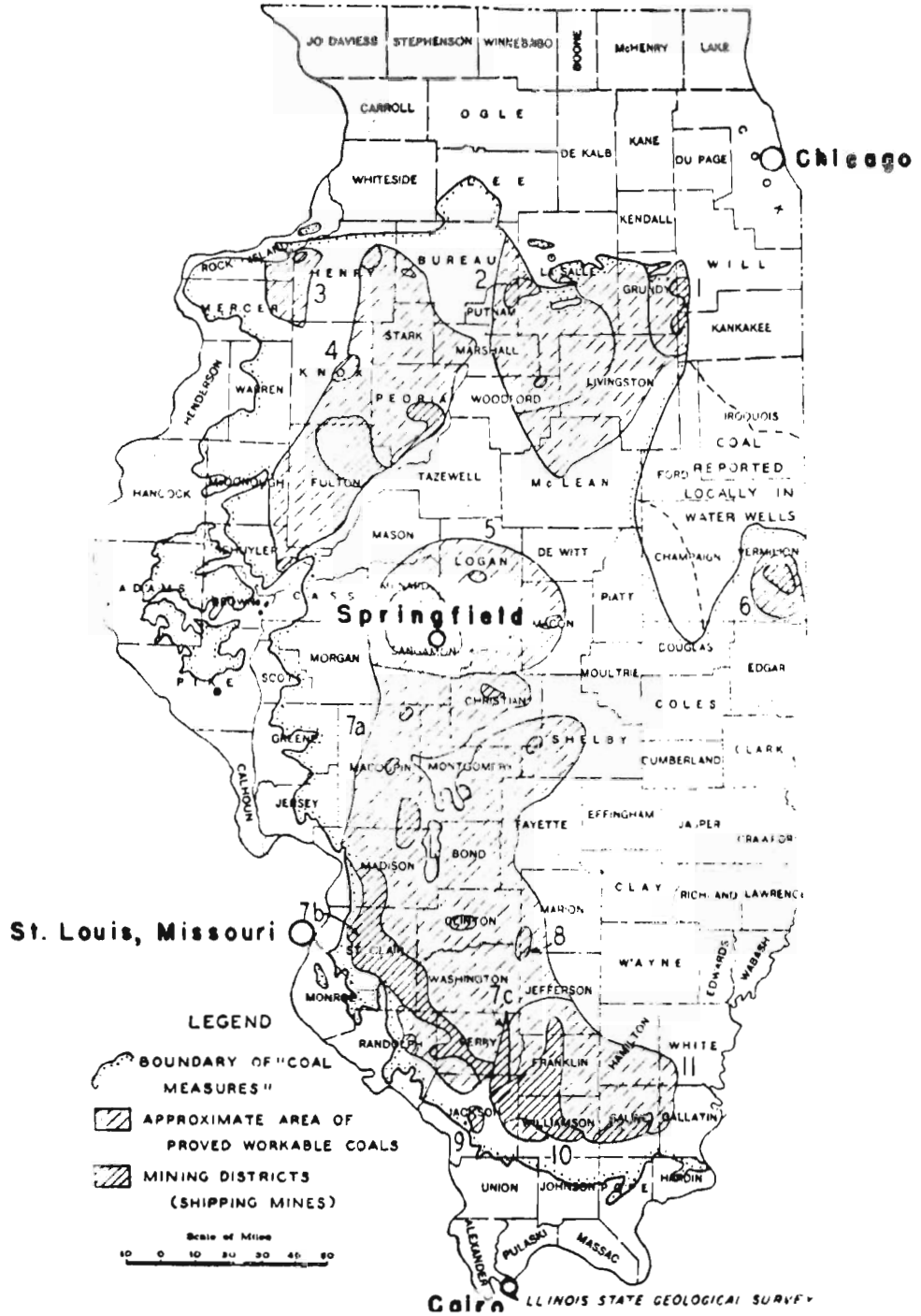
Performance studies enable the coal mine operators and others interested in coal mining to have some operational data of the coal-loading units and of the coal loading crew.

GEOLOGY

Ries[1/] designates the coal field studied as the Eastern Interior field

1/ Ries, H., Economic Geology. 7th ed., N.Y., John Wiley, 1942, pp. 8-30

"This is an oval, elongated basin extending northeast and southwest, with the marginal beds dipping gently toward the lowest portion, which lies



Map I Map of Illinois showing location of principal coal mining districts.

in Illinois, where the beds are nearly horizontal. It covers most of Illinois, southwestern Indiana, and a small part of western Kentucky, with some outliers in Missouri near St. Louis and St. Charles, and two in Illinois. The coal seams occur in the lower portion of the section, and hence outcrop around the margin, the mining operations being therefore confined to a narrow belt, because near the center of the basin the coal beds underlie too great thickness of unproductive strata to permit profitable workings under present condition."

This study was made in the Herrin (No. 6) coal bed of the Illinois series.* This seam ranges from five feet to twelve feet, the average

* Nine commercially important coal beds which correspond closely to the Carbondale formation of the Pennsylvania system found in Illinois.

mined is from seven feet to nine feet. In the southern Illinois district the general dip is one to two percent to the northeast. The Herrin seam is characterized throughout the southern part of Illinois by the "blue band", which is a one to two inch parting of blue-gray carbonaceous clay, sometimes locally pyritized. It generally occurs from one to two feet above the base of the bed.

MINING PRACTICES

In southern Illinois mechanical mining did not start until after 1920 when the operators adopted it to compete with other fields paying lower labor wages. By 1933, two-thirds or more of the southern Illinois mines were using mechanical equipment for mining coal. In 1936 rubber-tired haulage was introduced, which steadily increased production through trials and experiments.

Shafts predominate in southern Illinois, however newer operations have installed slope openings which use belt haulage.

Mining, with few exceptions, is based on the panel system (see Figure 1 and Figure 2) in which the working territory is divided into individual sections or panels normally protected by solid pillar on all sides. Rooms, as usual in this system of mining ordinarily are turned at right angles to the panel entries. The number of rooms on a panel range from 16 to 24 on each side, making the total rooms per panel 32 to 48. Usually, two loading machines work in one panel, one on each side. Room centers range from 45 to 60 feet; the width is generally 24 to 28 feet; and the depth normally ranges from 250 to 300 feet.

In the preparation of coal for loading, the seam is first cut (with a cutting machine) horizontally across the bottom of the face or the top of the face, or it may be cut vertically down the face (see Figure 3). The cutting machines are either track mounted or mounted on rubber tires. In the next operation of preparing coal for haulage the drillers put in blasting holes with auger drills. Post-mounted drills are used to a great extent but mobile drilling units are becoming more favored. As the Illinois State Mining law does not permit on-shift shooting with explosives the coal is blasted after the men, except those who are shooting the rounds, have all been removed from the underground. Coal is blasted by either using permissible powder or carbon-dioxide shells (Cardox). During the recent years, the compressed air shells or Airdox shells have been used because of the definite advantage of shooting on-shift.

A typical working crew includes:-

Track Haulage:		Shuttle Co. Haulage:	
1. Loader Operator	1	1. Loader Operator	1
2. Loader Helper	1	2. Loader Operator Helper	1
3. Cutting Machine Operator	1	3. Cutting Machine Operator	1
4. Cutting Machine Helper	1	4. Cutting Machine Helper	1

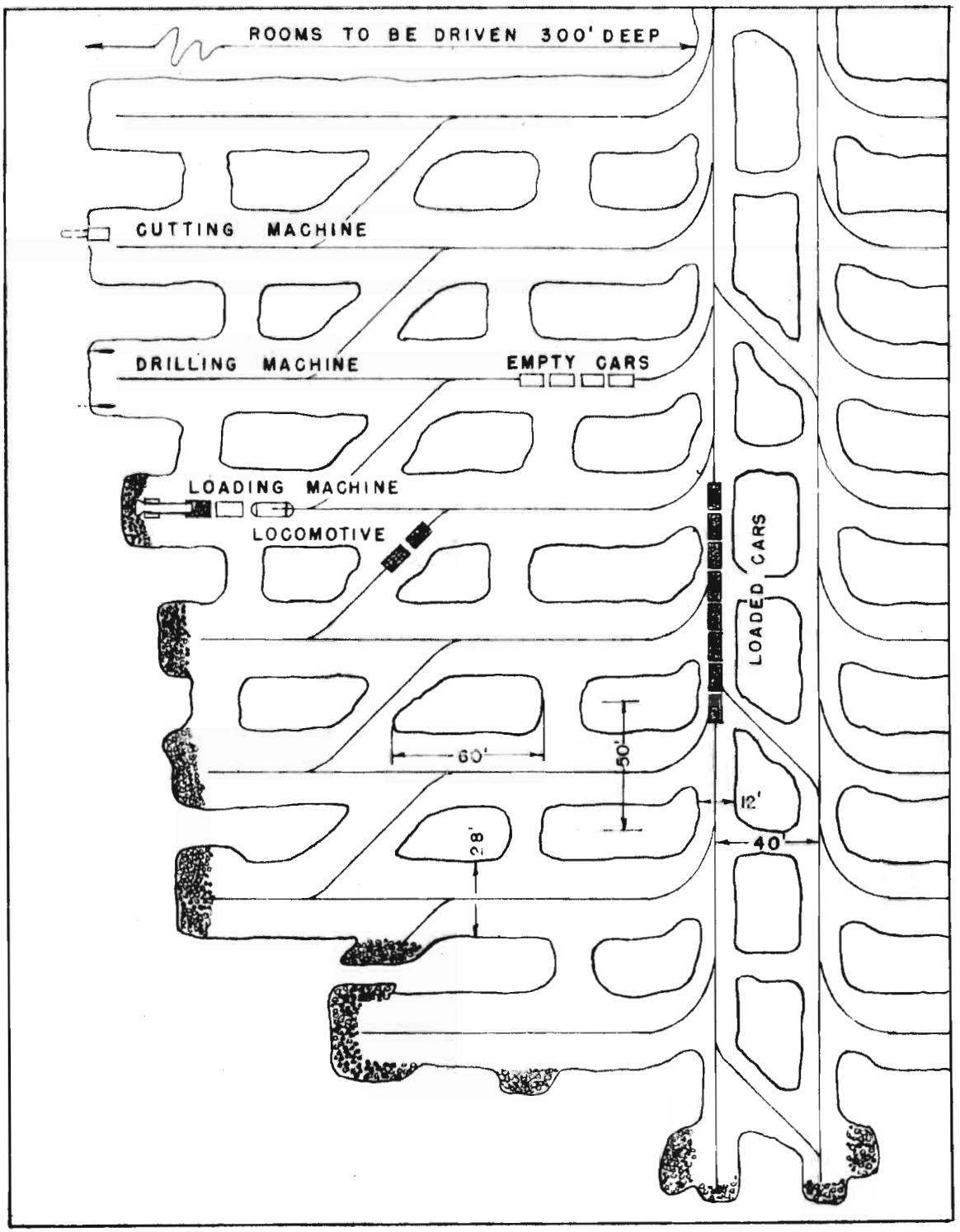


Fig.1 Advancing panel system with mobile loader and one battery locomotive.

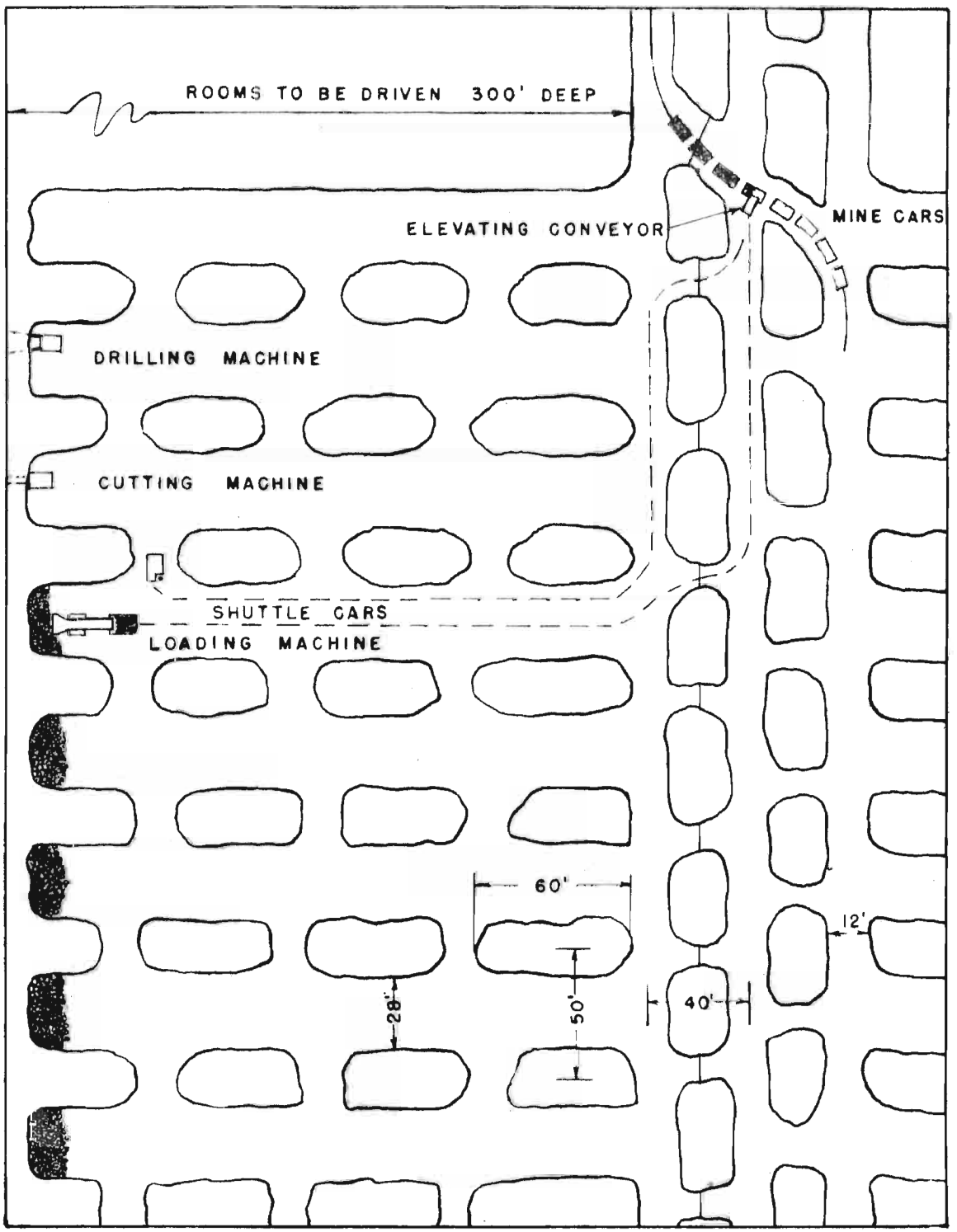


Fig.2 Advancing panel system with mobile loader and two cable-reel shuttle cars.

