COLLINS

report

Collins Radio Company

Volume 2

Research and Development Contract for Coal Mine Communication System

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Research and Development Contract for Coal Mine Communication System

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Section 1

Analysis of Mine Communications

A working understanding of present coal mine communications equipment and its usage is an essential prerequisite to the determination of future communications systems needs. As a means of gaining this understanding, a field survey program was planned and implemented. The plan formulated called for obtaining both qualitative and quantitative data from three main areas of interest: the types, physical condition, and performance characteristics of equipment presently used in the sample of mines to be visited; the relationship present communications has to safety and productivity; and the practical, future communications needs as derived through interviews with present mine management.

In compliance with the original plan, the type and physical condition of equipment in use was found through at-mine interviews of personnel responsible for installation and maintenance. Further evaluation was made through the review of equipment instruction books and maintenance manuals and through in-mine inspection of communications equipment and signal distribution networks. The performance characteristics were determined through listening to conversations and noise levels and by talk-testing from randomly selected stations throughout each mine. System operation was evaluated by asking communication system users their opinions and by noting any difficulties personnel had using the systems.

Plans in the second area of interest--that of relating communications to mining operations--were to observe mining operations and usage of communications; to gain insight through interviews with mine management, from mine superintendents to section foreman; and to look for correlation between communications, production, and safety.

Lastly the communication systems needs and requirements were determined from first hand interviews of mine personnel, from the analysis that lead to the individual reports on the eight mines, and from an overview of all of the mines studied. The latter was done to find commonality between the needs of the individual mines such that system requirements having the greatest universal value could be derived, thus lowering per-mine cost of equipment through economics of scale.

Armed with tape recorders, backgrounds in communications technology, and with an interview questionnaire that was improved as experience was gained, engineers visited the eight mines to obtain the raw data from which the needs and requirements could be developed through analysis. During the first part of the program two days were spent at each mine so that interviews and tours could be completed, and so that full eight hour shift phone usage recordings could be obtained for statistical analysis. One day visits were sufficient for those trips where tape recordings were not made. During the later trips less attention was given to the statistical nature of communications, and more to how communications relates to the total mining operation.

A Matrix of Mine Characteristics

The program's objective of defining communications requirements was met through the analysis of the mining processes of a wide variety of mines, aided by an understanding of modern communications technology. The selection of the eight mines surveyed was based on the goal of obtaining the widest possible range and cross-section of the following characteristics:

a. Age of mine
b. Size of mine
c. Coal seam characteristics
d. Number of employees
e. Yearly output
f. Mining methods
g. Haulage methods
h. Existing communications
i. Usefulness of present communications
j. Electrical power usage

The names of the eight mines visited, their geographic location, and the characteristics listed above, are all presented as table 2-1, a matrix of mines and those characteristics significant in determining future communications requirements.

The matrix of mine characteristics is presented before the narrower viewpoint of the individual reports so it can be seen how each mine fits into the overall picture. Any matrix entries not clear now will become so after reading the individual reports.

Table 2-1. Matrix of Mines.

MINE NAME	MINE DESCRIPTION						TONNAGE OF MINED COAL		MAN-POWER (each shift)		HAULAGE METHODS		NO. OF WORKING SECT (each shift)				NO. OF COMMUNICATIONS STATIONS						ELECTRICAL POWER			
				ENTRANCE																						
	SEAM NAME	SEAM THICKNESS (inch)	OVERBURDEN (ft)	MEN AND MAT.	COAL	MINE DIMENSIONS (mi x mi)	DAILY (t)	YEAR 1971 (t)	UNION	SUPERVISORY	SECTION TO MAIN	MAIN TO OUTSIDE	CONVENTIONAL	CONTINUOUS	LONGWALL	TOTAL	MAGNETO PARTY LINE	DIAL PRIVATE LINE	PAGER PHONE	PAGER ONLY	TROLLEY CARRIER	NUMBER OF DISPATCHERS	ALTERNATING CURRENT (AC)	DIRECT CURRENT (DC)	NUMBER OF FAN AND POWER BORE-HOLES	MINE NAME
Robena No. 4	Pittsburgh	93	545 to 1000	Shaft	Slope	2.4 x 3.9	4 to 5 x 10^3	1 x 10^6	88 88 88	12 12 12	Shuttle-car	Track		5 5 5		5 5 5	41				30	1		550 V	2	Robena No. 4
Greenwich (North and south)	Lower Freeport	40	420	Shaft (North) Drift (South)	Drift	2.7 x 2.2	8 x 10^3	463 x 10^3	200 200 200	20 20 20	Shuttle-car, belt	Belt	South 1 1 1	North 7 7 7 South 7 7 7	North 1 1 1	North 8 8 8 South 8 8 8			South 38	South 5	North 5 South 5		12,470 V, 600 V	300 V		Green-wich (North and south)
Somerset No. 2	Somerset B	144	0 to 2000	Drift	Drift	1.7 x 3.2	NA	1 x 10^6	71 55 45	8 6 4	Belt	Track		2 2		2 2		28	7		19		4160 V, 440 V	275 to 300 V	1	Somer-set No. 2
Keystone No. 1	Pocahontas No. 3	58	300 to 800	Drift	Drift	7 x 5	4.5 x 10^3	1.3 x 10^6	308 216 151	15 10 8	Belt and shuttle-car	Track		8 5 3	2 2 2	10 7 5	77		15		12 163 kHz 28 100 kHz	2	13,800 V, 440 V	250 V, 550 V	13	Keystone No. 1
Harris No. 1	Eagle	66	0 to 300	Drift	Drift	2.7 x 1.7	6.6 x 10^3	1.7 x 10^6	100 100 80	10 10 4	Shuttle-car, belt	Track	2 2	2 2	1 1	5 5			13	7	16	1	7,200 V, 440 V	250 V	3	Harris No. 1
Baldwin	Illinois No. 6	78	100	Drift	Drift	5 x 5	7.7 x 10^3	New Mine	85 75 75	20 15 15	Shuttle-car, belt	Belt		5 5 5		5 5 5			62		2		12,500 V, 480 V	300 V	2	Baldwin
Lovilia No. 4	Mammoth	60	180	Shaft	Shaft	1.2 x 1.2	800	246 x 10^3	20	4	Shuttle-car	Track, hoist	1			1			4				2,300 V	300 V	1	Lovilia No. 4
Orient No. 3	Illinois No. 6	108	790	Shaft, slope	Slope	5.3 x 4.25	1.4 x 10^3	2.44 x 10^6	300 300 40	25 25 3	Belt	Belt		13 13		13 13			38				4,160 V, 480 V	300 V	15	Orient No. 3

The following independent reports, in the order the surveys were made, represent the major output of the survey program. Following the last report--that for Orient No. 3--is an analysis of the similarities and differences between the eight mines. This comparative analysis will in turn be used to outline needs and requirements applicable to underground coal mines in general.

3.1 ROBENA NO. 4 COAL MINE ON-SITE SURVEY (MAY 1-2, 1973)

3.1.1 Mine Contacted

US Steel Robena No. 4 Mine
Star Route Greensboro
Waynesburg, Pennsylvania 15370

3.1.2 Initial Mine Contact

Bill Zeller - Superintendent
(412) 966-5003

3.1.3 Personnel Interviewed

Bill Zeller	- Superintendent
Stanley Stefl	- General Mine Foreman
Alex Halowich	- Dispatcher
Pat Hess	- Mining Engineer

3.1.4 General Mine Information

3.1.4.1 Mine Type

Robena No. 4 is part of a connected 4-mine complex owned by US Steel. This particular mine is approximately 20 years old and although they have some new working sections, the major coal extraction is from retreat mining where they are pulling pillers. Mine personnel estimate the coal will be removed and the mine closed in 2 or 3 years. Personnel entry is achieved through a vertical shaft approximately 545 feet deep. Coal is removed from the face area by shuttlecars and placed in a set of 6 tracked haulage cars. When full, this set of 6 cars are combined into one of the three trains or dual locomotives that remove the coal to Robena No. 1, nine miles away, where the coal is brought to the surface through a slope entry. Each train consists of 24 haulage cars making the total train approximately 650 feet long. Each train averages 2 runs per 8-hour working shift, and average coal production is between 4000 to 5000 tons per day for 240 working days setting yearly production at approximately 1 million tons.

3.1.4.2 Mine Size

The mine size is currently 2.4 miles north and south by 3.9 miles east and west with overburden from 545 feet to 1,000 feet. All tunnels and haulage ways are typically 6.5 feet high by

14 to 15 feet wide and coal is mined from the Pittsburgh seam. An average working section is 425 feet by 300 feet long and 10-foot roof bolts are used. The mine has only one bore hole which is used to supply the mine with water.

Currently the mine has 6 working sections of which 5 sections are worked every shift. Each shift is 8 hours in length and they run from 7:00 am to 3:00 pm, 4:00 pm to 12:00 am, and 12:00 am to 8:00 am.

3.1.4.3 Crew Composition

The mine typically has 100 men underground per shift and the following list, for the day crew, shows both the supervisor and crew organization:

- 1 - Overall Superintendent (Bill Zeller)
- 1 - General Mine Foreman (Stanley Stefl)
- 1 - General Assistance Mine Foreman (Tom Torry)
- 1 - Construction Foreman (Lew Tiberi)
  - 30 - Construction personnel made up from the following:
    - Track layers
    - Masons
    - Timber men
    - Roof bolters
    - Loading machine operators
    - Pipe men
    - Road cleaners
    - Shuttle car operators
    - Rock dusters
    - Supply men
- 1 - Ventilation Foreman (Berry Rodolec)
- 1 - General Maintenance Foreman (Ray Sinclare)
- 1 - Maintenance Foreman (Joe Zawalenski)
    - 4 - Wire men
    - 2 - Burners
    - 2 - Locomotive mechanics
    - 2 - Oil men
    - 2 - Maintenance back-up equipment
    - 1 - Compressed air equipment
- 5 - Section Foreman (Robinson 5L; Weaver 9R, Clark 10R, Bacon 7R-26 Room, Martelli 11R)
  - 8 - Mining personnel per section as follows:
    - 1 - Continuous miner operator (1 miner)
    - 2 - Shuttle car operator (2 shuttle cars)
    - 3 - Roof bolters (2 air drills)
    - 1 - Brattice men (ventilation at face)
    - 1 - Mechanic
- 7 - Miscellaneous personnel as follows:
  - 6 - Locomotive personnel (1 driver and 1 brakeman per train)
  - 1 - Dispatcher

A typical working section cycle starts with the continuous miner cutting coal and filling a shuttle car. When the shuttle car is full, the driver moves the coal load to the tracks and transfers the coal to one of the 6 haulage cars positioned on the side track. The shuttle car then returns to the continuous miner to repeat the cycle. Excluding mechanical trouble, the continuous miner will cut a block of coal 5 feet high, 15 feet wide, and 16 feet long in one hour and a section can mine 5 blocks this size in an 8-hour shift.

In a normal 8-hour shift, the working section personnel spend about 40 minutes traveling to and from the working section and 30 minutes for lunch. The lunches are staggered from working section to working section.

3.1.4.4 Mine Equipment and Power

The prime power for the mine is 550 Vdc brought in on a feeder cable. In the mine the trolley wire is run parallel to the feeder cable. At the working section the continuous miner, shuttle cars, and car pull are run off the 550-Vdc trolley line fed at nip stations. Compressed air is used to run the roof bolting machine.

The equipment at a working section includes 1 continuous miner, 2 shuttle cars, 1 roof bolting machine, and 1 car pull, and this equipment is duplicated at each working section. Other equipment includes 3 bottom loading machines, 2 miner type cutting machines, and 12 pumps.

The tracked vehicles include the 3 dual locomotives or tandems, 24 man trip motors, and 3 porta-buses.

3.1.5 Current Mine Communications

The present communication consists of a carrier phone system and a magneto phone system. All vehicles are equipped with FEMCO carrier (or trolley) phones and all active working sections along with selected underground positions have Western Electric magneto phones.

3.1.5.1 Telephone System

The heart of this mine's communication system is a central dispatcher located at the bottom of Blaker Shaft, or the main portal.

Eight party-line phone circuits terminate at a simple switchboard in the dispatcher's office. Each of these eight circuits has wired in parallel several of the 41 telephones. Calls between circuits must be made through the dispatcher and his switchboard; whereas calls within a circuit need not.