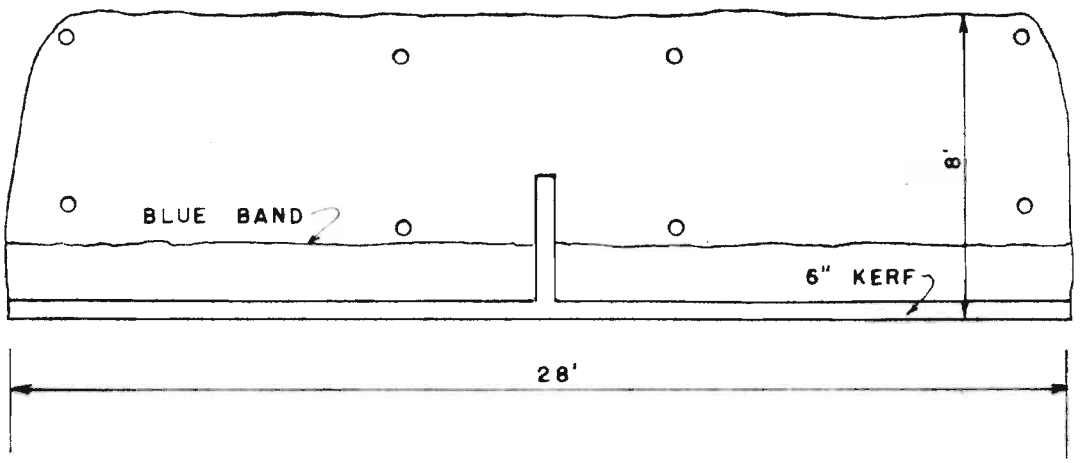
Track Haulage (con't)		Shuttle Co. Haulage (con't.)	
5. Drillers	2	5. Drillers	2
6. Face Man	1	6. Face Man	1
7. Dust Man	1	7. Dust Man	1
8. Timberman	1	8. Timberman	1
9. Tracklayers	1½*	9. Gathering Motorman	1
10. Gathering Motorman	2	10. Gathering Trip Rider	1
11. Gathering Trip Rider	1	11. Relay Motorman	½
12. Relay Motorman	½	12. Relay Trip Rider	½
13. Relay Trip Rider	½	13. Shuttle car operator	2
14. Shot Firer	½	14. Shot Firer	½
15. Repairman	½	15. Repairman	½
16. Brattice man	¼	16. Brattice man	¼
17. Foreman	½	17. Foreman	½
Total	17¼	Total	16 3/4

* As many as 4 or 5 extra men work with the loading crew when it is necessary to do considerable track work and/or switch laying.

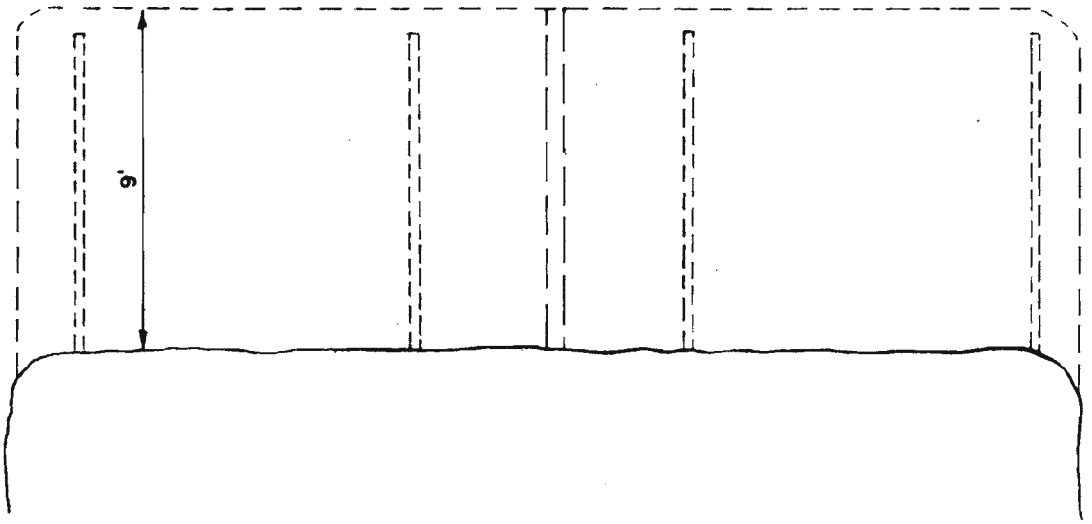
LOADING EQUIPMENT

The mobile coal loading machines which are now in use may be divided into two popular classes in accordance with the type of mounting. These are the crawler mounted loading machines and the track mounted loading machines. Each essentially is comprised of a gathering mechanism and a conveying system supported on a frame. The electrically driven motors and the control system are also mounted on the frame, which in turn are mounted on the tramming gear. (See Figure 4, Figure 5, and Figure 6).

The gathering mechanism, depending upon the type of machine, consists of gathering arms, or gathering chains, or shovels; the object of



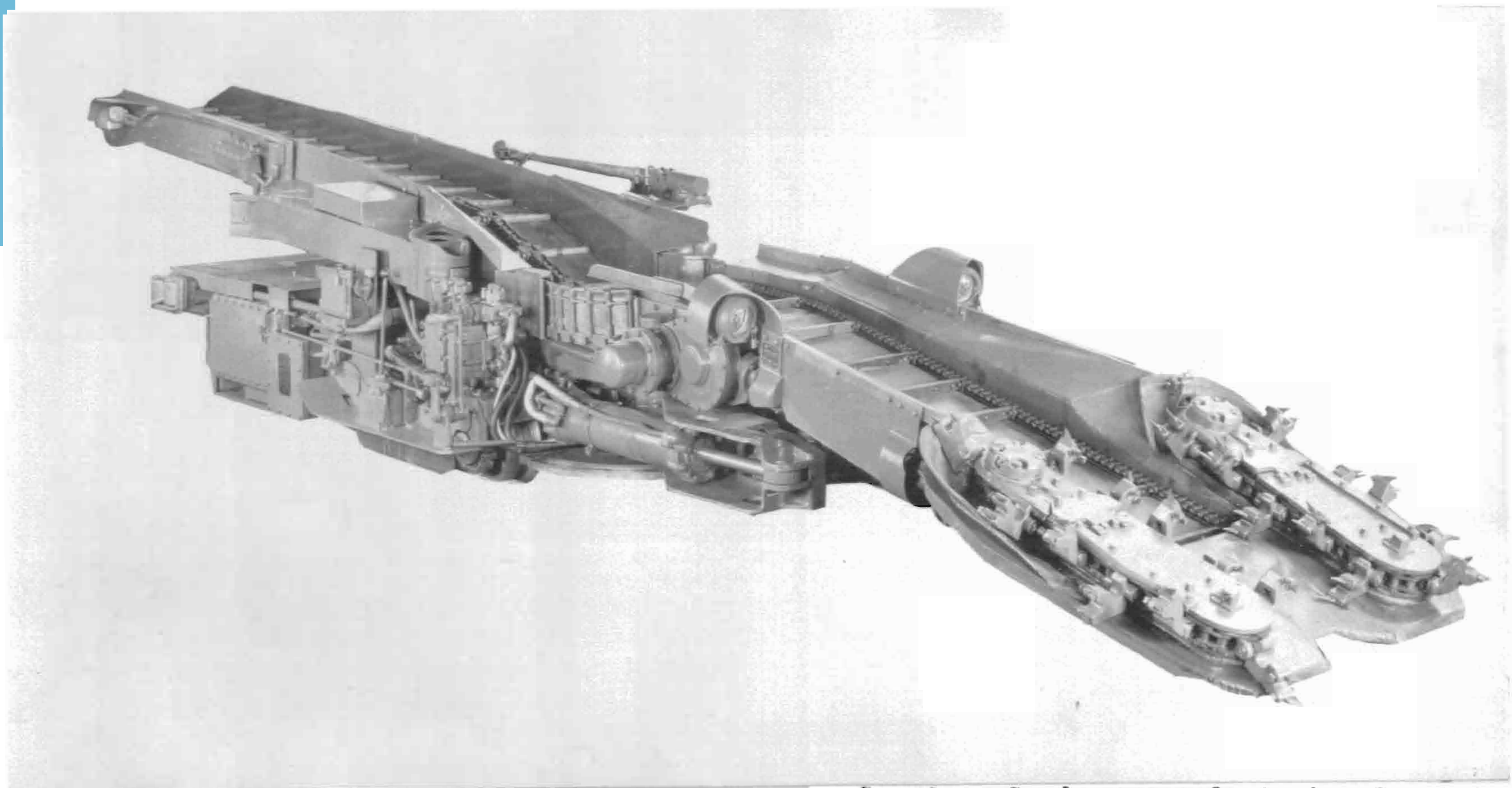
FACE ELEVATION



PLAN VIEW

SCALE 1" = 5'

Fig. 3 Typical face preparation.

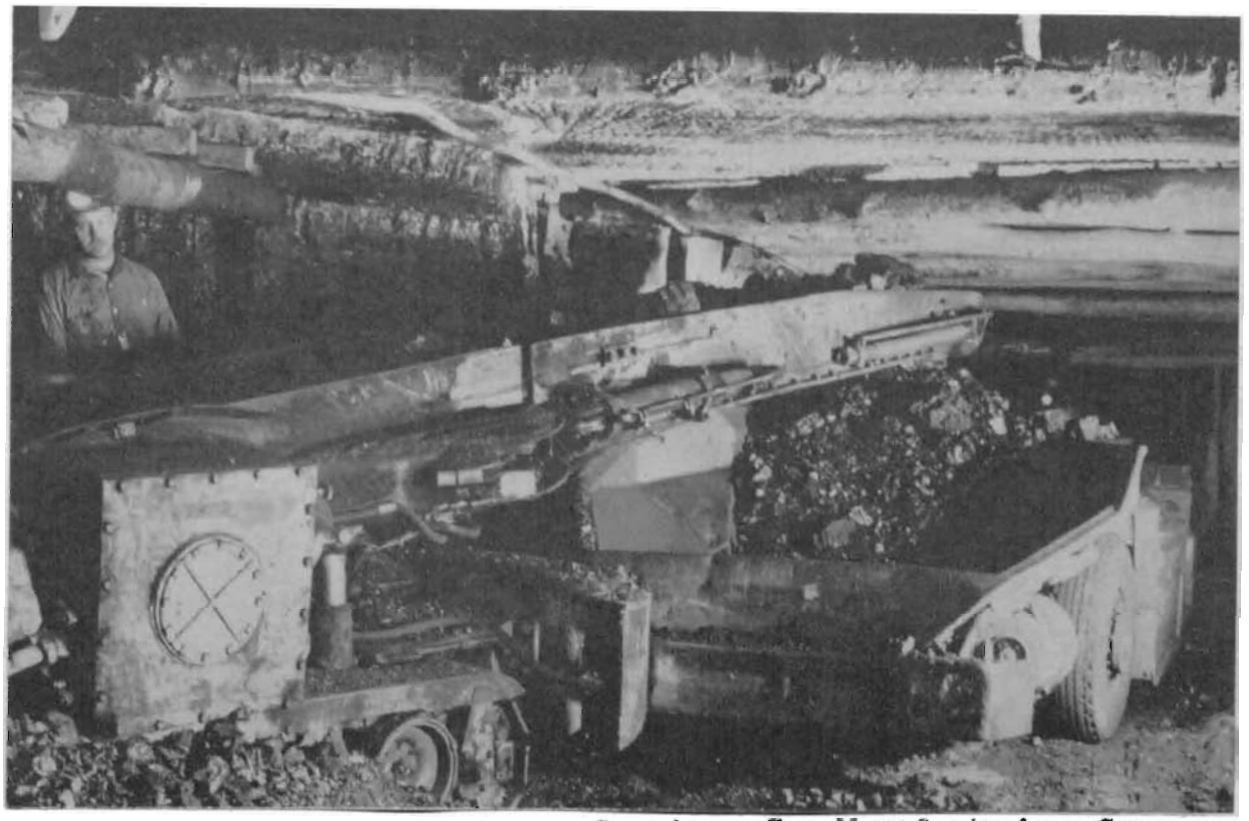


Courtesy Goodman Manufacturing Company

Fig. 4 Track-mounted loading machine

Courtesy Joy Manufacturing Company

Fig. 5 Crawler-mounted loading machine



Courtesy Joy Manufacturi ng Company

Fig. 6 Crawler-mounted machine loading shuttle car

these mechanisms being to pull or drop the coal into the conveying system which lifts the coal up and moves it back to the mine cars or the shuttle cars. The 11 B U Joy coal loading machine, the Goodman 460 or Clarkson 24 coal loading machine, and the Myers-Whaley shovel respectively, are good examples of different types of gathering heads. The gathering mechanism may also dig tight coal although such digging action reduces the efficiency of the loading machine.

Given[2] describes the features of the two types of loading machine.

2/ Given, I. A., Mechanical Loading of Coal Underground, N.Y., McGraw H ill, 1943. pp. 108-109

With the crawler mounted equipment, the loading head and the frame normally are integral. In other words, the loading head cannot be swung from side to side independent of the mountings; which means that provision is made for a wide tail swing to accomodate changes in direction of the head. In most crawler mounted machines, the tail or the rear conveyor swings 45 degrees to each side of the center-line of the machine. The two machines, however, are built with the conveying system in two parts, with a hopper between, which permits swinging the rear conveyor a full 90 degrees.

On the track-mounted machine, the loading head is normally pivoted so that even though the main frame and the mounting stay in one position the head can be swung up to 90 degrees to each side of the centerline to reach the coal. Since it seldom is necessary to swing the rear conveyor except on curves, and as the car follows right behind the machine on the same track, the rear conveyor swings only 15 to 20 degrees on each side of the centerline. However, swings up to 40 to 45 degrees may be had although this maximum is seldom required.

TIME STUDY PROCEDURE

The purpose of time study is to measure effective work. It seeks to point out waste effort, lost time and inefficient management. Co-ordination of men and machine can be obtained by detailed analysis of time study records followed by the application of corrective measures for the elimination of unnecessary losses. The time studies of the loading machines were made by the time study man being stationed at the loading machine in production, observing and noting the time elements. The required equipment included: a stop watch, observation sheets mounted on a clip board, several soft pencils, and a measuring tape.

The time taken in performing a given operation or activity is regarded as the time elapsing between the nearest five seconds an operation is begun to the nearest five seconds it is completed. Fig. 7 is a sample Observation Sheet with the recordings entered. The summary for each shift is recorded on the back of the Observation Sheet as shown in Fig. 8 with the recordings entered. This time study begins with the start of the shift time. "Man-hoist and wait for man-trip" in combination is the first element recorded. This includes, waiting for the man-hoist, hoisting of men, and waiting for the man-trip to leave for their respective places. During underground "man-trip" time or travel time the men are transferred from the man-trip station at the shaft to the man-trip station at the working place. It is recorded to the nearest minute. "Get-ready time" is the time elapsing between the time the last man left the man-trip to the time the loading operation started. This period is used for any preparation needed for loading procedures. "Get-ready time" was also posted to the nearest minute. Productive time is posted to the

Time Study Sheet No. 1

Name of Company Franklin County Coal Co. Name of No. of Mine Royalton #7

Location of Mine Royalton, Illinois Date 6-11-41

Territory in Mine 25 & 26 S N4W Crew Foreman Thomas Young

Type of Haulage Shuttle Car Ave. Car loaded 4.23 T / Pit Car 6.3 T / Shuttle car

Type of Machine 11 BU Joy

Operator Edwards Shuttle Car Oper. Watts John Motorman —

Helper Webb Trip rider

Loading in Room 1-8 Entry

Min. Moving from Room to Room

7-00 - 7:35 Man-Hoist; 7:35 - 7:54 Travel time; 7:54-8:00 Get ready

Car No.	Car Under	Car Out	Change Time	Loading Time	Total Time	Car Off Track	Shift Mach.	Break Lump	Tight Coal	Mech. Delay	Low Power	Remarks
1	8] 00:00	02:05	0	2:05	2:05						Shuttle Car Change = 100'	
2	02:45	05:35	:40	2:50	3:30							
3	06:00	08:26	0:25	2:25	2:50							
4	09:25	12:35	1:00	3:10	4:10							
5	13:05	18:25	0:30	5:20	5:50							
6	19:25	22:15	1:00	2:50	3:50							
7	23:05	25:20	0:50	2:15	3:05							
8	27:10	29:30	1:00	2:20	4:10							
9	30:10	32:50	0:40	2:40	3:20							
10	33:45	36:05	0:55	2:00	3:15		:20					
11	38:00	40:30	1:55	2:30	4:25						Wait on MTs 9:00	
12	52:35	9] 10:45	3:05	7:25	30:15					1	Cable Repair 10:45	
13	11:40	26:15	0:55	5:15	15:30				3:00		Double load 6:20	
14	27:20	35:40	1:05	8:20	9:25							
	Move to Rm 8				1:30*		* Note: shuttle car followed Joy					Change = 70' Track 20'
15	37:10	40:00	0:00	2:20	4:20			:30				

Fig.7 Sample of time study sheet.

SUMMARY

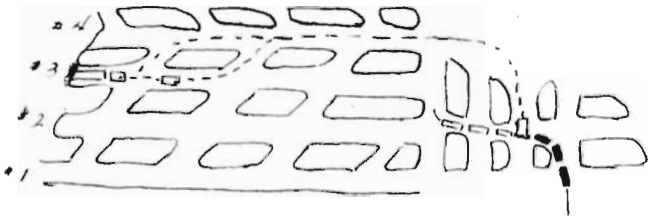
Total No. Cars Loaded 126 in 226:35 ~~minutes~~.

Ave. Loading time 1 min 48 sec

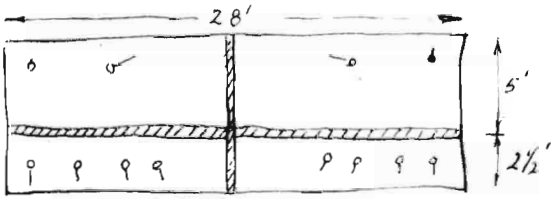
Ave. change time 48 sec

Distance cars must be pulled to change 280'

Sketch of Switching Arrangement:



Sketch of Drilling and Shooting Procedure:



Mining Method Panel

Height of Coal 7½ Width of Place 28'

Roof Condition Good

Prominent Delays Digging tight Coal

Recommendations The use of one additional shuttle car does warrant consideration.

Fig. 8 Sample of time study sheet.

nearest five seconds.

The first car loaded during the shift is called car number one; the cars loaded thereafter are numbered consecutively.

"Car under" designates the beginning of loading time for the coal loading machine.

"Car out" denotes the time a particular car is loaded. The loading time is the interval elapsing between "car under" and "car out" and is entered in the "loading time" column.

"Change time" is that time required to remove the loaded car from the loading machine and to replace it with an empty car.

Delays are entered when any delay or interruption occurs in the loading operation.

Total time includes the change time, the loading time, loader delays, and other delays.

When extraordinary length of time is observed in loading or changing a mine car or a shuttle car reasons are given in the remark column.

It is obvious that two elements of operation may occur at the same time. Such would be the case when a mine car is being changed, the loading machine is shifting to be in better position to gather coal. In this instance, the mine car is not in position to be loaded, therefore, the loader delay cannot be charged to the loading machine as "shift machine" is done at the same time the "car change" is made. However, when a mine car is under the loading machine, the shifting of the machine interrupts the flow of coal in the loading operation and therefore, the loading machine is charged with a "shift machine" delay. When the loading machine is trammed from one room to another, oftentimes the cars follow the loading machine to the fresh fall of coal. In other words,

"change time" is simultaneous with the tramming time. For these instances in this study the change time is recorded as zero.

Certain delays appear which are unforseen and which do not have a specific column; these delays are noted and posted as either loader delays or other delays in the remark column.

Continuous watch readings are used during this study.

When the field studies are completed for any one producing unit, results are computed and entered on the summary sheet. The working time consumed by each separate time element is calculated and then grouped in useful totals. The delay times are grouped in similar categories and totaled. Using these totals, a distribution chart of one shift is constructed.

Study No. 1

Track-mounted Goodman 460 mobile loader
and two battery locomotives

This study was made at the Valier Coal Company, Valier, Illinois on June 3 and June 4, 1947. The Goodman mobile loader was then working in the panel entries, 31N and 32N off 8W, 31S and 32S off 8W and the main entries, 7W, 8W, 9W, 10W.

A summary of the two studies is given in Table No. 1. The time distribution charts for these studies are shown in Fig. 9 and Fig. 10.

The entries were driven 12 feet wide. In this particular section the roll in the seam and also the bad top made loading very difficult. In some workings the top rock had fallen upon the track and upon the fall of coal, thus it was necessary to either load the rock out or gob it to the side.

The loading machine study was characterized by low efficiency. The loaders are rated* at 5 ton per minute -- time study shows the actual

* Rated capacity is the average which includes digging and cleaning up the face. The machines are rated by the manufacturers.

tonnages to be nearer to 2 ton per minute. In other words the machine was operated at approximately 40 percent of the rated capacity. The contributing factors to the low efficiency included: difficult mining condition, long tramming distance, and a new operator.

Examination of the summary of the time study discloses that the major delays were caused by bad track. "Broken rail", "loader off track", "car off track" were some of the delays that were directly responsible to poor track work.

In these narrow workings the coal was found only slightly shattered and therefore the loading machine used the gathering head to dig down the

tight coal. Although the actual time in digging tight coal was not definable, the increased loading time establishes the desirability of taking more time to produce a good fall of coal. Improper cutting of the coal resulted in leaving a foot of coal on the bottom. The loading machine was used to root the bottom coal.

The percentage of the productive time spent in loading for one day was 40.6 percent while it was only 34.7 percent the following day. About 31.5 percent of the productive time was consumed in car changing time for each day.

Fast tramming speed and good digging action indicates the suitability of the loading machine for entry work.

Table No. 1

Summary of Time Study 1

Productive time	June 3	June 4
Loading coal	182'15"	152'55"
Car change	142'25	139'35
Tramming time	82'55"	88'15"
Loader delays:		
Broken rail	3'00"	13'10"
Loader off Track	8'10"	
Break rock	4'00	
Power Interruption		1'00"
Cable repair		18'00"
Coal wedged in machine		2'05
Other delays:		
Car off track	10'55	
Lunch		26'15"
Others	15'55"	
Total Productive time	449'35"	441'15"
Make Ready time		
At working place getting ready	3'00"	8'20"
Wait at end of shift	10'25"	0'00"
Travel time - Morning		
Man hoist and wait for man-trip	15'00"	14'00"
Travel time	30'00"	28'00"
Afternoon		
Man hoist and wait for man hoist	13'00"	19'00"
Travel time	19'00"	29'25"
Total Pay time	540'00"	540'00"
Type loader	Goodman 460	Goodman 460
Rated tonnage	5 ton/min.	5 ton/min.
Actual tonnage	2.0 ton/min.	2.3 ton/min.
ton loaded	370	370
No. cars loaded	82	79
Load time/car	2'18"	1'56"
Change time/car	1'30"	1'46"
Percentage of Productive time, loading	40.6%	34.7%
Percentage of Productive time, changing cars	31.6%	31.5%
Percentage of Productive time, tramming	18.4%	20.0%
Percentage of Productive time, delays	9.4%	13.8%