It should be noted that the statistics on phone use are based on recordings of the use of one of the two switchboard buses used to interconnect two or more of the eight circuits. Any phone traffic carried by the second bus was not recorded. Whenever possible, the dispatcher switched all traffic to the bus we monitored to give as much data as possible. But it should be kept in mind that we recorded only the traffic on this most used bus. The dispatcher can connect any two phone circuits together and he can make two of these connections generating two independent phone circuits for 2-channel operation. The eight circuits that can be connected together are listed as follows:

Desk phone (dispatcher's desk)
Spare
3/main
Colvin outside (Robena No. 1)
Blaker outside (surface phones)
9/right (working section)
10/right (working section)
Dispatcher (all 4 Robena mines)

On these circuits are the 35 underground phones and the 6 surface phones which are listed as follows:

a. Underground

6 flat, 9 shoot, 29 shoot, 7R, 5L, 5L (working section), Bailey Shaft, 58 shoot, 74 shoot, 9R, 9R-1 shoot, 9R (working section), 112 shoot, 121 shoot, 138 shoot, 7L, 10R-1 shoot, 10R, 10 shoot, 10R (working section), 7L (front), 17 shoot, 7L flat (working section), 7L-26 room (working section), 11R-17 room, 11R (working section), 11R, 189 shoot, 131 shoot, motor barn, supply house, bottom, dispatcher, shaft bottom, and 167 shoot.

b. Surface

1 - Lamp House, 2 - Mine Foreman's Office, 1 - Maintenance Office, 1 - First Aid Room, and 1 - Superintendent's Office.

Since this magneto phone system operates with a bell ringer rather than a loudspeaker, the rings are coded to indicate certain places or individuals. The following is a list of rings and destination:

3S 3L 3S	Emergency
1S 1L	Mine foreman
2S 1L	Blaker dispatcher
3S 1L	All sidetracks
1S 1L 1S	6 left ramp
1S 1L 1S 1L	6 left section
1S 1L 2S	8 right ramp
1S 1L 2S 1L	8 right section
1S 1L 3S	9 right ramp
1S 1L 3S 1L	9 right section
1S 1L 4S	10 right ramp
1S 1L 4S 1L	10 right section
1L	Maintenance foreman
1L 1S	Blaker bottom supply house
1L 1S 1L	Blaker outside
1L 2S 1L	Lamp house
2S	First aid attendant
3S	Mine superintendent

The dispatcher communicates through a single headset, and selection of either the mine phone or carrier phone is made using a two-position switch. Other switches connect and disconnect the various mine telephones' circuits. This dispatcher controls all vehicle traffic and serves as a telephone operator. Operator duties include: answering phone calls; switching phone circuits; personnel calling and location; and taking and relaying messages.

Because the dispatcher is more likely to contact a working section through the motor and an associated carrier phone in that section, the mine phone is used relatively little compared to the carrier phone.

The location of the underground phones is shown in figure 3-1, a map of the Robena 4 mine. This figure also shows the tracks for coal haulage.

To record all phone calls would have required an 8-channel tape recorder. To get the most information from our single channel recorder we attached our equipment to a desk phone, asked the dispatcher to keep that circuit switched to one of the two switching buses, and asked the dispatcher to route over this bus all traffic between any of the eight circuits. Thus, the only calls we missed were the calls <u>within</u> each of the seven other circuits and those routed on the second bus when the bus we were on was in use.

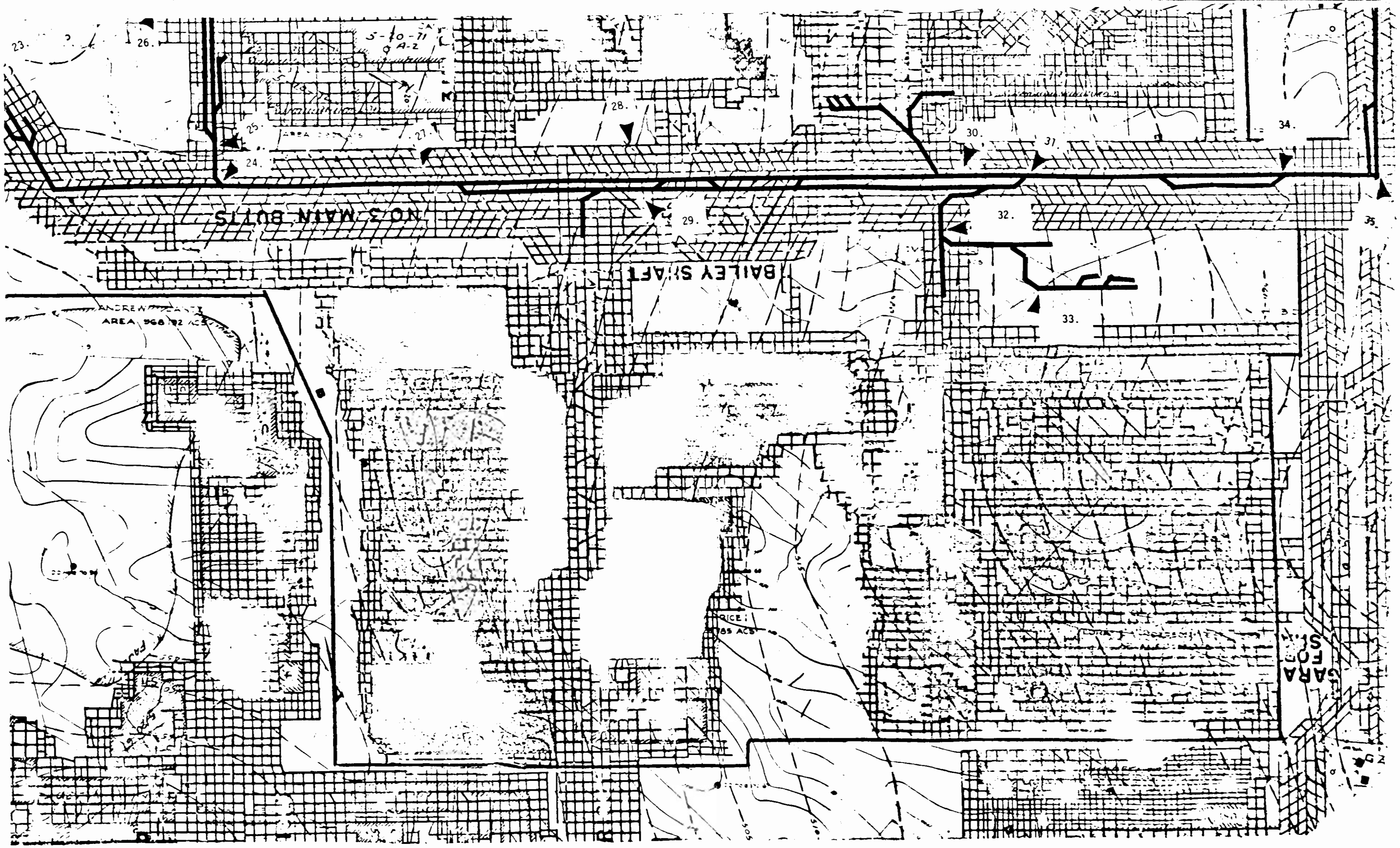
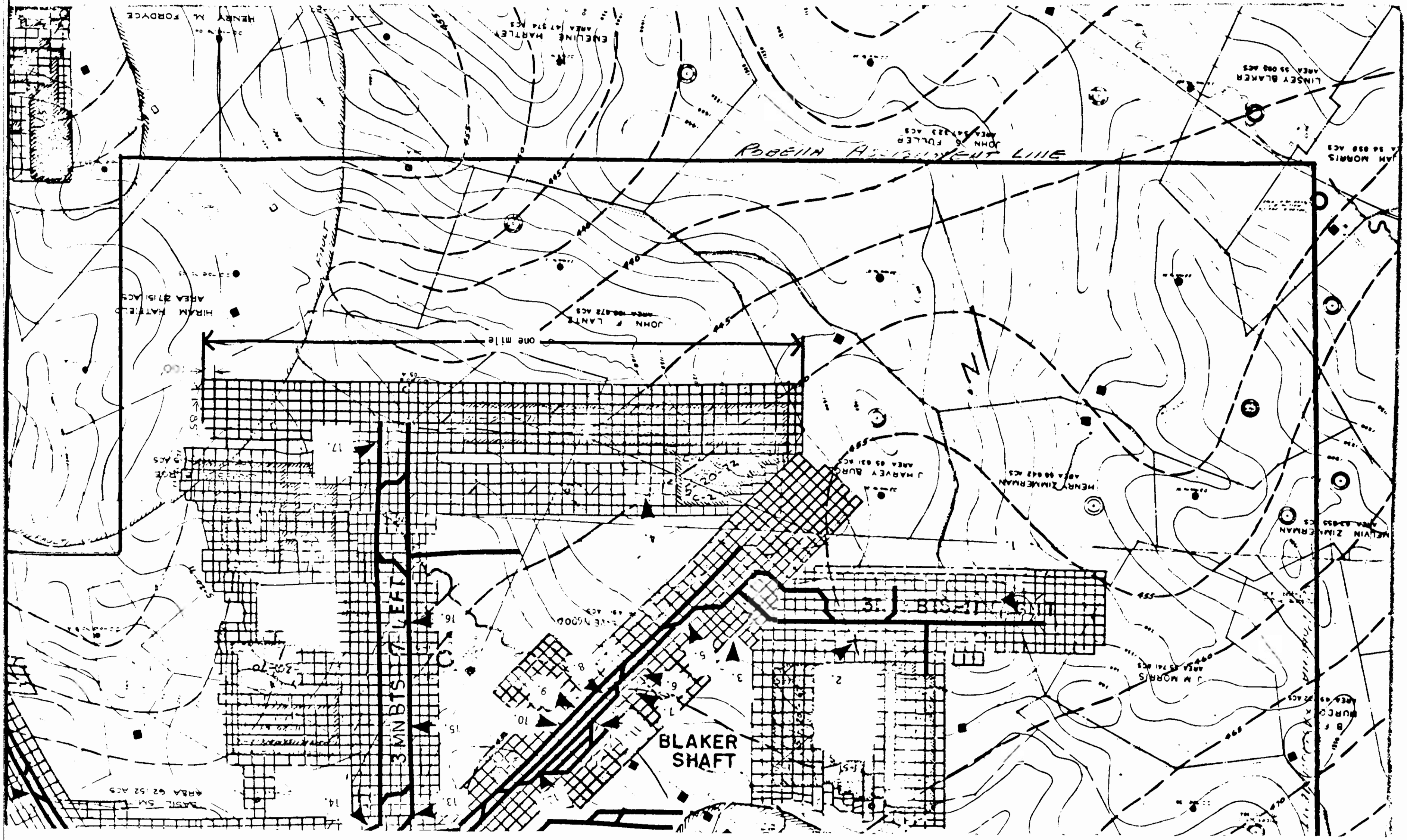
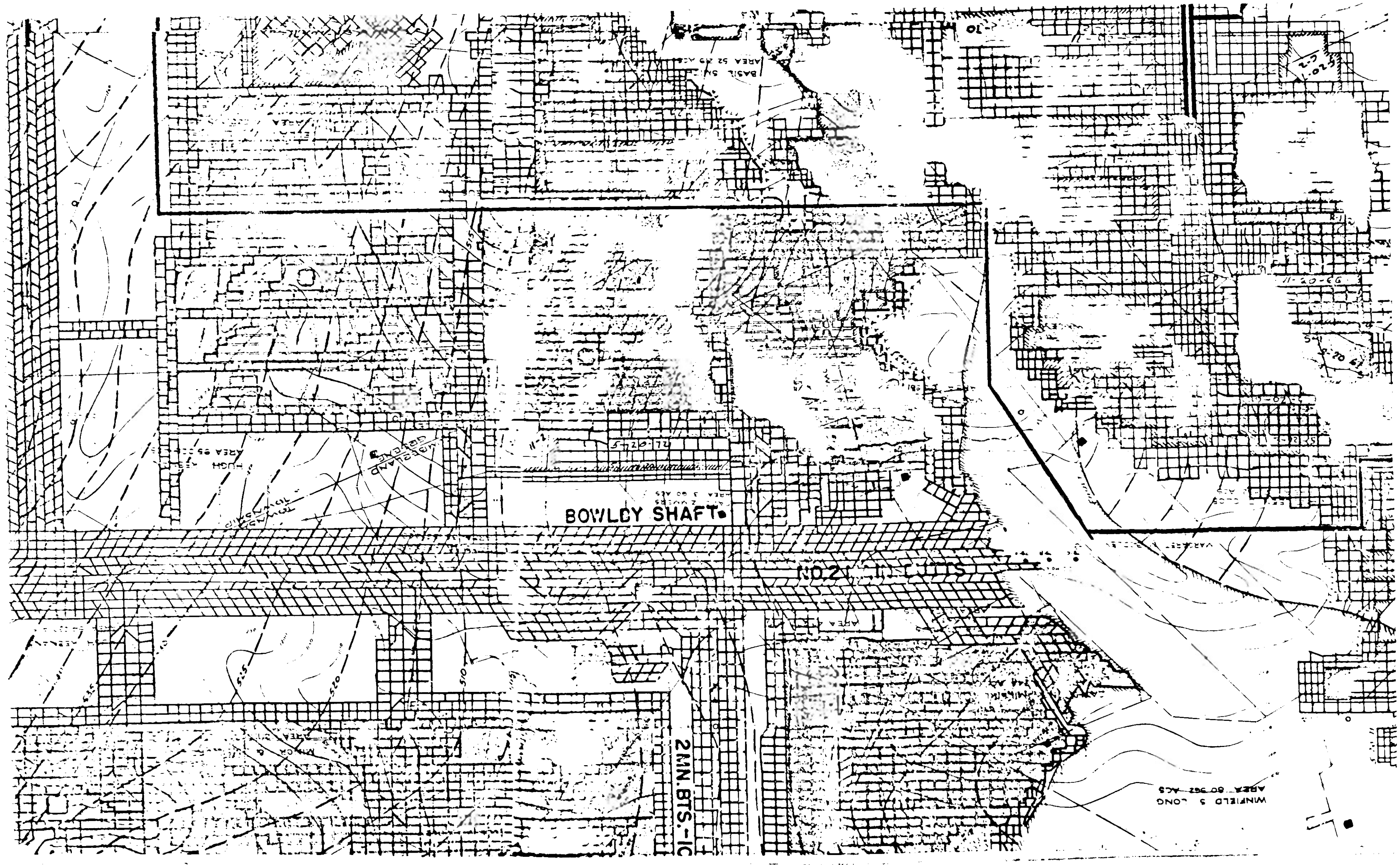


Figure 3-1. Map of Robena 4 Mine.