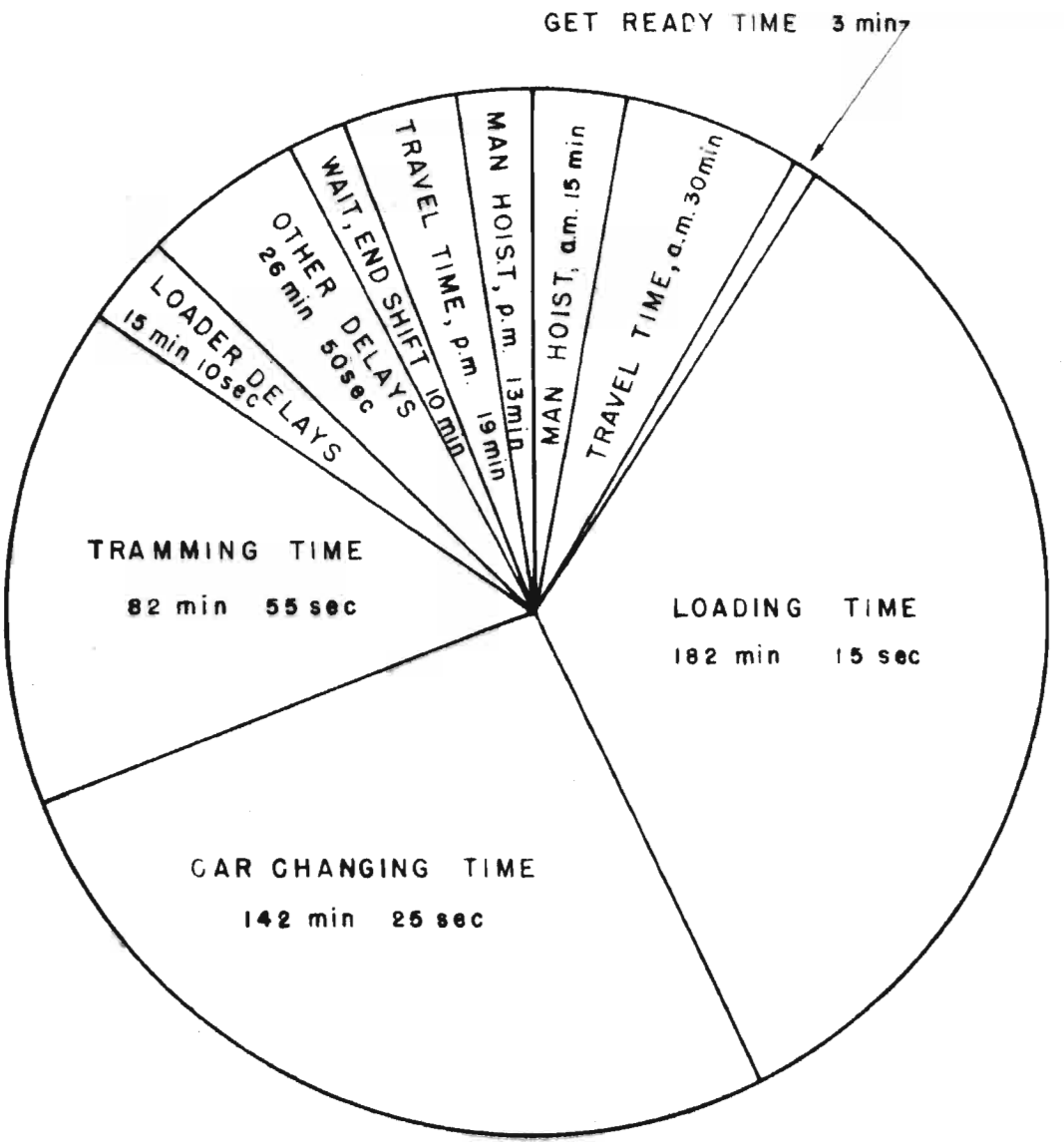


Fig. 9 Time distribution chart of 9-hour shift.

JUNE 3, 1947

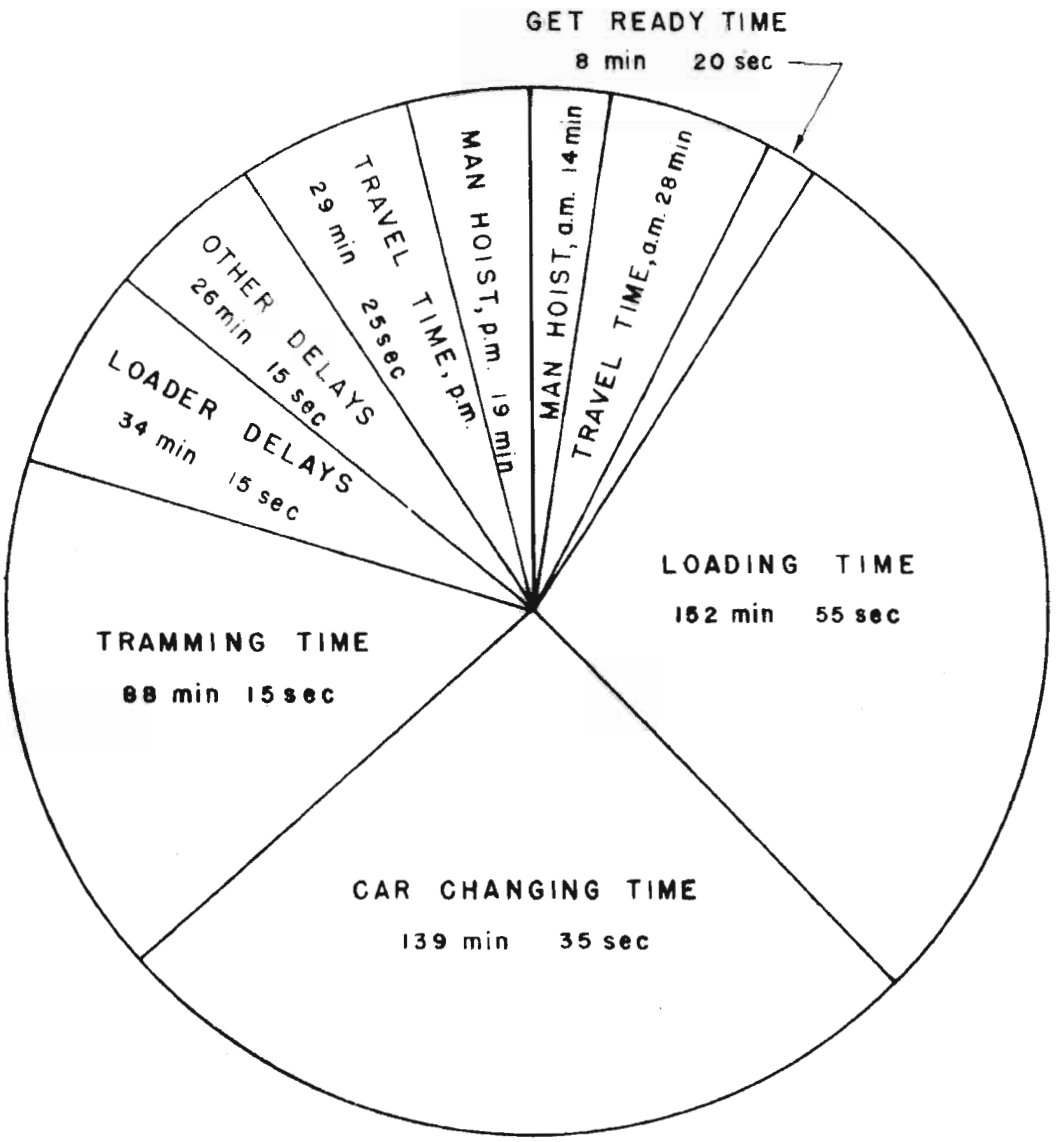


Fig. 10 Time distribution chart of 9-hour shift.
JUNE 4, 1947

Study No. 2

Crawler-mounted 7 B U Joy mobile loader
and two cable-reel shuttle cars

This study was made at the Valier Coal Company, Valier, Illinois on June 5, 6, 7, 1947. The 7 B U Joy mobile loader was then working in the rooms off 29S and 30S of 12W-3SW. The two shuttle cars each had a capacity of 8 tons.

A summary of the three time studies is given in Table 2. The time distribution charts for these studies are shown in Fig. 11, Fig. 12, and Fig. 13.

The rooms were driven 30 to 35 feet wide. The roof condition was good. The bottom condition was only fair as in one instance one of the shuttle cars had worked itself into the fire clay and was delayed nearly 20 minutes before it was in service.

The loading machine is characterized by fairly high efficiency. The loaders are rated at 2 ton per minute while the time-study discloses the actual tonnages to be 1.5 tons per minute, 1.73 tons per minute, and 1.87 tons per minute for the three days. Since shuttle car haulage had been installed just a short time with more experience with the shuttle cars the efficiency of the loading machines could be increased.

Loading operations were frequently interrupted by delays caused by the breakdown of the shuttle cars. Cable repair was the most prominent. In one shift the cable was repaired five times.

Fall of roof cut off power in this section for 54'45" of one shift.

Although the actual time was not taken of the loading machine digging tight coal, longer loading time was noticed. It was indicated that the tight coal was caused by large amounts of bug dust* in the

* Dust developed by the cutting machine

kerf**. By cleaning out more of the bug dust in the undercut or by having the cutting machine cut slower and thereby giving the bug-dust man easier shoveling, it would tend to eliminate tight coal after blasting.

** Opening developed in the coal seam by the cutting machine

Table No. 2

Summary of Time Study 2

Productive time	June 5	June 6	June 7
Loading coal	271'30"	181'20"	195'40"
Car change	93'25"	181'00"	92'30
Tramming time	14'40"	4'20"	36'15"
Loader delays:			
Take down bad top	8'45"		
Shift machine			5'45"
No power			54'45"
Cable repair	2'00"		
Other delays:			
Wait on empties	36'20"	15'00"	15'00"
Motor off track	8'35"		
Take down bad top	45"	2'00"	
Shuttle car stuck			19'45"
Repair shuttle car		12'35"	
Repair cable		39'25"	
Misc.	1'00"		4'20"
Total Productive Time	437'00"	435'40"	423'40"
Make Ready Time			
At working place getting ready	4'00"	4'10"	14'15"
Wait at end of shift	9'00"	11'10"	10'05"
Travel Time - Morning			
Man hoist and wait for man trip	15'00"	15'00"	15'00"
Travel time	30'00"	35'00"	35'00"
Afternoon:			
Man hoist and wait for man hoist	15'00"	9'00"	11'00"
Travel time	30'00"	30'00"	31'00"
TOTAL PAY TIME	540'00"	540'00"	540'00"
Type loader	7 BU Joy	7 BU Joy	7 BU Joy
Rated tonnage	2 ton/min.	2 ton/min.	2 ton/min.
Actual tonnage	1.5 ton/min.	1.73 ton/min.	1.87 ton/min.
Tons loaded	420	338	340
No. cars loaded	68	56	58
Load time/shuttle car	3'59"	3'22"	3'14"
Change time/shuttle car	1'22"	1'36	3'14"
Percentage of Productive time, loading	62.0%	41.6%	46.0%
Percentage of productive time, changing cars	21.3%	41.5%	21.8%
Percentage of productive time, tramming	3.3%	1.1%	8.5%
Percentage of Productive time, delays	13.4%	15.8%	23.7%