BLAKER SHAFT
3 MN BTS 7 LEFT
3 BTS
one mile
FAULT
ROBENA ASSIGNMENT LINE
HIRAM HATFIELD AREA 27.151 ACS
JOHN F LANTZ
EMELINE HARTLEY AREA 147.574 ACS
HENRY M. FORDYCE
JOHN S. FULLER
LINSEY BLAKER AREA 55.092 ACS
J HARVEY BURG
HENRY ZIMMERMAN
MELVIN ZIMMERMAN
J M MORRIS
B F BURGOON


BOWLEY SHAFT
2MN.BTS.

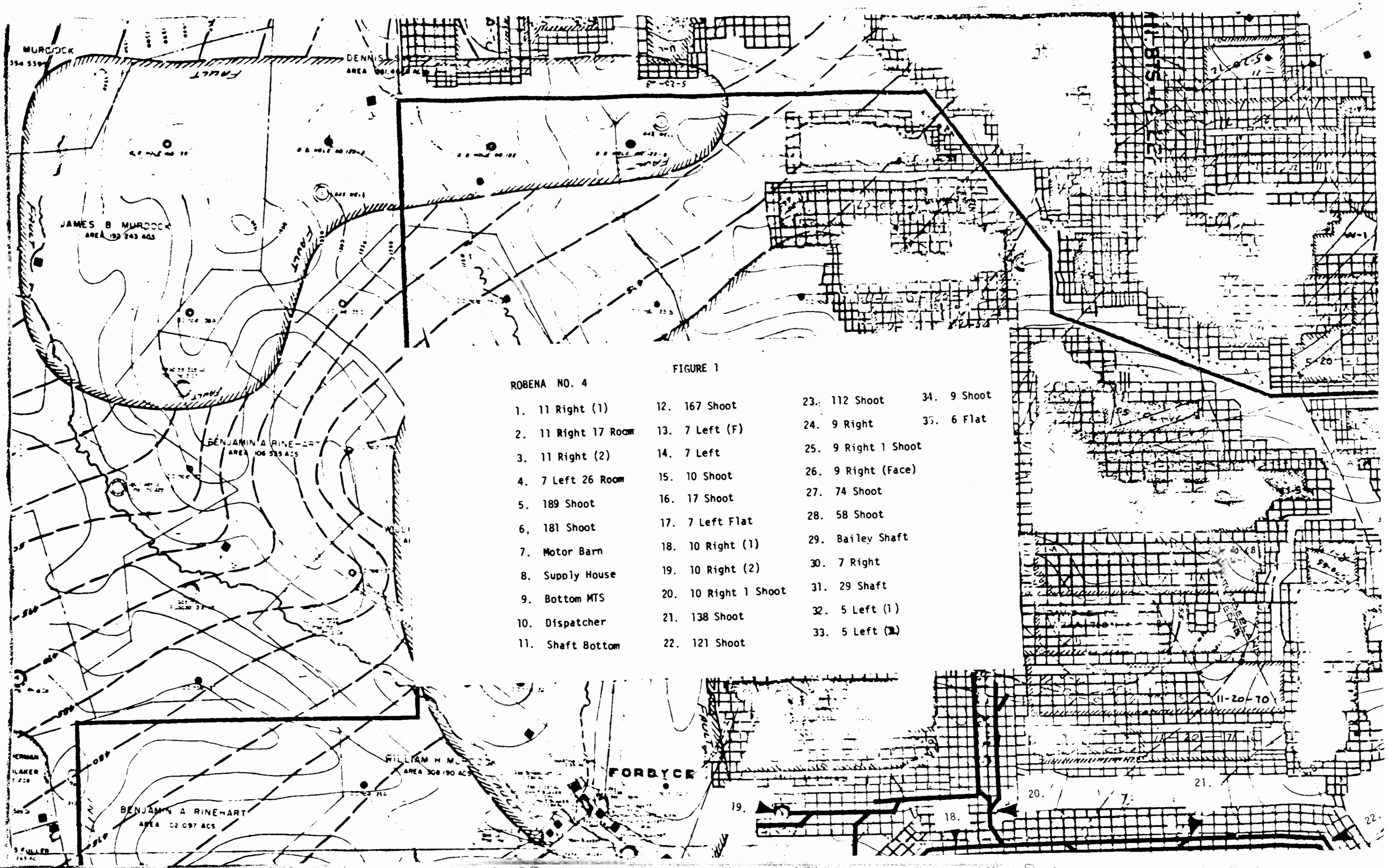


FIGURE 1

ROBENA NO. 4

1. 11 Right (1)
2. 11 Right 17 Room
3. 11 Right (2)
4. 7 Left 26 Room
5. 189 Shoot
6. 181 Shoot
7. Motor Barn
8. Supply House
9. Bottom MTS
10. Dispatcher
11. Shaft Bottom
12. 167 Shoot
13. 7 Left (F)
14. 7 Left
15. 10 Shoot
16. 17 Shoot
17. 7 Left Flat
18. 10 Right (1)
19. 10 Right (2)
20. 10 Right 1 Shoot
21. 138 Shoot
22. 121 Shoot
23. 112 Shoot
24. 9 Right
25. 9 Right 1 Shoot
26. 9 Right (Face)
27. 74 Shoot
28. 58 Shoot
29. Bailey Shaft
30. 7 Right
31. 29 Shaft
32. 5 Left (1)
33. 5 Left (2)
34. 9 Shoot
35. 6 Flat

Figure 3-2, total time phone is used, shows how much of each hour was used by the circuit and bus on which recordings were made. Because the busiest circuit and bus were monitored, it can be assumed that traffic was much less on the one other bus.

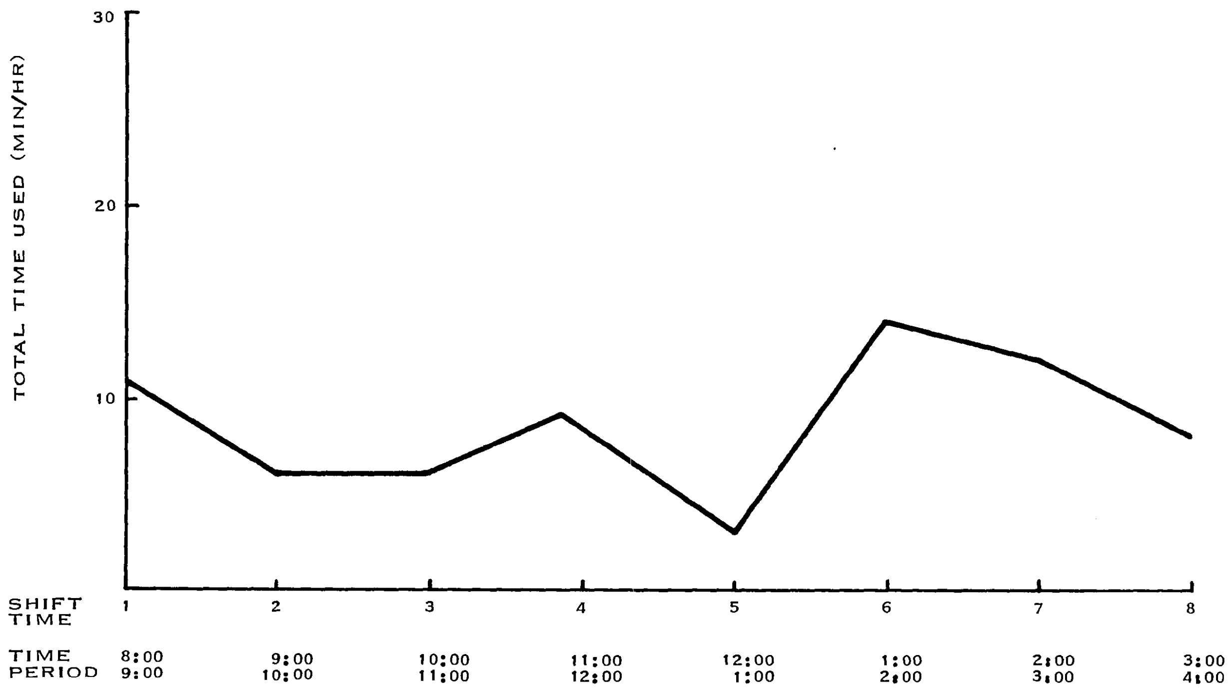


Figure 3-2. Total Time Phone is Used.

Figure 3-3 shows the total number of calls placed during each hour of the first shift. Again this is for one circuit and one bus.

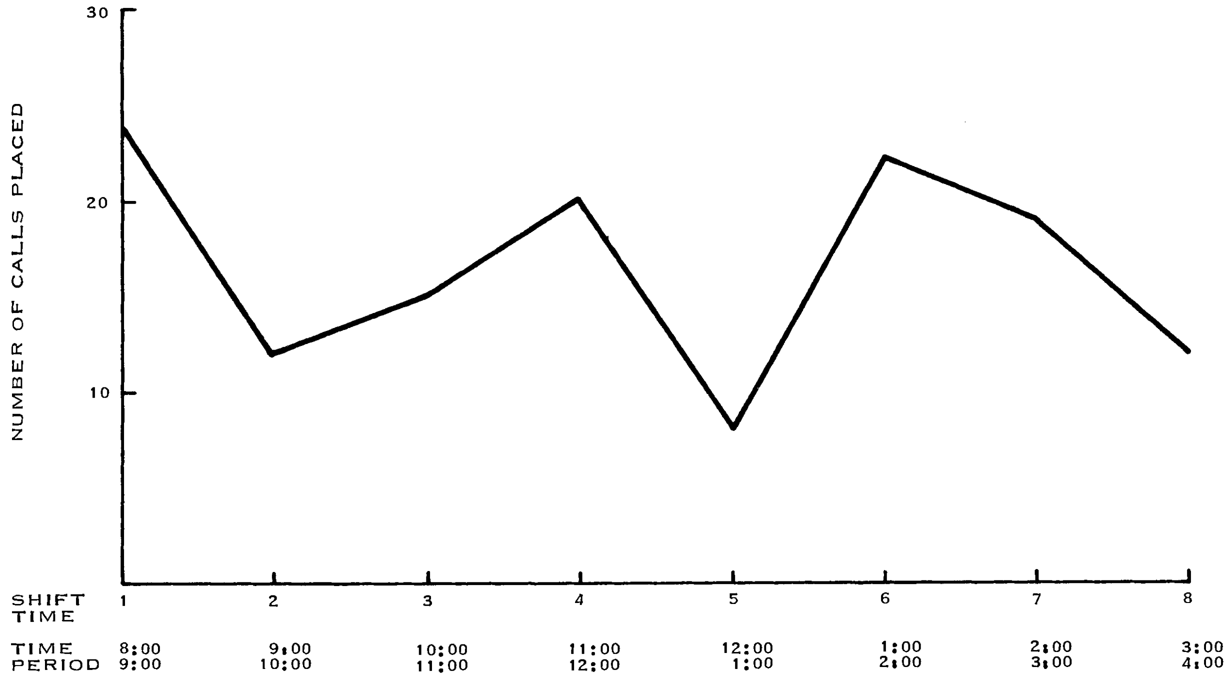


Figure 3-3. Total Number of Calls Each Hour.

Figure 3-4 shows the percentage of time the phone (one circuit, one bus) was used during the first shift. Note the effect of considering quarter-hour intervals rather than hour.

During the busiest quarter hour of the shift, from 2:15 to 2:30 pm, the one channel we recorded was used 40 percent of the time. Note that this measure of traffic density, percentage of time a channel is used, is the international dimensionless unit of traffic intensity, the Erlang. 1.00 Erlang (E) is one channel occupied 100 percent of the time; or two channels, each occupied 50 percent of the time, etc. The Erlang measure of traffic density is important here because it can be used to determine the probability of anyone using the phone system obtaining a busy signal. For many industrial operations where delays in communication effects productivity, one in a thousand is an acceptable probability of getting a busy signal.

To find the probability of a busy signal we must consider how closely the Robena telephone system matches the model used to determine probability. The Robena system has 41 telephones (subscribers) which can use two buses (trunks), and which can communicate within their eight individual circuits without using the trunks. The theoretical model allows for numbers of subscribers, numbers of trunks, and traffic density on these trunks; but, it does not allow for within-circuit traffic while trunks are being used. For the sake of analysis we are considering here that traffic within each of the eight circuits be equivalent to an additional trunk being used by the 41 subscribers. The traffic on each of these three trunks will now be determined.

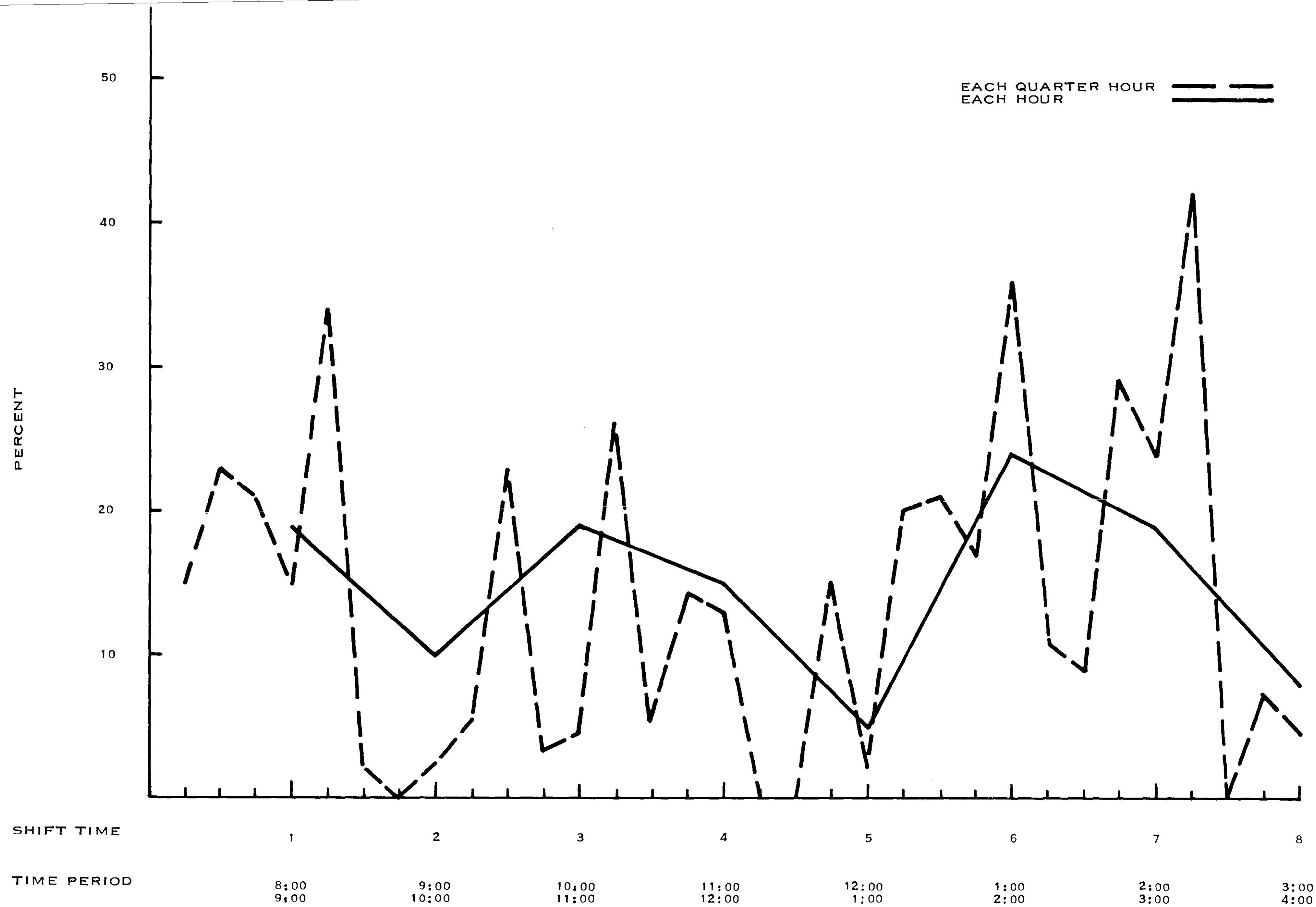


Figure 3-4. Percent of Time Phone is Used.

During the time we observed the dispatcher's work we noted the second bus was used about half as often as the first, and calls within each of the eight circuits were somewhat fewer than those for the second bus. This was during a time when the main bus was used about 20 percent of the time. So for the busiest time the traffic densities were measured and estimated as follows:

Measured on channel being recorded	0.40 (E)
Estimated for second bus	0.30 (E)
Eight circuits taken as one channel	0.20 (E)
Total Erlang intensity	0.90 (E)

Based on this traffic density, and on the number of phones in the system, the probability is:

Probability of a busy signal on next call: 5 percent

This one part in twenty (5%) is considerably worse than the one part in a thousand (0.1%) considered adequate by many industries.

Figure 3-5 is a bar graph showing the number of times various subjects were discussed during the first 8-hour shift. The last category, "Not Understood," refers to the analysis of the recordings, not to the parties communicating. There were no cases where mine personnel failed to understand each other.

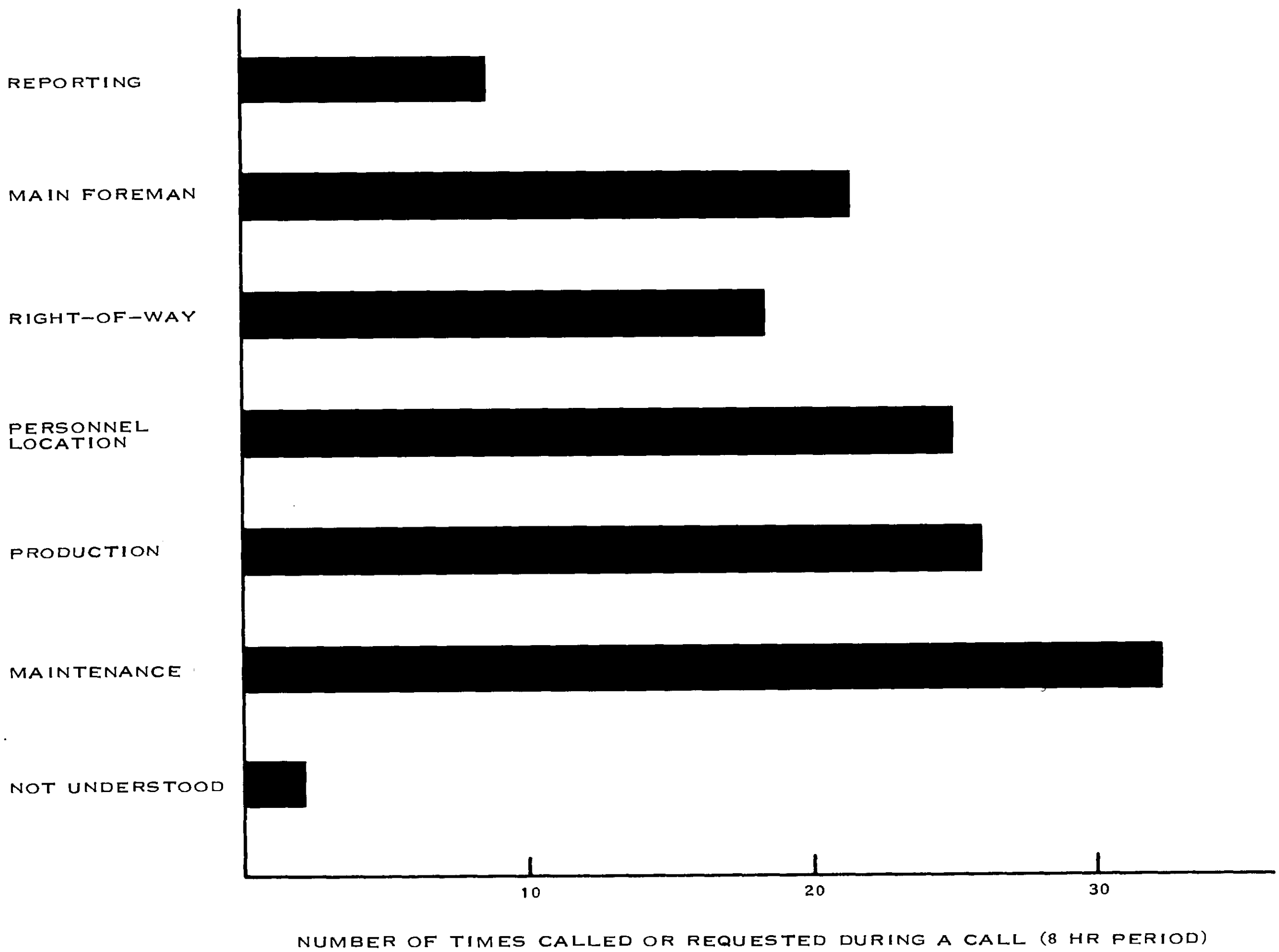


Figure 3-5. Telephone Call Categories.

3.1.5.2 Trolley Phone System

Vehicle-mounted trolley phones made calls from all locations along the tracked haulageways shown on the map, figure 3-1.

The total time trolley phones were used during the first shift of two days is shown in figures 3-6 and 3-7. Figures 3-8 and 3-9 show the percentage of time the trolley phones were used during these same two periods. Also, figures 3-10 and 3-11 show the number of times calls were made on the trolley phones.

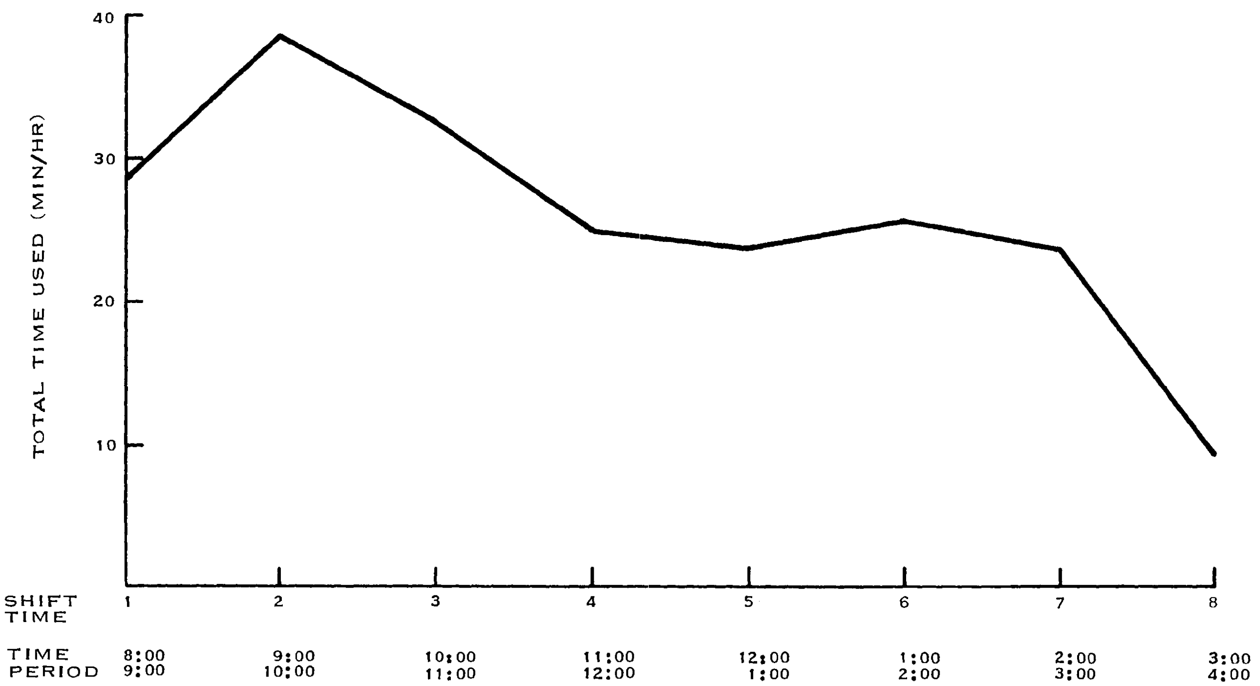


Figure 3-6. Total Time Trolley Phones Used (Day 1).