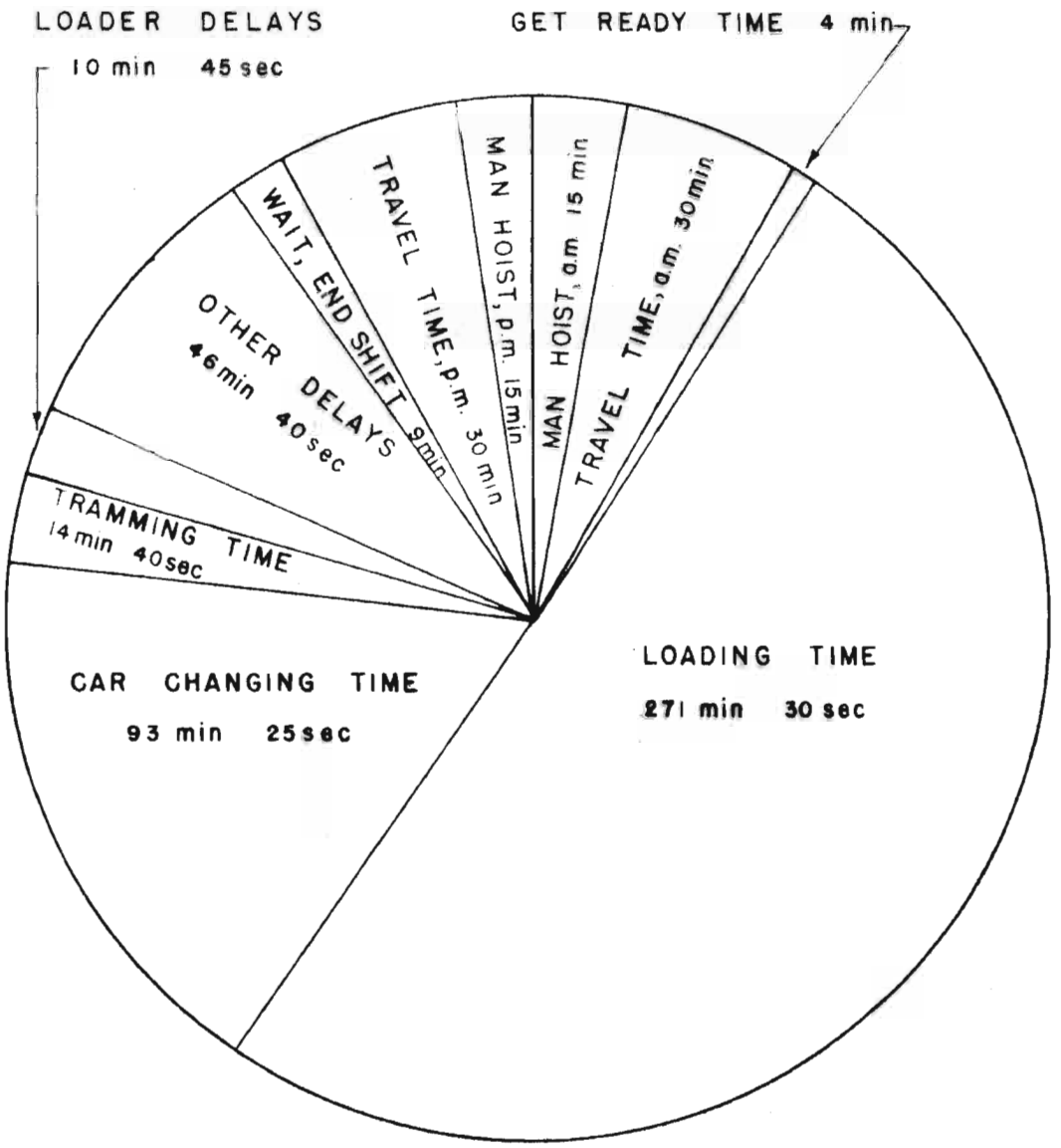


Fig. 11 Time distribution chart of 9-hour shift.
JUNE 5, 1947

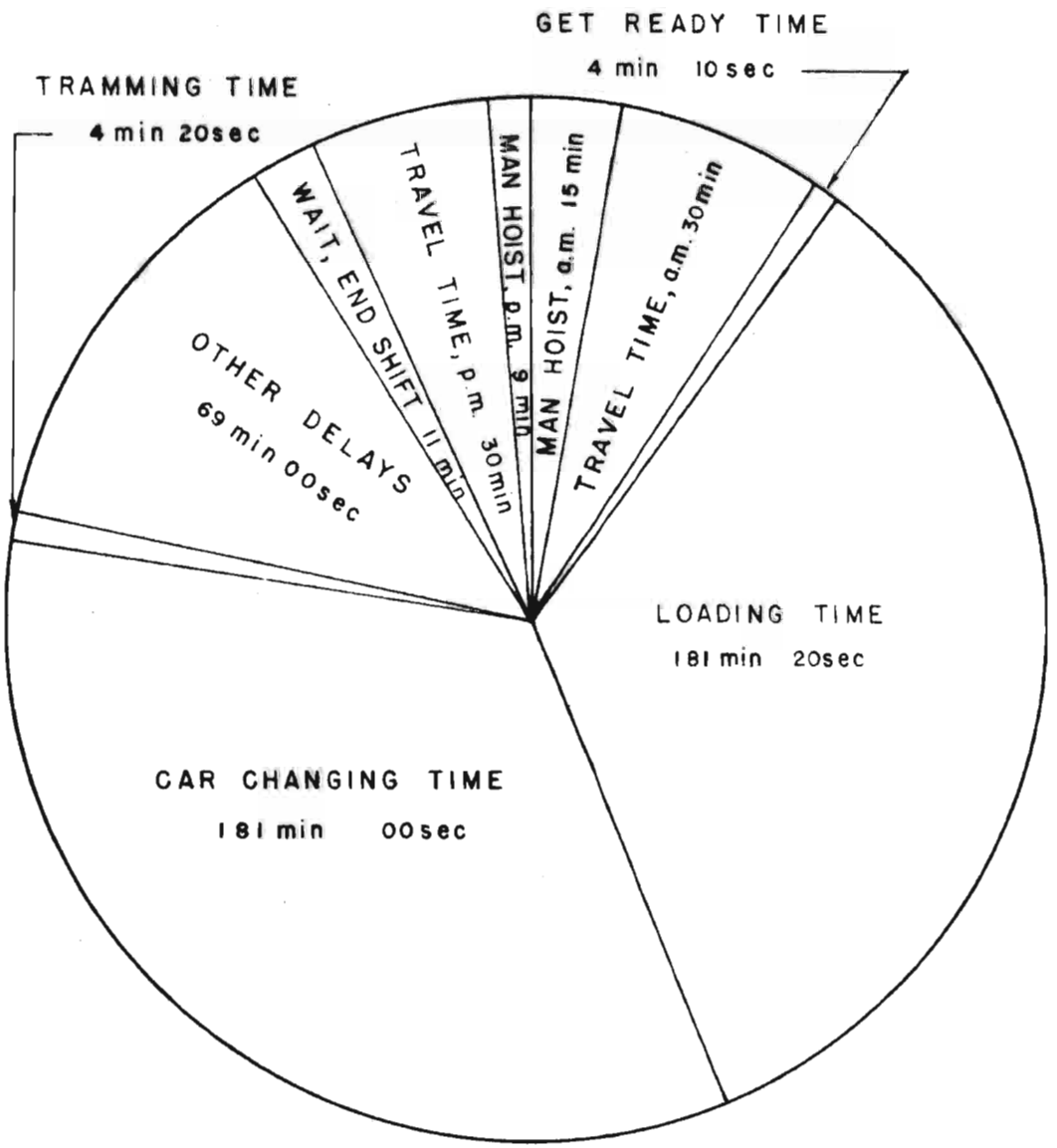


Fig.12 Time distribution chart of 9-hour shift.

JUNE 6, 1947

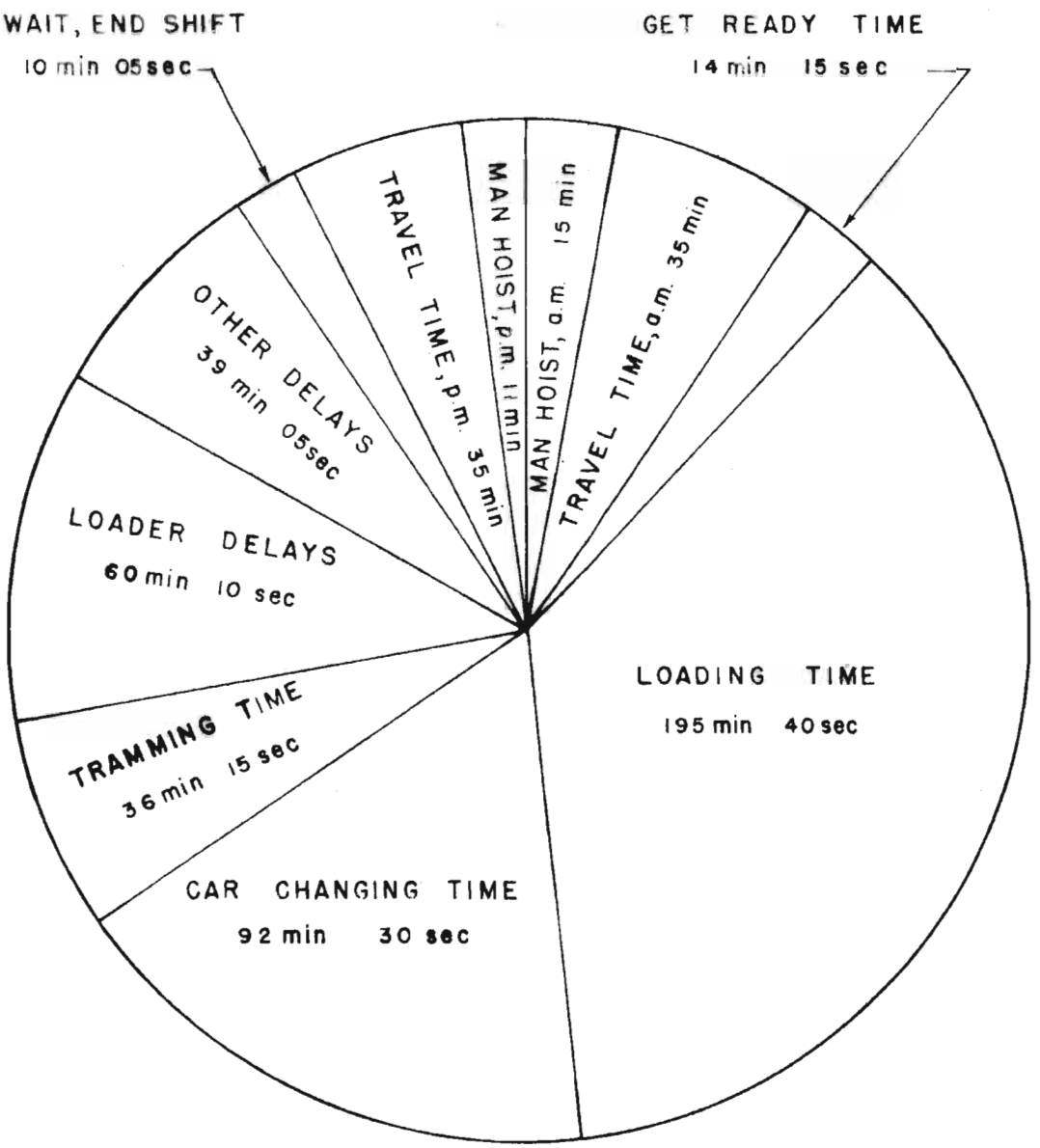


Fig.13 Time distribution chart of 9-hour shift.

JUNE 7, 1947

Study No. 3

Crawler-mounted 7 B U Joy mobile loader
and two cable reel shuttle cars

This study was made at the Franklin County Coal Company, Freeman Spur Mine, Herrin, Illinois on June 10, 1947. The 7 B U Joy Mobile loader was then robbing pillars in Rooms, 3, 5, 6, 7, and 8 in 17N and 18N panel. The two cable reel shuttle cars each had a capacity of 5½ tons.

A summary of the time study is given in Table 3. A time distribution chart for this study is shown in Fig. 14.

The pillars were not robbed in a systematic manner. The pressure of the roof was evidenced in the old workings and, therefore, the pillars were robbed where the mining condition was safe and where the coal was most easily available. In some parts of the section the pressure of the roof had crushed the coal pillar so that it could ordinarily be loaded without undercutting or blasting.

The loading machine was operated at high efficiency despite the difficult working condition. The loader is rated at 2 tons per minute while the time-study disclosed the actual tonnage to be 1.4 tons per minute.

Although the tramming distances were short, 9 percent of the productive time was spent in tramming from one working to another. This was due to the fact that the loading was not done in a systematic manner. The loading machine crew loaded wherever they saw fit. As the workings were mostly left up to the miners the shuttle car men took the road that was most advantageous to them and therefore considerable cable trouble was evidenced. Total delays amounted to nearly 21% of the productive time.

During the tramming time in order to reach some of the working faces, considerable cleaning was necessary along the haulage way.

Table No. 3

Summary of Time Study 3

Productive time	June 10
Loading coal	214'50"
Car change	92'35"
Tramming time	39'40"
Loader delays:	
Take down bad top	2'55"
Shift machine	3'00"
Break lump	1'05"
Pick coal	5'25"
Low power	10"
Double load	6'20"
Cable repair	7'00"
Other delays:	
Car off track	4'10"
Wait on empties	9'00"
Bad top	3'25
Lunch	28'00"
Cable repair	13'55"
Misc.	7'00"
Total Productive Time	439'30"
Make Ready Time	
At working face getting ready	10'00"
Wait at end of shift	10'30"
Travel time: Morning	
Man hoist and wait for man trip	35'00"
Travel time	15'00"
Afternoon:	
Man hoist and wait for man hoist	15'00"
Travel time	15'00"
TOTAL PAY TIME	540'00"
Type loader	7 BU Joy
Rated tonnage	2 ton/min.
Actual tonnage	1.4 ton/min.
Tons loaded	300
No. shuttle cars loaded	61
Load time/shuttle car	3'31"
Change time/shuttle car	1'31"
Percentage of productive time, loading	49.0%
Percentage of productive time car changing	21.1%
Percentage of productive time tramming	9.0%
Percentage of productive time delays	20.9%