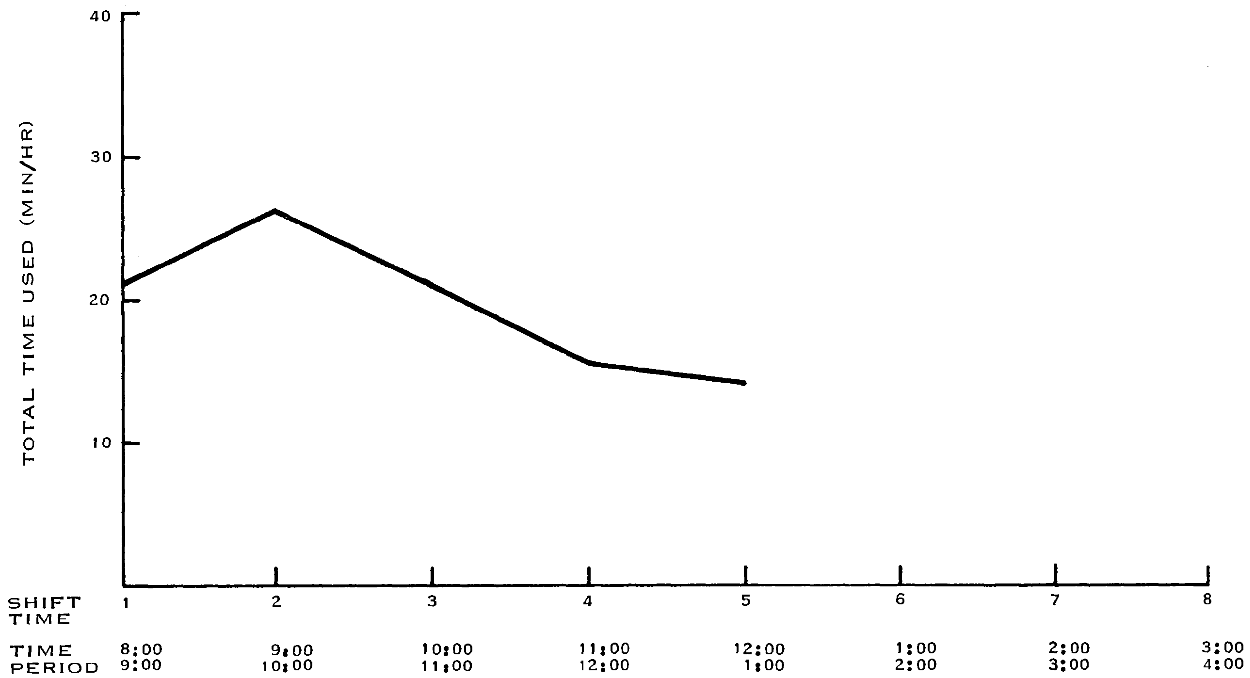


Figure 3-7. Total Time Trolley Phones Used (Day 2).

As far as communications categories are concerned for the trolley phones, the overwhelming job of the dispatcher was, naturally, dispatching. During the first shift there were 982 dispatching calls, but only 20 calls relating to personnel location, and 58 to placing empty and loaded cars.

3.1.6 Communications Requirements--Users' Viewpoint

It must be remembered that mine management (from superintendent to foreman) have justly earned their positions by the day-in and day-out resolution of realistic production problems with existing equipment in actual situations. It is thus a little naive to expect these same successful practical-minded managers to dream up, on a moments notice, communications requirements (for nonexisting equipment) to be used in a yet to be defined mining operation. Nevertheless, the personnel interviewed did suggest requirements that were compatible with those derived from the analysis of the mine survey. Evidence of this mine's interest in communications is shown by the expression of one foreman that their production would be cut in half if they lost either telephone or trolley-phone communications.

The most important communications requirement as defined by the management of this mine concerned safety. They strongly felt that a secure channel was needed where only the persons calling and called could hear the conversation. There are two reasons for this:

First, and most important, anyone calling, seeking aid for an injured miner, tends to belittle the seriousness of the injury because he knows that friends and relatives of the injured miner, and those just curious, will be listening to the conversation. The problem is not unique to this mine. Secondly, the phones of these eavesdroppers load the line to the extent that the emergency communications are impaired.

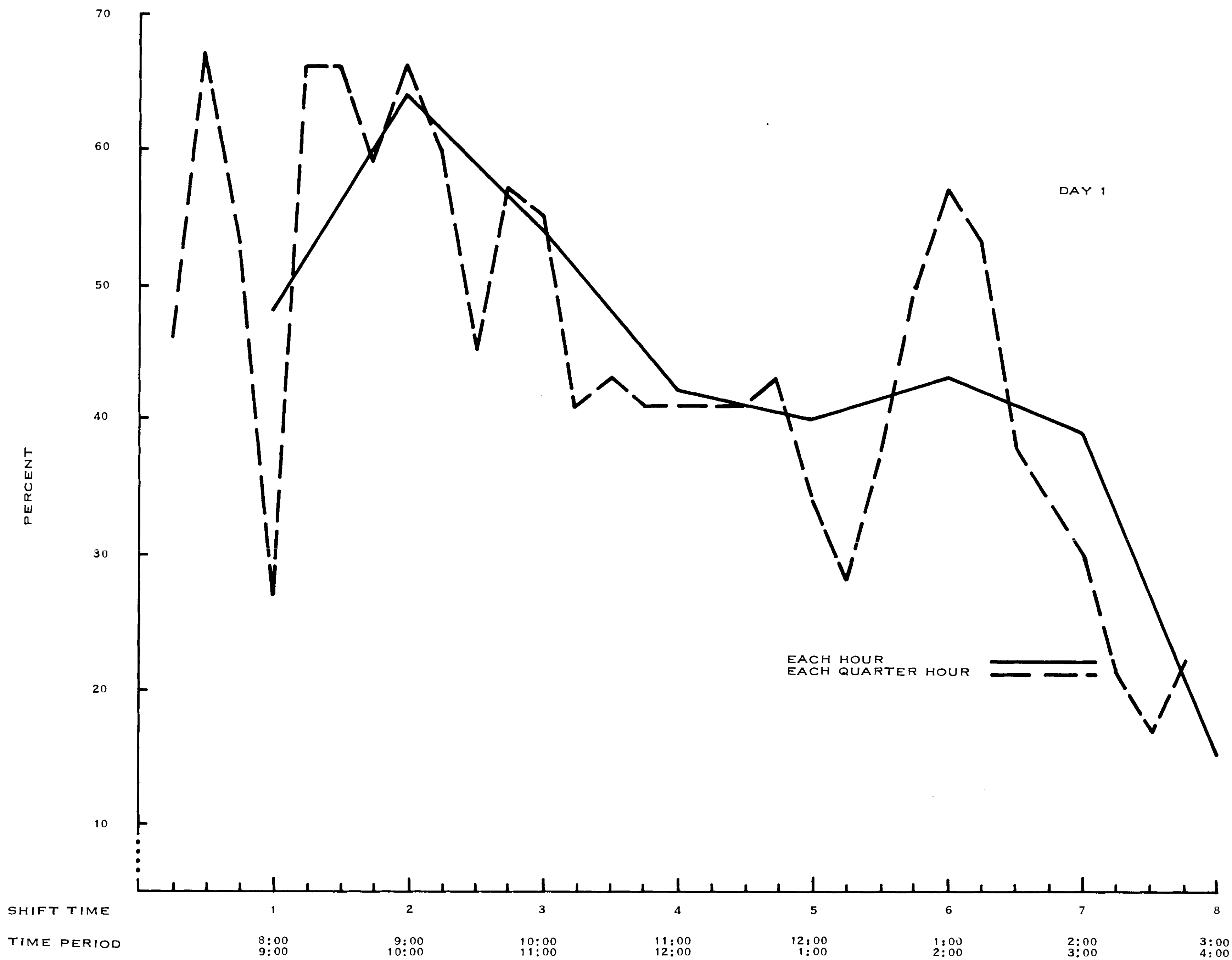


Figure 3-8. Percent of Time Trolley Phone Used (Day 1).

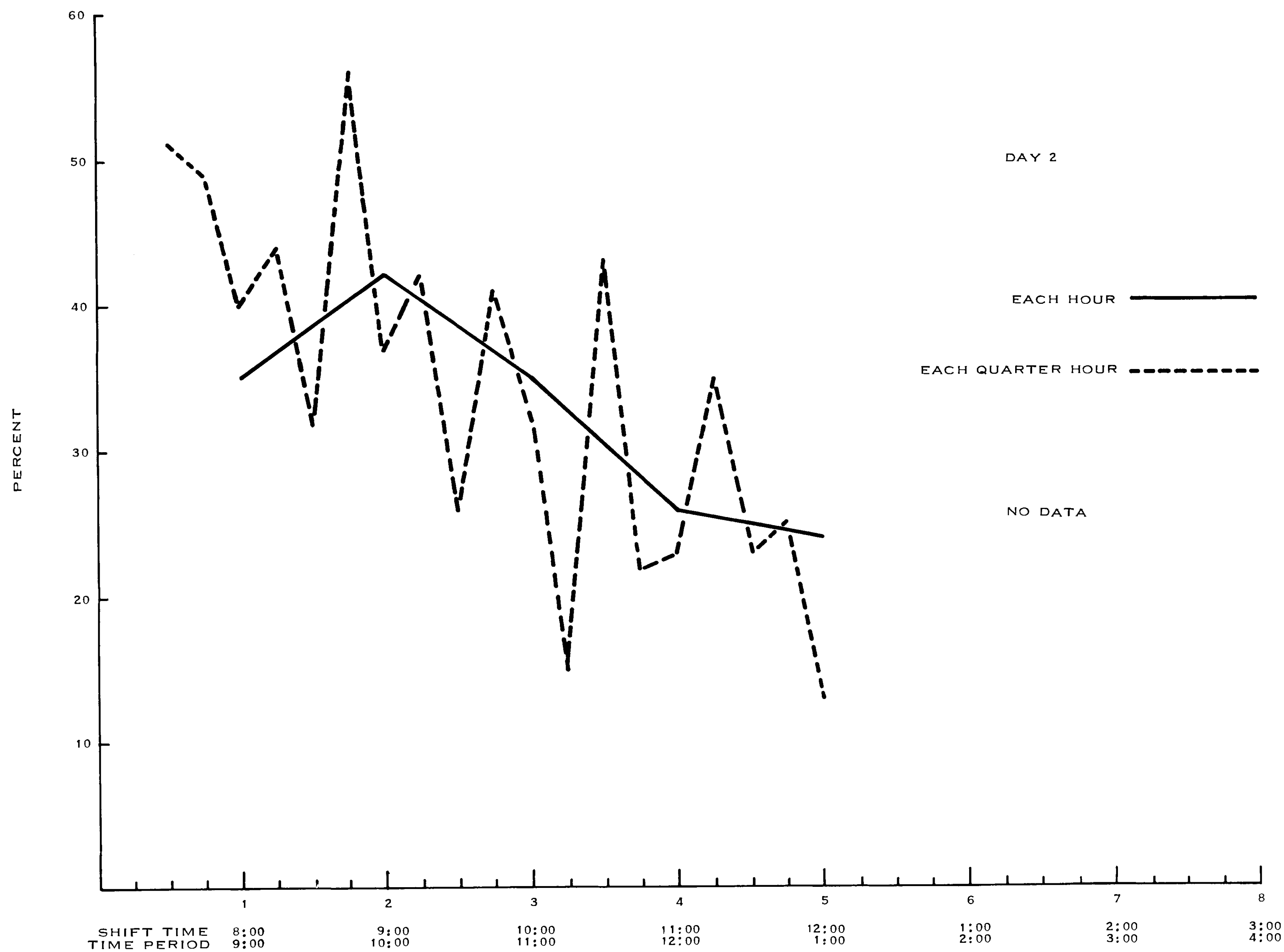


Figure 3-9. Percent of Time Trolley Phone Used (Day 2).

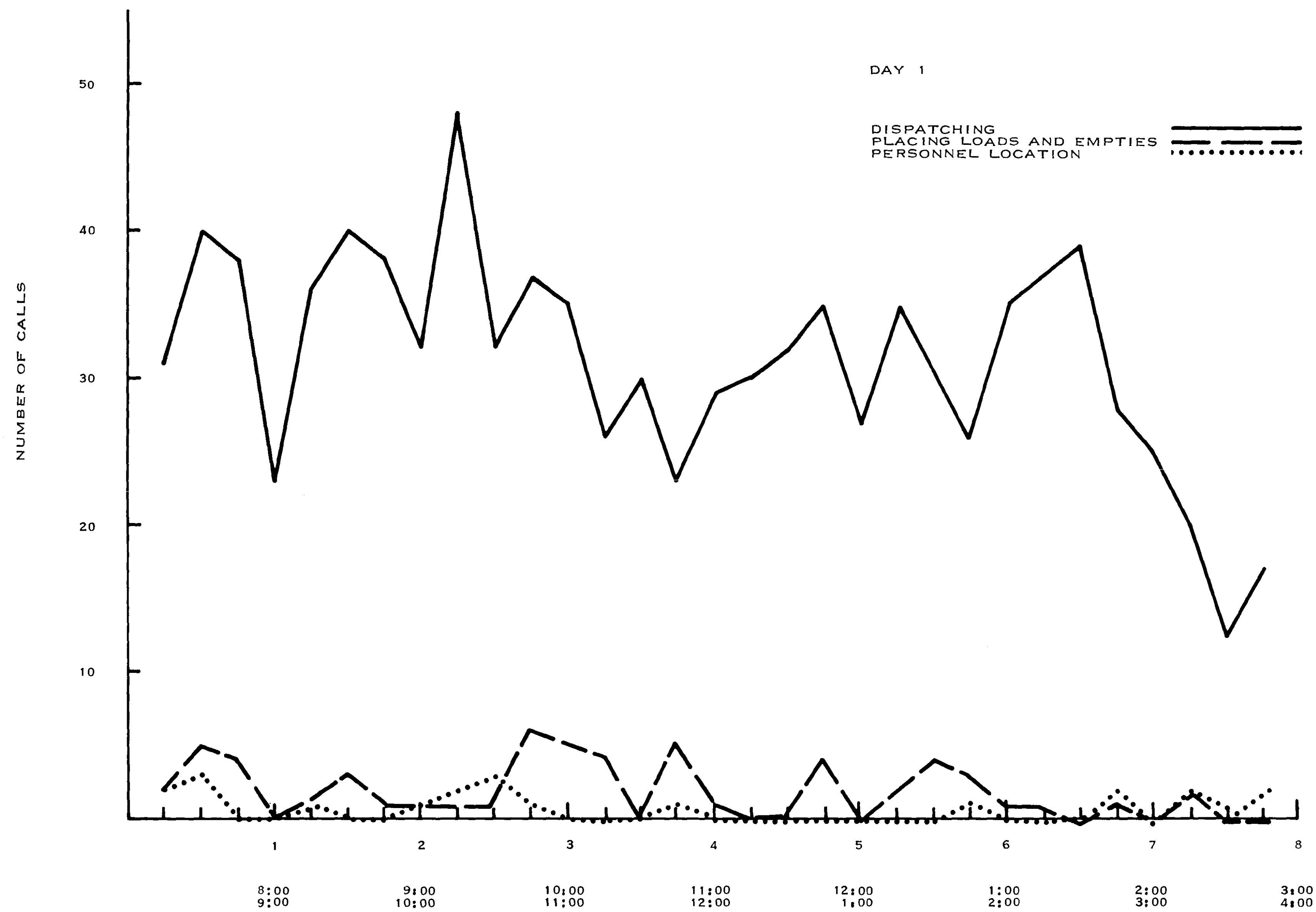


Figure 3-10. Number of Calls Placed on Trolley Phones (Day 1).

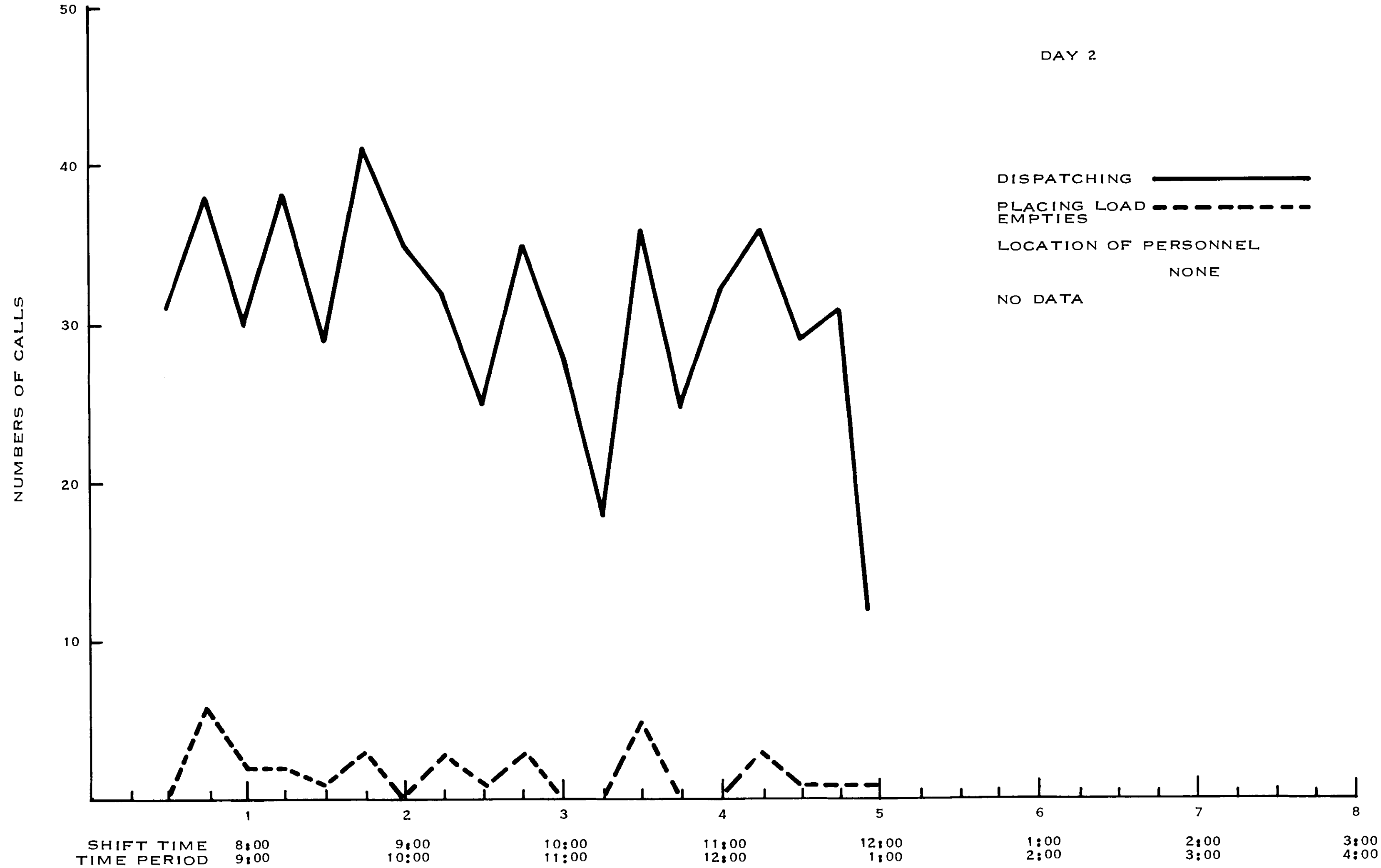


Figure 3-11. Number of Calls Placed on Trolley Phones (Day 2).

Based on this realistic situation, a basic communications requirement is a private line, selective calling channel over which the person attending an injured person can privately call, at his discretion, the mine foreman, the dispatcher, the safety foreman, or the nearest hospital or ambulance service. Note that a conventional private dial system meets this requirement. One mine visited had a dial phone adjacent to each pager-phone. This met their need for a secure channel for both management and emergency communications.

Contrary to our initial analysis, mine management was not interested in a paging or portable communications system with which higher management could initiate communications with section foreman, or where the section foreman could have mobile communications with select members of his crew. And management was only a little interested in a mobile system where the section foreman could initiate calls to maintenance and supply personnel provided the size and weight of the foreman's equipment would be much much less than a lamp battery; the foremen presently have more to carry than is humane.

3.1.7 Communications Requirements - Based On Survey Analysis

Although the personnel interviewed felt the quality of their communications was adequate, our analysis indicates excessive noise and distortion present. Therefore, a requirement that applies to this mine as well as all communication systems is that of reasonable signal-to-noise ratio for good intelligibility. At a minimum, Robena needs to clean up the noise on their phone system.

The fact that the chances of getting a busy signal are 50 times greater than most industries find acceptable is proof that additional channel capacity is needed. Adding additional channels to a wired system appears to be an acceptable solution since these extra channels will minimize the telephone duties the dispatcher now performs and will eliminate the communication system blocking problem.

Moreover, additional channels will in all probability increase the total traffic from the estimated current peak of 0.90 Erlang to a higher level. A reasonable assumption for increased traffic density appears to be obtained by increasing the current density by 50 percent to a total of 1.35 Erlangs. Also, rather than using the 0.1-percent probability of blocking used by current industrial phone systems, a value of 1 percent appears more reasonable. With 1 percent probability of blocking and 1.35 Erlangs of total traffic density, a minimum of 5 communication channels are needed for Robena No. 4. Furthermore, making one of the 5 channels a private line will fulfill the requirement for private communications.

Also, from observing the mine operation and talking to various personnel it appears that section foremen, like the foremen in most industrial operations, are overworked, and yet are the key to improving productivity. Therefore, wireless communication, whether it be 1-way page or 2-way voice, is at least needed for the section foremen along with various other select supervisors or maintenance personnel.

Because of the mine's size and corresponding communication traffic density, a communication center is a requirement for Robena No. 4. However, the current dispatch center seems to satisfy this requirement.

From this brief analysis of the mine and its current communication, the following is a list of minimum communication requirements for Robena No. 4:

a. Reasonable communication channel signal-to-noise level
b. At least 5 independent voice channels
c. At least 1 secure voice channel that may be included in the 5 voice channels

d. Some form of wireless communication to select individuals on the working section or roving in haulageways
e. A communication center

3.2 GREENWICH COLLIERY MINES, ON-SITE SURVEY OF MAY 3 AND 4, 1973

3.2.1 Mine Contacted

Pennsylvania Power and Light Greenwich Collieries
Box 367
Ebensburg, Pennsylvania 15931

3.2.2 Initial Mine Contact

George Trevorrow - General Manager
(814) 743-6631 (North Mine, No. 1)
(814) 948-5400 (South Mine, No. 2)

3.2.3 Personnel Interviewed

George Trevorrow	-	General Manager
Nick Letizia	-	Mine Foreman (No. 1)
Ray Noon	-	Mine Foreman (No. 2)
Joe Kreutzberger	-	Production Manager
Howard Kyock	-	Electrical Superintendent
Butch Simmon Gray	-	Chief Electrician (No. 2)

3.2.4 General Mine Information

3.2.4.1 Mine Description

The Greenwich Colliery mines, Ebensburg, Pennsylvania, consist of adjacent North (No. 1) and South (No. 2) low-coal mines. The North Mine employs longwall and continuous mining. The South Mine employs conventional and continuous mining, and is preparing for their first longwall operation. Both mines employ belt coal haulage to closely located drift entrances. Men and supplies enter the North Mine by a 400-foot shaft remotely located from the South Mine drift entrance.

From the two mines, 8,000 tons of coal per day are mined by about 600 union men under the supervision of about 60 officials.

3.2.4.2 Crew Composition

A "working section" is the unit of organization engaged directly in the production of coal. All other personnel are either engaged in administration or provide services for the section crew. Figure 3-12, an approximate table of organization for the entire mining operation, shows the unofficial relationship between the section crews and the overall mining organization. A section crew and a maintenance crew are shown in heavy outline.

The seven section crews and the maintenance crew for each shift are composed of the following members:

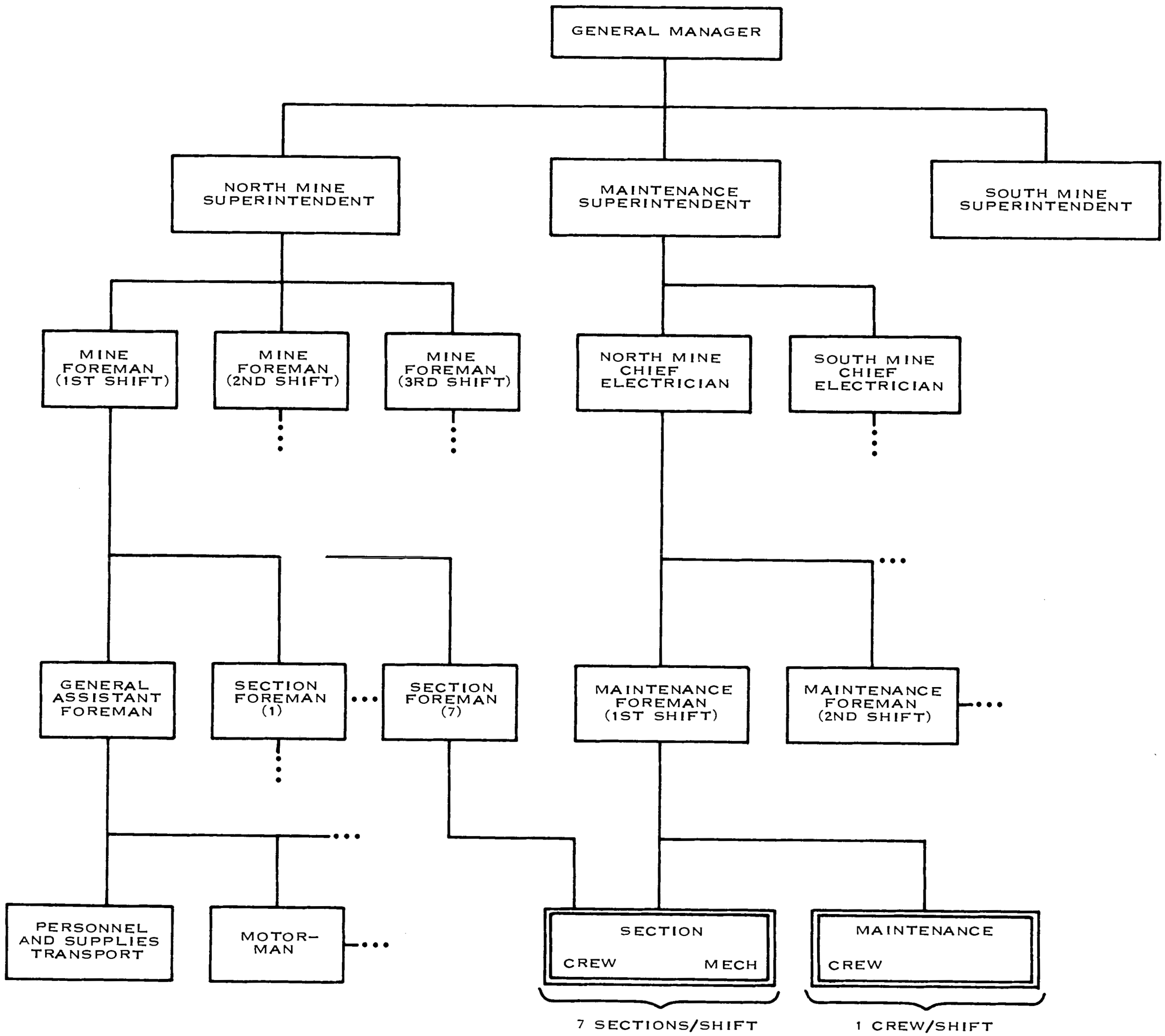


Figure 3-12. Table of Organization.

a. Working Section--Longwall

Foreman (1)

Shearer operator (1)

Helpers (7)

Repairmen (2)

b. Working Section--Continuous Mining

Foreman (1)

Miner operator (1)

Miner operator helper (1)

Roof bolter operator (1)

Shuttlecar operators (2)

Mechanic (1)

c. Maintenance Crew

Foreman (1)

Greasers (2) (take care of 3 miners, battery equipment, and track equipment)

Mechanics (2)

Apprentice mechanics (2)

Wiremen (4) (trolley and feed lines, electric equipment and cables, and belt line fire detection system)

Battery repairman (1)

3.2.4.3 Mine Equipment and Power

The North Mine currently employs one longwall mining unit and seven working sections of Lee Norse continuous miners. The South Mine is preparing for its first longwall operation. For the North Mine's Longwall mining, coal is moved by an armoured face conveyor to a stage loader at one end of the longwall, to an extendable belt, and finally to a conventional belt. During the two days the mine was visited, the North's Longwall miner was down with a burned-out shearing motor.

In addition to preparing for Longwall mining, the South Mine employs a full dimension unit, a conventional mining unit, and Lee Norse continuous miners for seven working sections per shift.

The equipment used in conventional mining consists of a cutting machine, a Joy Loader, and two shuttlecars. With a full dimension system, the shuttlecars are replaced by an extendable belt.

Coal is brought out of the two mines by conveyor belt, and men and supplies are moved by track. The coal is moved by belt from the two mines to a screening house having 1,250 tons of storage capacity. To cope with slacks and overflows, coal can be automatically diverted to a 12,000-ton capacity storage pile.

Ac power is brought into the mines at 12,470 volts. Two rectifiers are positioned at every 6,000 feet of track, each with a capability of 300 kW, to supply 300-Vdc power to the trolley wires and their feeders. In addition to supplying locomotives with power, the trolley lines supply power, at nip points along the line, for the operation of the 300-volt dc shuttlecars. At points where needed, the 12,470 volts ac is transformed to 600 volts to provide ac power for: rock dusters, conveyor belt drives, miners, roof bolters, and belt feeders.

3.2.5 Current Mine Communications

The equipment used in each of the two mines includes paging type party-line telephones; trolley phones; the fire sensor tape recordings that would automatically be patched into the phone system, should there be a belt fire; and the fan sensors that utilize the phone lines.

The North Mine's communications systems are independent of the South Mine's, but generally of the same size and equipment types. The South Mine's chief electrician's office does have a North Mine phone, as does the South Mine's foreman's office.

3.2.5.1 Telephone System

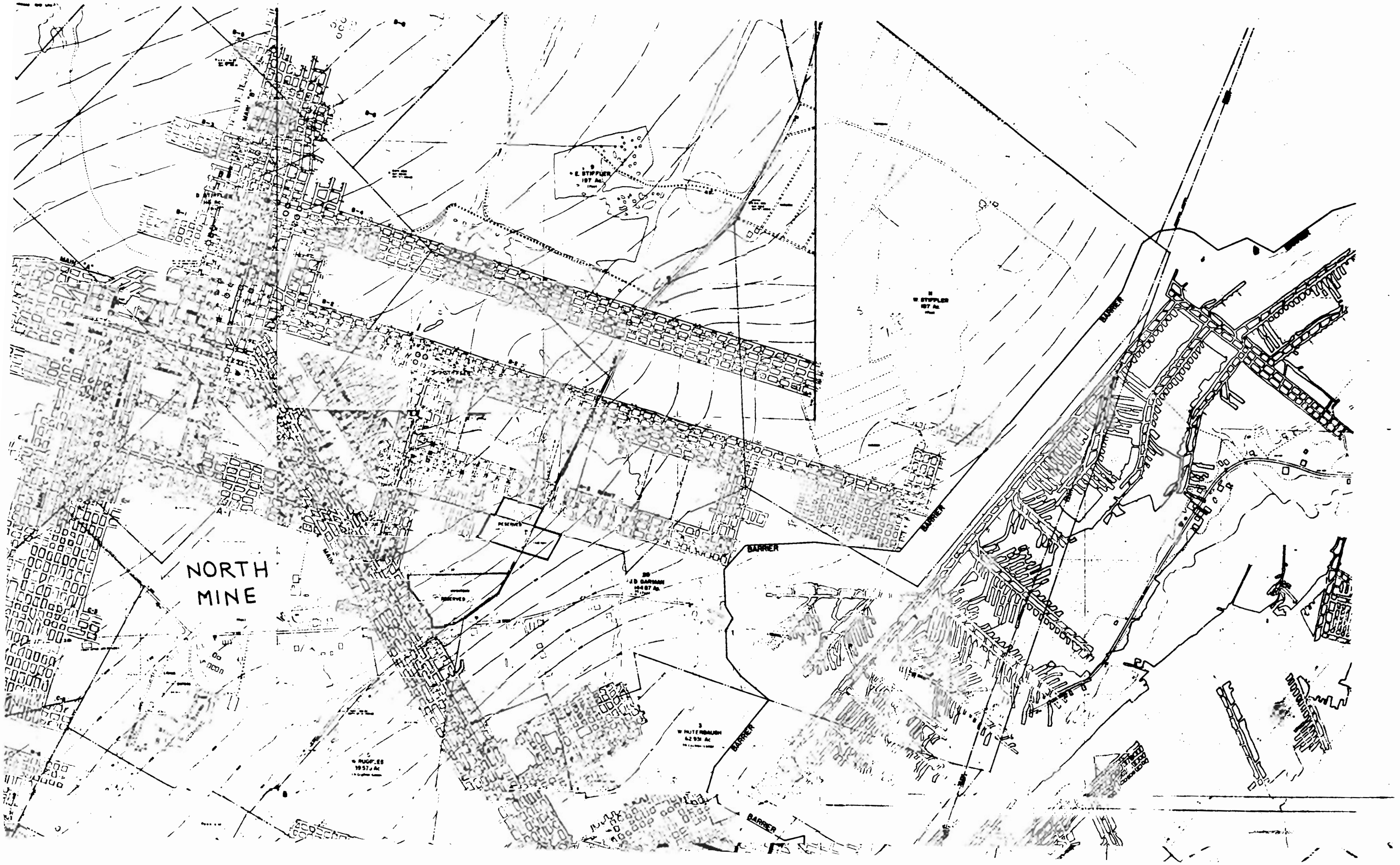
Since both mines have similar communication equipment and interview time was limited, locations of the underground telephones were taken for the South Mine only.

Figure 3-13 is a map of the South Mine showing the location of the 31 underground loudspeaking telephones. The underground phones are all in a single network, and also in this network are the following seven surface phones:

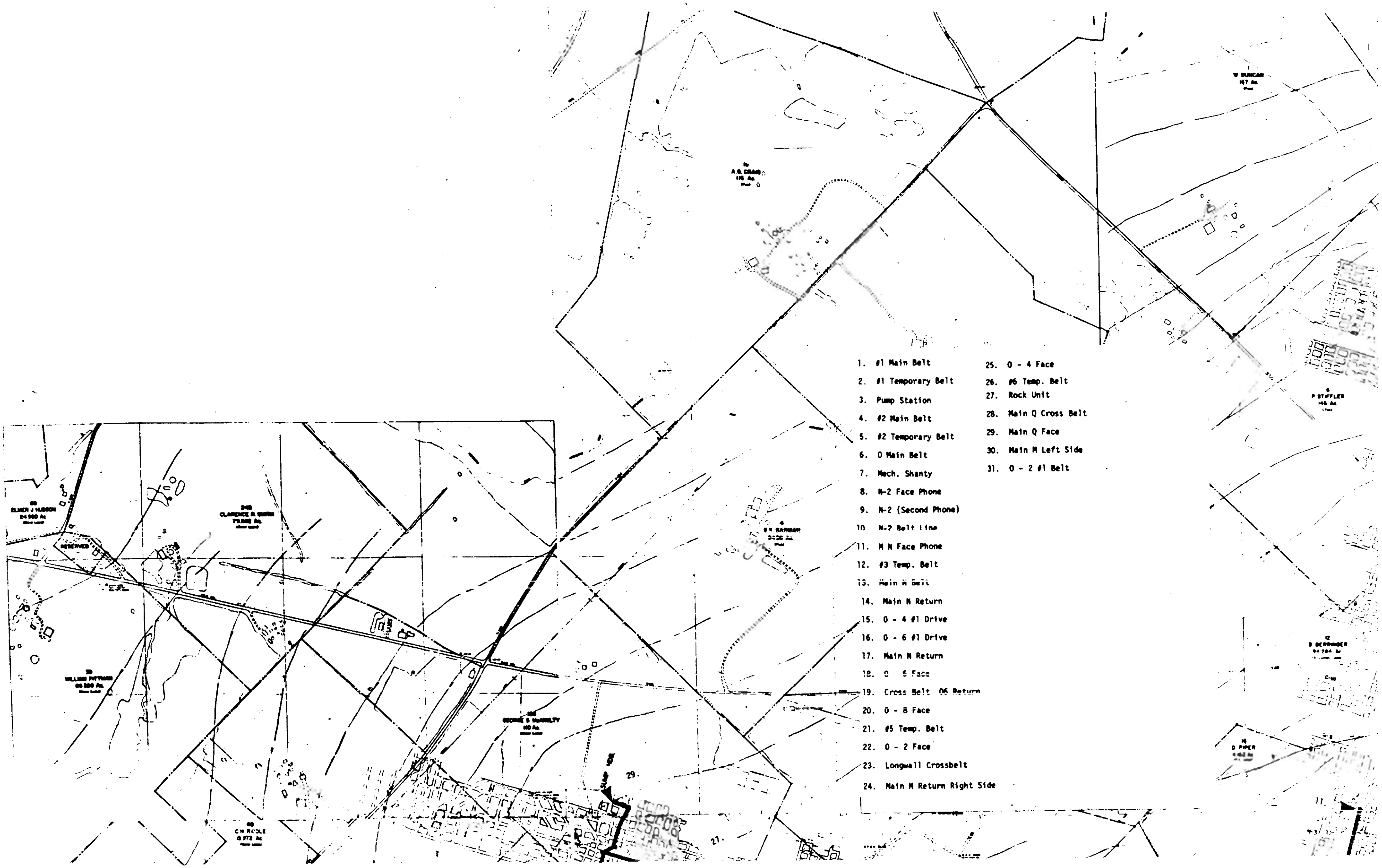
Outside mechanics shanty 1
Outside shop 1
Auditorium 1
Chief electrician 1
Cleaning plant 2
Double breaker switch house 1

The paging phones used in these mines are built by FEMCO, use 6 volts for normal phone use, and 22.5 volts during paging. With these phones, depressing the paging button at any station permits the operator to broadcast through the loudspeakers on the remaining 30-some telephones. On releasing the paging button the operator can converse with anyone who picks up the handset on any other phone.

At the South Mine, tape recordings were taken of both the South and North Mine's party-line telephone system and the South Mine's trolley phone system. The following paragraphs reflect the analysis of these tapes.