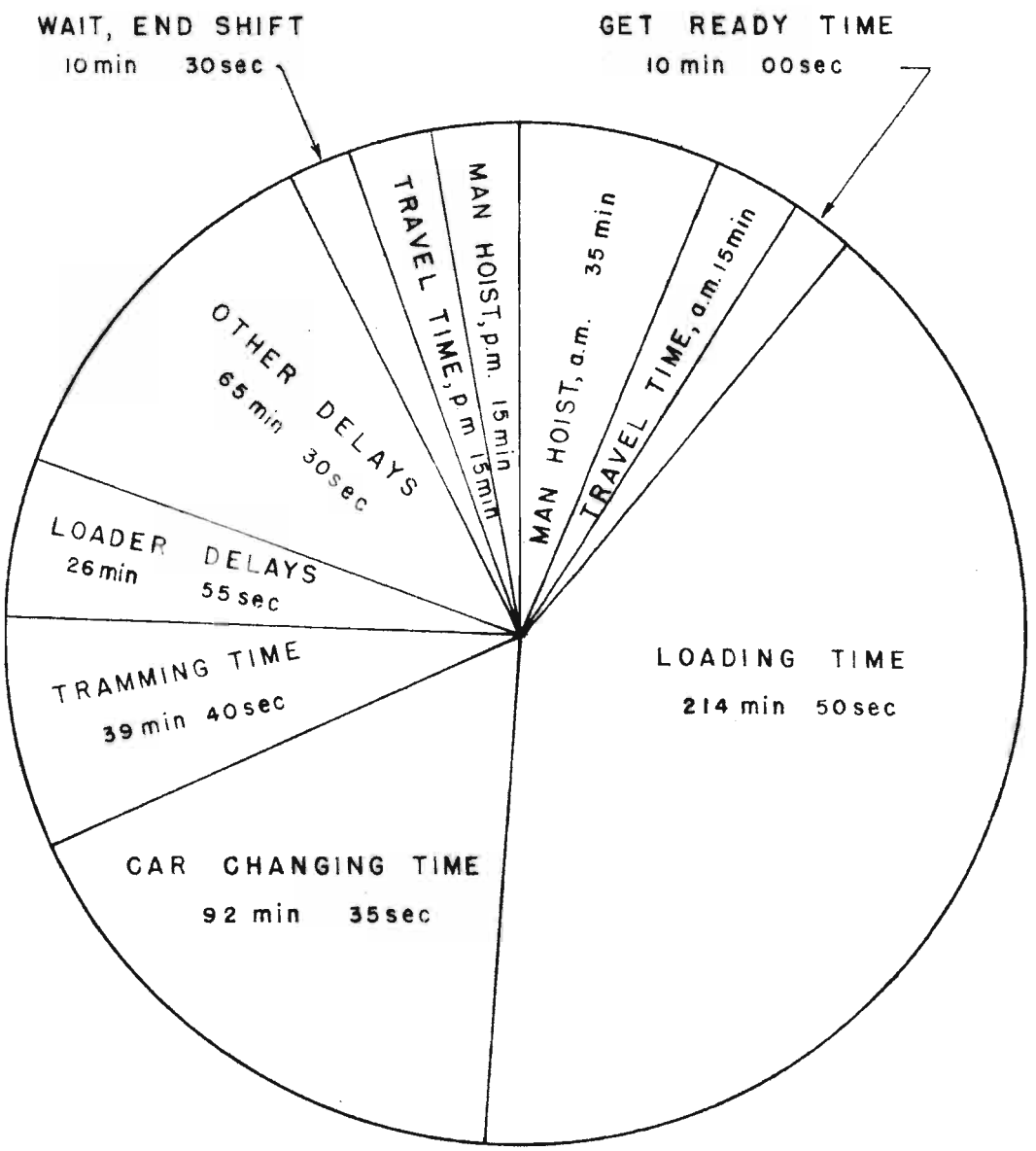


Fig. 14 Time distribution chart of 9-hour shift

JUNE 10, 1947

Study No. 4

Crawler-mounted 11 BU Joy mobile loader and two cable -reel shuttle cars

This study was made at the Franklin County Coal Company, Royalton No. 7 mine, Royalton, Illinois on June 11 and 12, 1947. The 11 BU Joy mobile loader was working in 25S and 26S panel off N4W. The two cable-reel shuttle cars each had a capacity of 6.3 tons.

A summary of the two time studies is given in Table 4. A time distribution chart for this study is shown in Fig. 15 and Fig. 16.

The rooms were driven approximately 28 feet wide. The roof condition was excellent. The mining method was definitely pre-established and the haulage roads were made ready for the shuttle car haulage by hanging the power cables from the roof and by keeping the roadway clear from obstructions.

The loading machine operation was characterized by uniformity in operation, high production and high efficiency, although only 50 percent of the productive time was used in loading. The loader is rated at 4 tons per minute while the time-studies show that the actual tonnage is 3.52 tons per minute one day and 3.86 tons per minute the following day. This high efficiency indicates a good operator and also well prepared coal face. In most of the mines the loaders must necessarily clean up the face so that the cutting machine will not be retarded by the loose coal when cutting. In this mine the cutting is not done on the bottom but 30 inches above the bottom, thus the small scatterings of coal does not hinder the cutting machine. Although direct time was not noted, there was an absence of "clean-up" operation for the little coal left at the face would be loaded during the next loading operation. This feature eliminated considerable lost time.

Mechanical delay resulted from a 73'05" loading machine breakdown. During this time the loading crew repaired the brattice and the temporary stoppings of the working section.

Table No. 4

Summary of Time Study 4

Productive Time	June 11	June 12
Loading coal	226'35"	221'40"
Car change	121'30"	190'00"
Tramming time	26'45"	22'35"
Loader delays:		
Shift machine		25"
Low power	1'00"	
Double load	10"	
Mech. delay	73'05"	5'40"
Other Delays:		
Wait on empties		11'05"
No power on shuttle car		50"
Oiling		35"
Total Productive time	449'05"	452'50"
Make Ready Time		
At working face getting ready	6'55"	9'15"
Wait at end of shift	10'00"	2'55"
Travel Time: Morning		
Man hoist and wait on man trip	35'00"	35'00"
Travel time	19'00"	20'00"
Afternoon:		
Man hoist and wait for man hoist	5'00"	5'00"
Travel time	15'00"	15'00"
TOTAL PAY TIME	540'00"	540'00"
Type loader	11 BU Joy	11 BU Joy
Rated Tonnage	4 ton/min.	4 ton/min.
Actual tonnage	3.52 ton/min.	3.86 ton/min.
No. shuttle cars loaded	126	135
Tons loaded	800	854
Load time/shuttle car	1'48"	1'39"
Change time/shuttle car	58"	1'24"
Percentage of productive time loading	50.5%	49.0%
Percentage of productive time car changing	27.2%	42.0%
Percentage of productive time tramming	6.0%	4.8%
Percentage of productive time delays	16.3%	4.2%

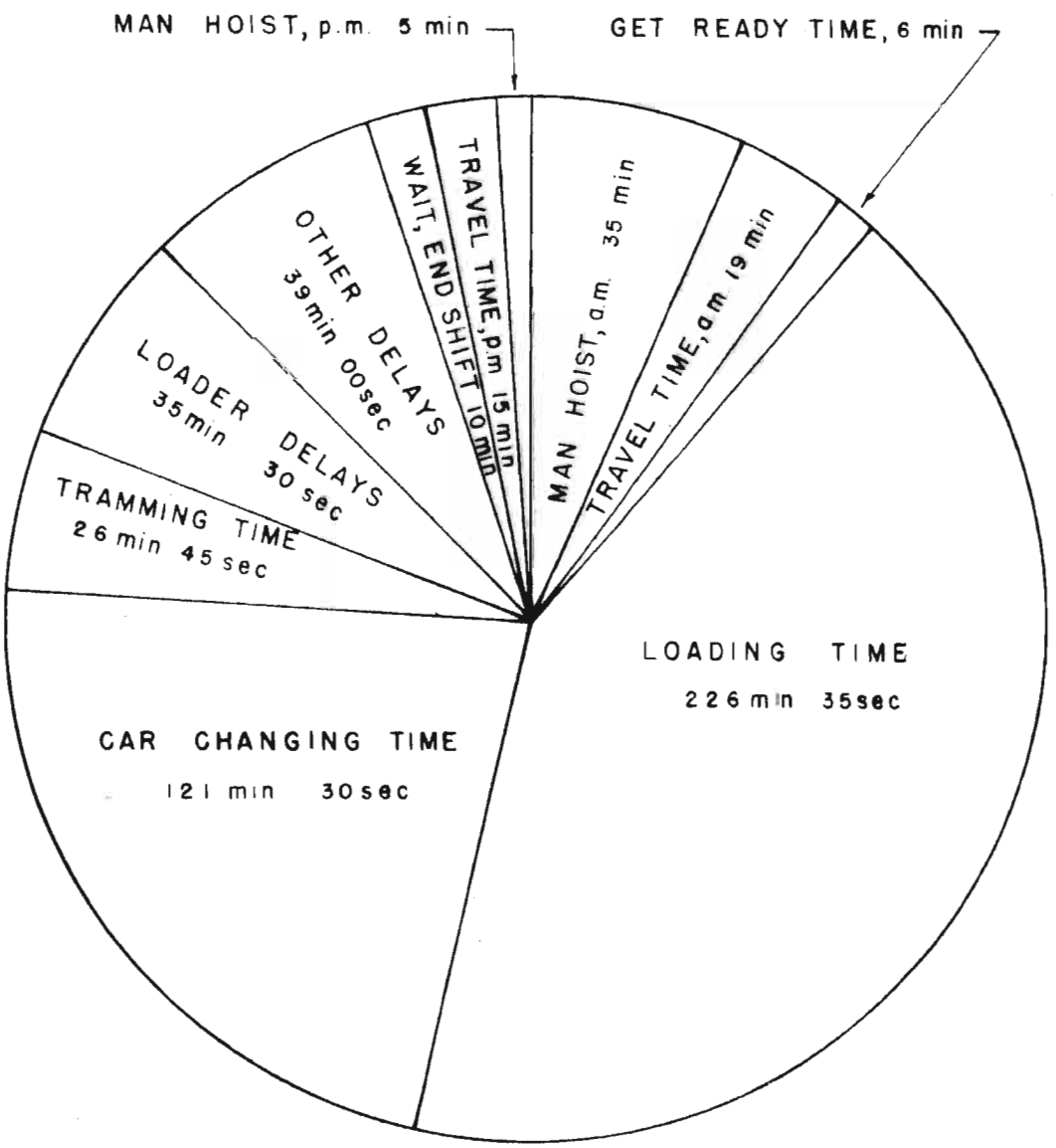


Fig. 15 Time distribution chart of 9-hour shift.

JUNE 11, 1947

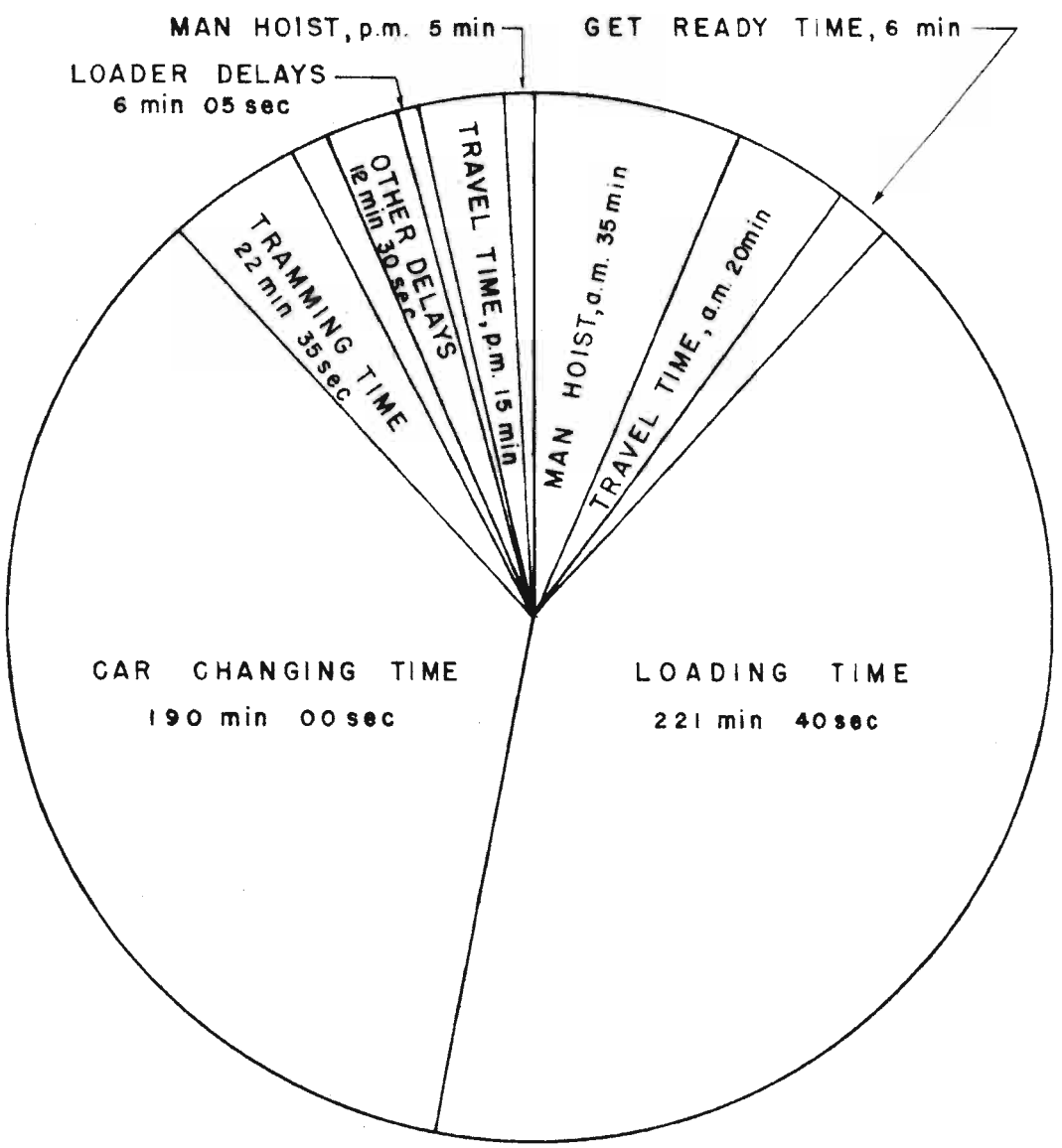


Fig.16 Time distribution chart of 9-hour shift.

JUNE 12, 1947

Study No. 5

Track-mounted Clarkson 24 mobile loader and one battery locomotive

This study was made at the Chicago, Wilmington, and Franklin Coal Company, Orient No. 1 mine, Orient, Illinois, on June 13, 1947. The Clarkson 24 loader was working in the rooms off 3N and 4N panel in the 16 WS section. The capacity of the mine cars is 5 tons but the average cars loaded with the loading machine was 4.6 tons.

A summary of the study is given in Table 5. A time distribution chart for this study is shown in Fig. 17.

The width of the room was about 25 feet. The top condition was good. In places the bottoms were rolling, but this condition did not hamper the efficiency of loading machine appreciably, however during the car changes some difficulty was experienced.

The loading machine was characterized by low efficiency. The loaders are rated at 4 tons per minute while the time study shows the actual tonnage to be nearer to 2 tons per minute. Since the working territory was not familiar to the crew, loading efficiency was decreased. Time study shows an unusually long time as "Get ready time" which was used to familiarize the men with the power connections, the fall of coal, and the sounding of the top.

Wait on the relay motors, although no definite delay times are given, might indicate that by using two locomotives would solve the problem.

Table No. 5

Summary of Time Study 5

Productive time	June 13
Loading coal	204'15"
Car change	153'10"
Tramming time	36'10"
Loader delays:	
Shift machine	5'05"
Pick coal	7'15"
Loader off track	10'15"
Track repair	2'05"
Other delays:	
Track repair	2'30"
Grease	30"
Misc.	8'15"
Total Productive Time	429'30"
Make Ready time	
At working face getting ready	24'00"
Wait at end of shift	21'20"
Travel Time: Morning	
Man trip hoist and wait for man trip	25'00"
Travel time	20'00"
Afternoon	
Man trip hoist and wait for man-hoist	3'00"
Travel time	17'00"
TOTAL PAY TIME	540'00"
Type loader	Clarkson 24
Rated tonnage	4 ton/min.
Actual tonnage	1.96 ton/min.
Tons loaded	400
No. of cars loaded	89
Load time/car	2'18"
Change time/car	1'42"
Percentage of productive time loading	47.6%
Percentage of productive time car changing	35.7%
Percentage of productive time tramming	8.4%
Percentage of productive time delays	8.3%

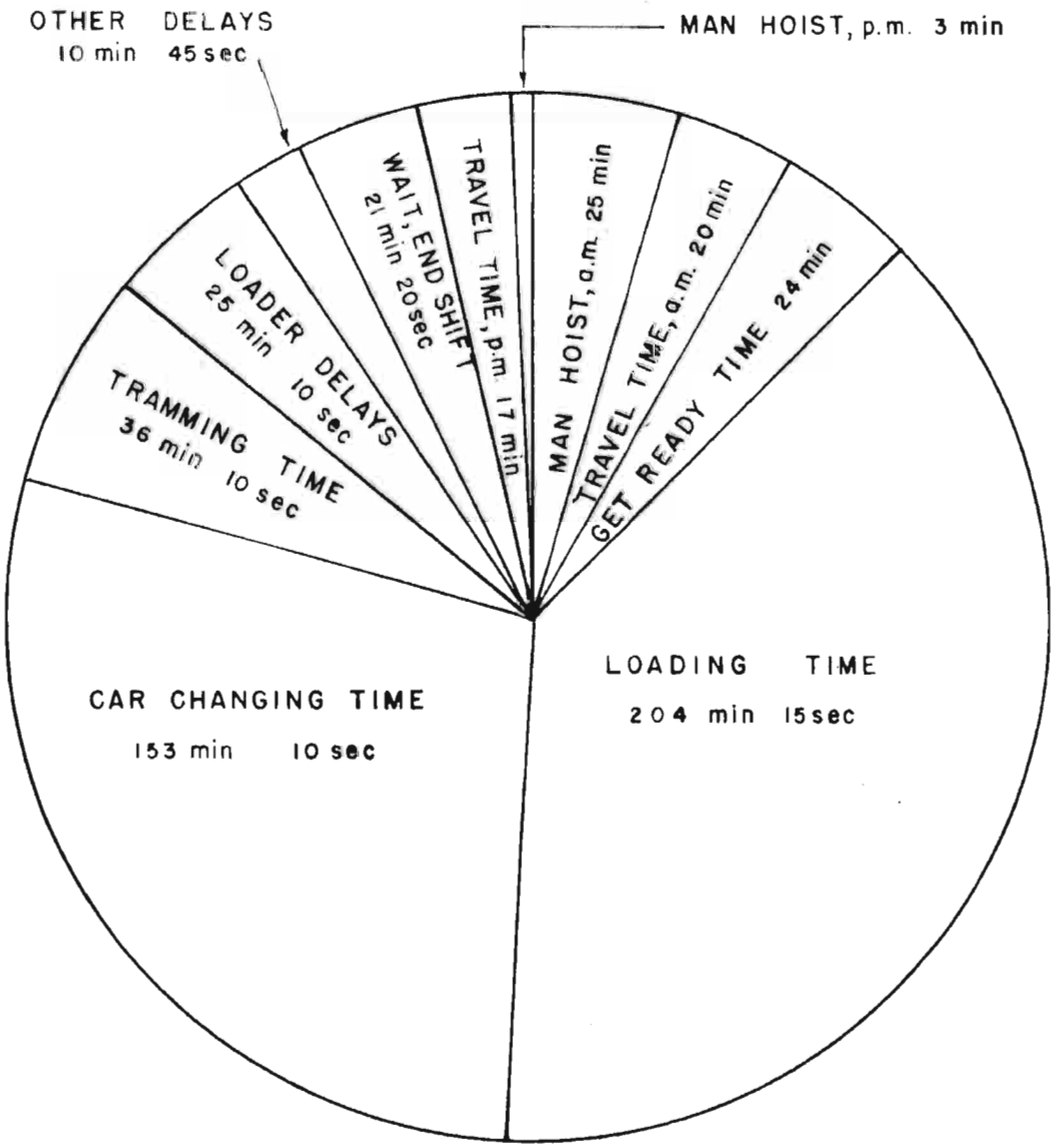


Fig.17 Time distribution chart of 9-hour shift.

JUNE 13, 1947

Study No. 6

Crawler-mounted 11 BU Joy mobile loader and two cable reel shuttle cars

This study was made at the Consolidated Coal Company Lake Creek mine, Johnston City, Illinois on June 20, 21, 1947. The 11 BU Joy loader was loading in Rooms 1, 2, 3 , 4, 5, 6, in the 11N section of the mine. Two cable reel shuttle cars were used and had a capacity of 4.35 tons per shuttle bar.

A summary of the two time studies is given in Table 6. A time distribution chart for this study is shown in Fig. 18 and Fig. 19.

The rooms were 14 feet to 18 feet wide. The working place was generally wet but not so wet as to hinder the loading machine operation. Some parts of the working indicated bad top but generally it was fair. Six rooms were worked continuously. This was accomplished by the use of compressed air shooting or Airdox, which by the Illinois law may be used to blast coal during the shift. The shuttle cars unloaded the coal into the conveyor belts, which eliminated the prominent delay of waiting for the relay motors.

The operation of the loading machine was characterized by high efficiency. The rated tonnage of the loader is 4 tons per minute while the actual tonnage of the loading machines was 3.3 tons for both days. The important contributing factor was due to the concentrated working, which decreases the tramming distance and closer supervision was possible.

Table No. 6

Summary of Time Study 6

Productive time	June 20	June 21
Loading coal	202'05"	216'55"
Car change	168'40"	168'20"
Tramming	28'05"	23'30"
Loader delays:		
Take down bad top	25"	3'25"
Shift machine	10'30"	
Break lump	1'10"	3'00"
Pick coal	2'25"	20"
Double load	2'15"	3'10"
Mech. delay		3'00"
Other delays:		
Lunch	30'00"	34'00"
Misc.	50"	4'35"
Total Productive Time	446'25"	460'15"
Make Ready Time		
At working face getting ready	2'30"	7'00"
Wait at end of shift	31'05"	17'45"
Travel Time: Morning		
Man trip hoist and wait for man trip	5'00"	5'00"
Travel time	30'00"	25'00"
Afternoon		
Man hoist and wait for man hoist	5'00"	5'00"
Travel time	20'00"	20'00"
TOTAL PAY TIME	540'00"	540'00"
Type loader	11 BU Joy	11 BU Joy
Rated tonnage	4 ton/min.	4 ton/min.
Actual tonnage	3.3 ton/min.	3.3 ton/min.
Tons loaded	680	720
No. of shuttle cars loaded	151	158
Load time/shuttle car	1'21"	1'22"
Change time/shuttle car	1'07"	1'04"
Percentage of productive time loading	45.2%	46.9%
Percentage of productive time changing	37.7%	36.4%
Percentage of productive time tramming	6.3%	5.1%
Percentage of productive time delays	10.8%	11.6%

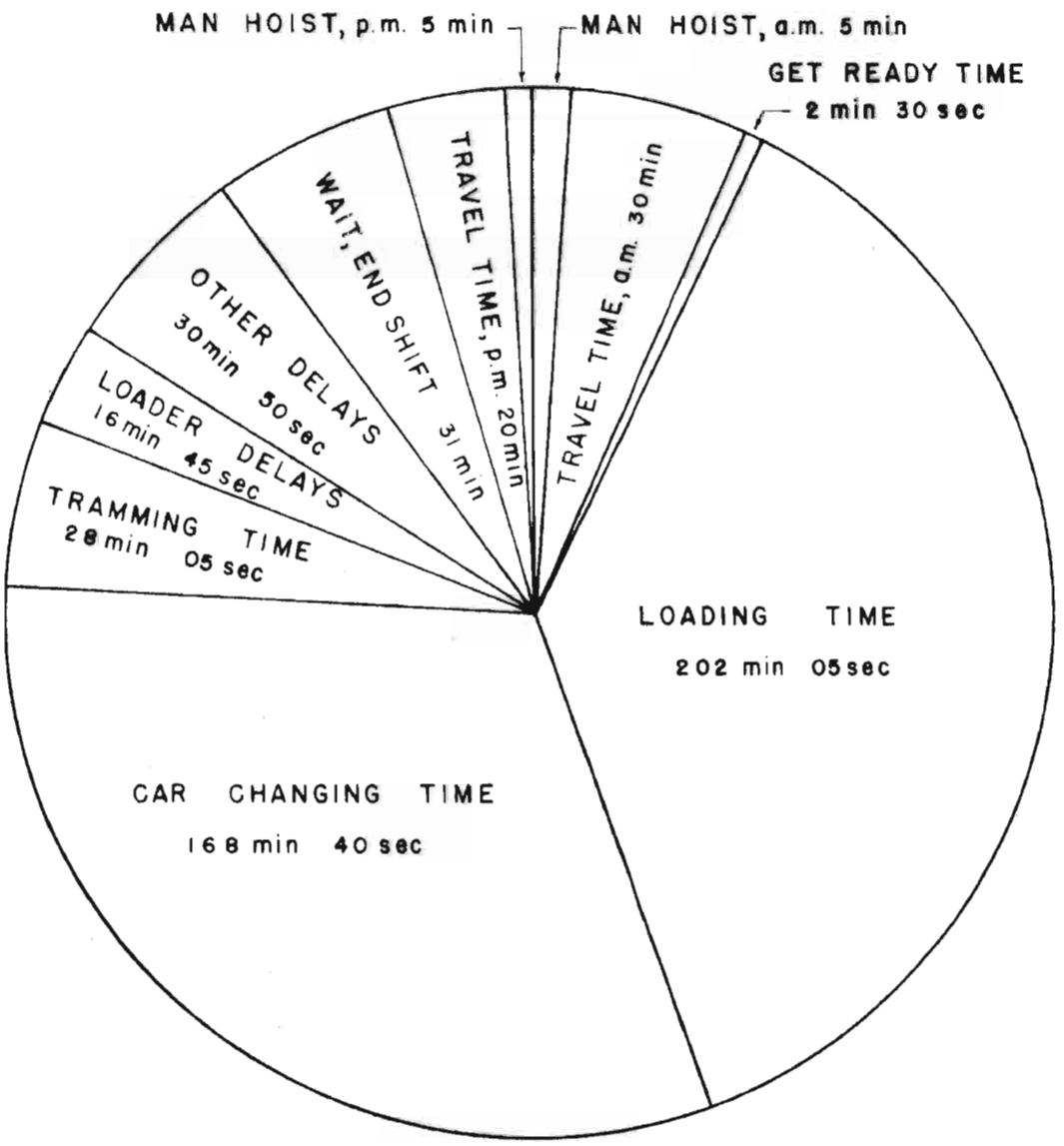


Fig. 18 Time distribution chart of 9-hour shift.

JUNE 20, 1947

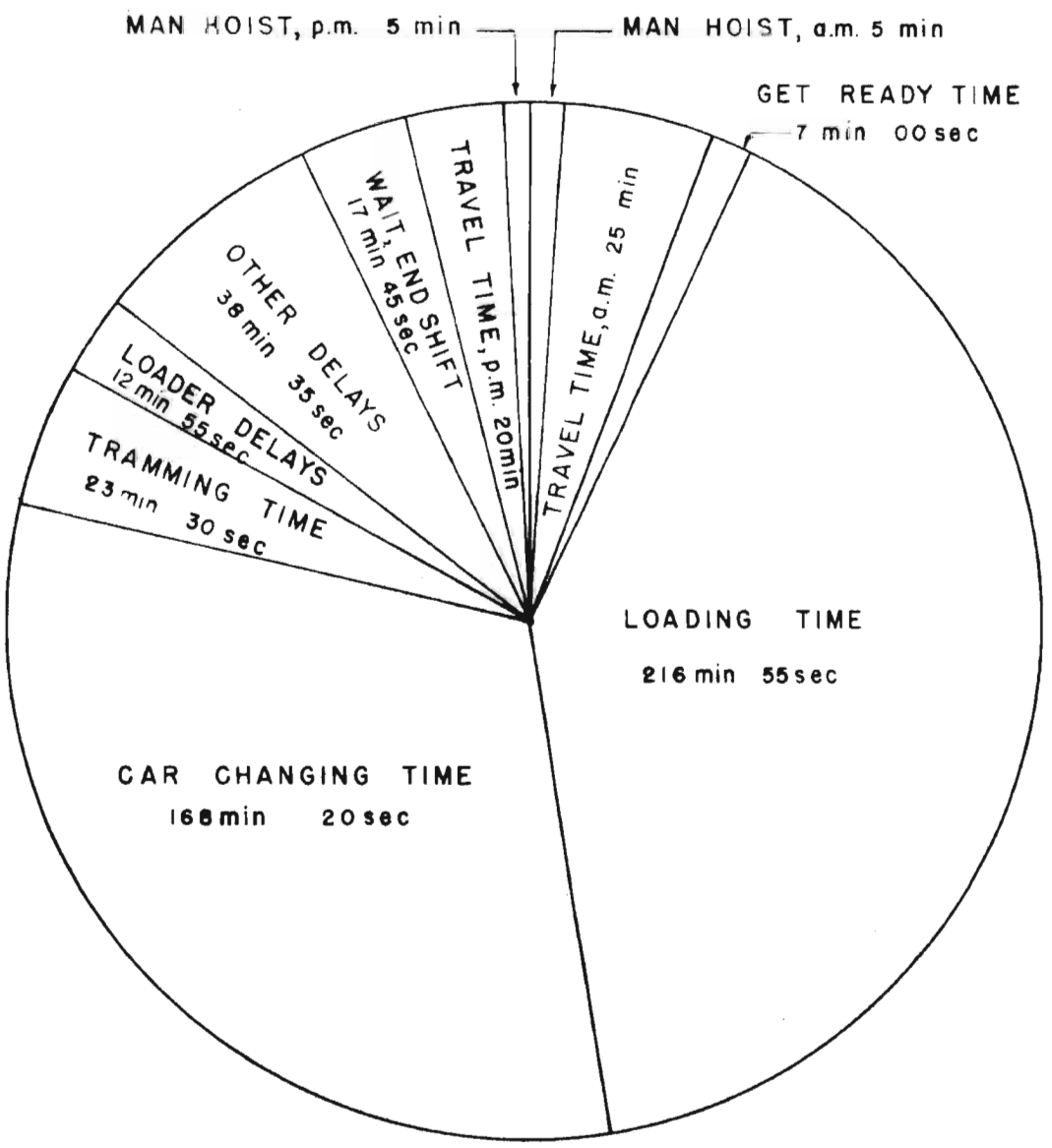


Fig. 19 Time distribution chart of 9-hour shift.

JUNE 21, 1947

Study No. 7

Track-mounted Goodman 460 Mobile loader
and one battery locomotive

This study was made at the Superior Coal Company, No. 3 mine Mt. Clare, Illinois on July 8, 1947. The Goodman 460 loader was working in the rooms off 25W panel in the 7NW section of the mine. The capacity of the mine cars was 2.8 tons.

A summary of the time study is given in Table 7. A time distribution chart for this study is shown in Figure 20.

The rooms were mined approximately 25 feet wide. The top condition was excellent.

The rated tonnage for this type of loader was 4 tons per minute but the actual tonnage shown by the time study was found to be 3.14 tons per minute or about 60 percent of the rated capacity.

It was the policy of the miners to arbitrarily determine the maximum number of cars to be loaded during one shift. Whatever time was left after loading this amount, was spent waiting for the man trip. Such examples show the need of better cooperation between the men and the management. The wait period in this particular case amounted to 23 minutes.

Examination of the time study results in this case show that the average loading time required only 54 seconds, while the average change time required 1'08". This would indicate that improvement could be made in the change time by obtaining larger mine cars or installing transfer cars and transfer stations*.

* Transfer cars and transfer stations are used to increase production where the existing conditions make it impossible to use large mine cars. The larger cars, ortransfer cars, which are used only in the working area transport the loaded coal from the face to a transfer station where it is reloaded into smaller cars.

Table No. 7

Summary of Time Study 7

Productive time	July 8
Loading coal	130'50"
Car change	160'25"
Tramming	32'25"
Loader delays:	
Shift machine	5'20"
Break lump	1'35"
Pick coal	2'25"
Dig bottoms	20"
Track repair	1'00"
Set timbers	2'50"
Other delays:	
Wait on relay motor	3'05"
Car off track	1'05"
Lunch	38'25"
TOTAL PRODUCTIVE TIME	379'45"
Make Ready Time	
At working face getting ready	9'00"
Wait at end of shift	57'15"
Travel time: Morning	
Man hoist and wait for man trip	37'00"
Travel time	17'00"
Afternoon	
Man hoist and wait for man hoist	23'00"
Travel time	17'00"
TOTAL PAY TIME	540'00"
Type loader	Goodman 460
Rated tonnage	5 ton/min.
Actual tonnage	3.12 ton/min.
Tons loaded	408
No. of cars loaded	146
Load time/car	54"
Change time/car	1'08"
Percentage of productive time loading	34.5%
Percentage of productive time changing	42.3%
Percentage of productive time tramming	8.6%
Percentage of productive time delays	14.6%

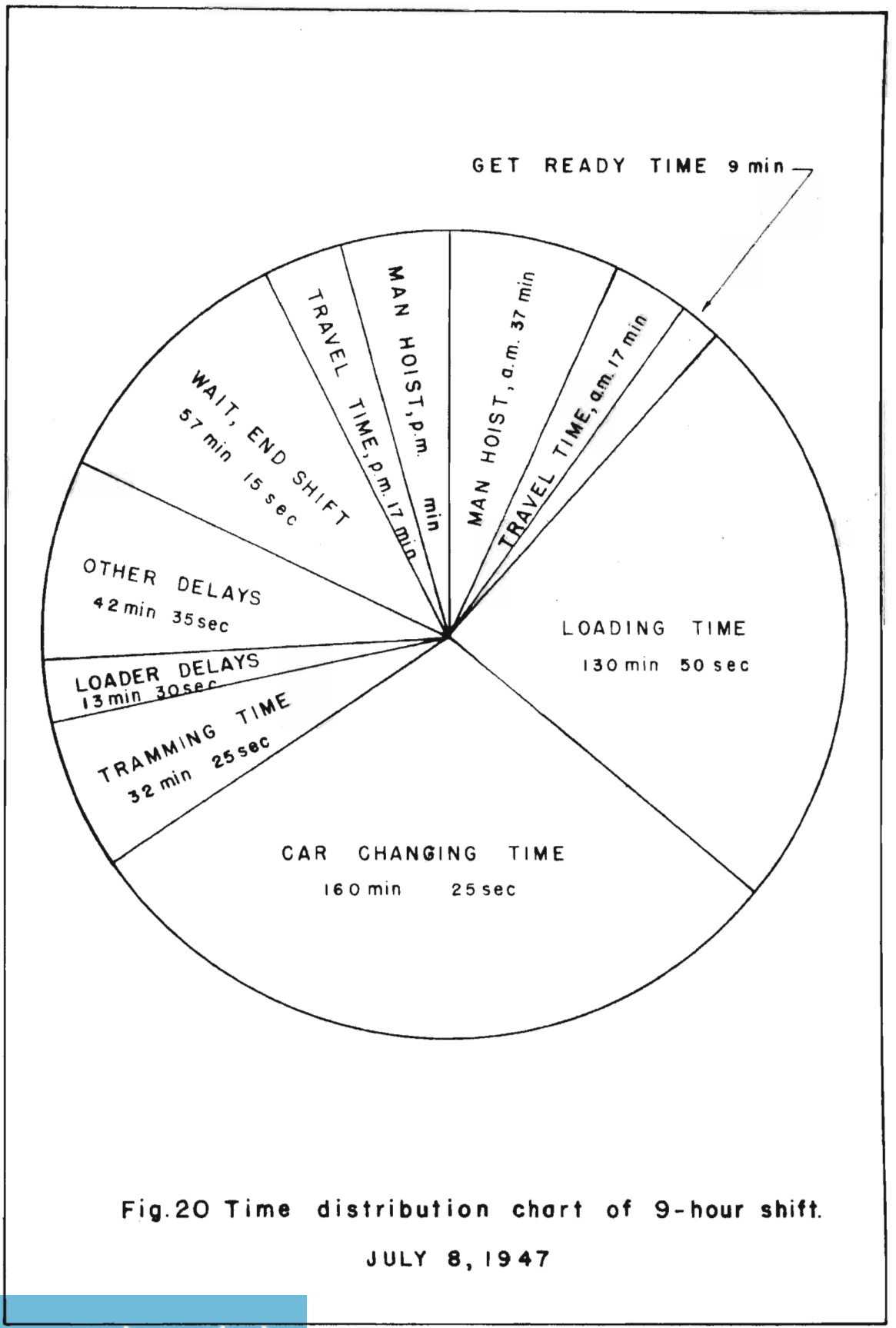


Fig. 20 Time distribution chart of 9-hour shift.

JULY 8, 1947

SUMMARY

In the foregoing analyses, an attempt has been made to discuss the performance of the coal loading machine in actual practice, and to propose some corrective measures that may be applied to those elements that decrease productive efficiency.

These analyses indicate that only one third of the productive time was used in the loading of coal. Loading time is increased by decreasing the change time which in turn is accomplished by using larger mine cars, transfer cars and transfer points, or by loading coal into some method of continuous conveyors. When the loaders must dig the tight coal, the efficiency of the loading machine is reduced. The coal face should be properly broken to gain maximum efficiency. The roof condition should be so controlled as to maintain safe working conditions at all times. Depending upon the type of work, one type of loader is more flexible than another. Such would be the case as in entry driving where tramming time is large, track-mounted machines are more flexible than crawler-mounted. It must be borne in mind that the loading efficiency depends upon the skill of the operator and the cooperation among the loading crew.

Approximately one third of the productive time was used in the change of cars. This productive delay could be reduced by the installation of larger mine cars. In some mines where it would be uneconomical to install larger cars because of the limited shaft and the involved haulage problem, transfer cars and transfer points have been established. The reader must bear in mind that it requires approximately the same amount of time to change a 2-ton car as a 6-ton car. By using larger cars, the percentage of the total time charged to change time will be reduced in direct proportion with the capacity of the larger cars. Change time may be reduced by closer switching or by keeping the loading points closer

to the working face. Unobstructed haulage ways aid in reducing change time. Auxiliary cars may warrant an investment when the changing distance becomes too far.

One-third of the shift time is distributed in delays, travel time, tramming time, and make ready time. Loader delays and other delays that affect production are unpredictable and non-cyclic, therefore, experienced maintenance men and efficient loading crew men would be desirable in every loading crew. Tramming time is influenced by the method of mining. Time studies show that by the concentration of workings, within a smaller area in the mine, tramming time could be reduced considerably thereby giving more time for loading. For long tramming distances track-mounted loading machines have a faster tramming time than the crawler mounted loading machines. Travel time is directly dependent upon the distance from the shaft to the working face, therefore, it could not be reduced without endangering the lives of the loading crew. The time consumed in make ready time largely depends upon the condition of the working faces left by the previous crew and whether the mine cars are immediately obtainable for loading. Wait at end of shift results mostly from bad practice among the men.

For maximum efficiency, intelligent management and cooperation among men is needed.

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