NORTH MINE
BARRIER
BARRIER
BARRIER
BARRIER
BARRIER
MAIN
E. STIFFLER
W. STIFFLER
J.D. GARMAN
RESERVES



1. #1 Main Belt
2. #1 Temporary Belt
3. Pump Station
4. #2 Main Belt
5. #2 Temporary Belt
6. O Main Belt
7. Mech. Shanty
8. N-2 Face Phone
9. N-2 (Second Phone)
10. N-2 Belt Line
11. M N Face Phone
12. #3 Temp. Belt
13. Main N Belt
14. Main N Return
15. O - 4 #1 Drive
16. O - 6 #1 Drive
17. Main N Return
18. O - 6 Face
19. Cross Belt O6 Return
20. O - 8 Face
21. #5 Temp. Belt
22. O - 2 Face
23. Longwall Crossbelt
24. Main M Return Right Side
25. O - 4 Face
26. #6 Temp. Belt
27. Rock Unit
28. Main Q Cross Belt
29. Main Q Face
30. Main M Left Side
31. O - 2 #1 Belt
RESERVED

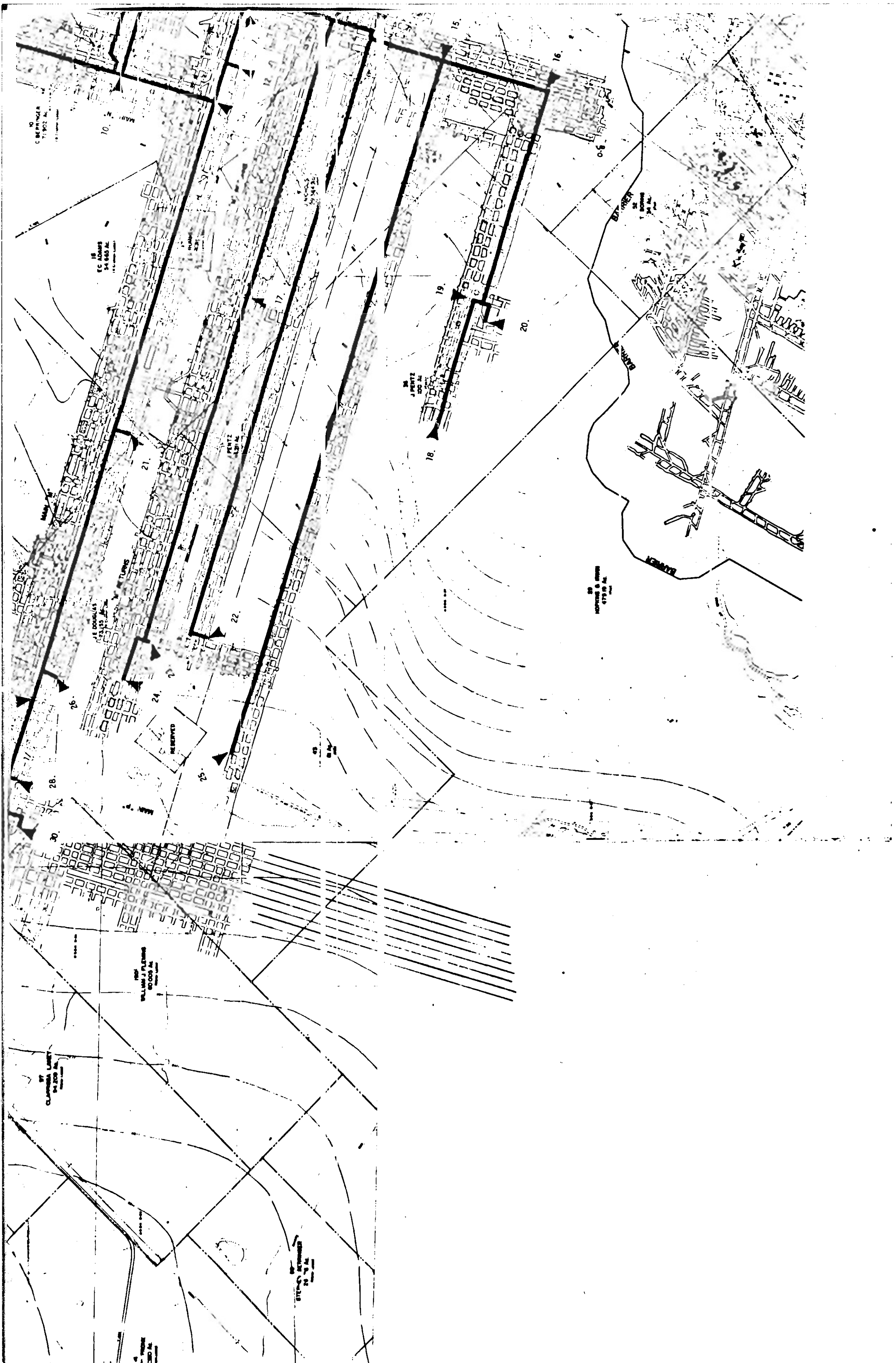


Figure 3-14, for the South Mine, shows the number of times specific subjects were discussed during the eight hours of a normal first shift. Often more than one topic was discussed in a single conversation. Figure 3-15 presents the same information, during the same shift, but for the North Mine. In reviewing these two figures the reader should keep in mind that only gross conclusions can be drawn from such a small sample, and that the North Mine was engaged primarily in Longwall Mining, and the South mostly in conventional and continuous mining.

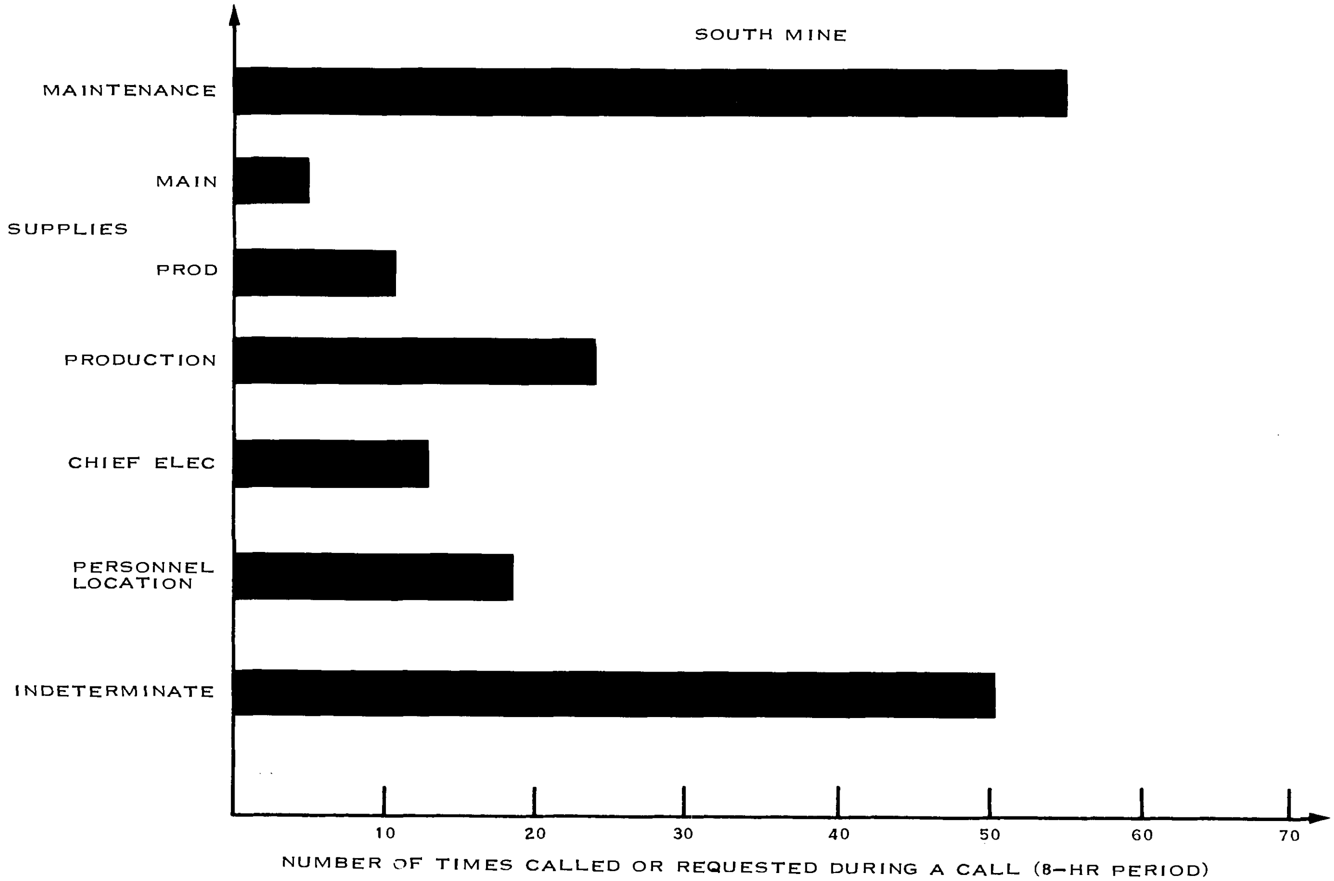


Figure 3-14. Telephone Call Categories (South Mine).

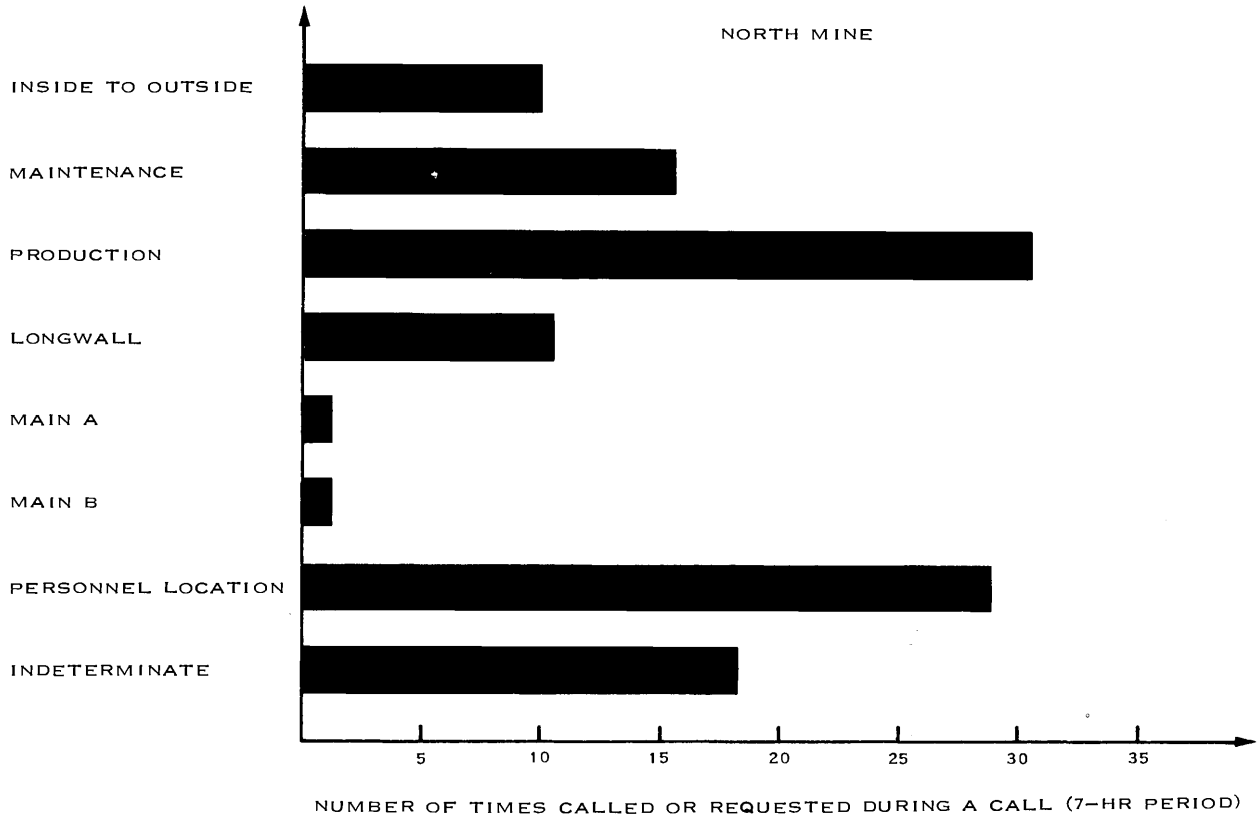


Figure 3-15. Telephone Call Categories (North Mine).

Figures 3-16 and 3-17 show the percentage of the time the phones were used during the eight hours of the first shift, for the South and North Mines respectively. To show the significance of different base periods, the percentage of usage is presented based on 1-hour intervals (solid lines) and 15-minute intervals (dashed lines). Note that, for the South Mine, based on hour intervals, the most the system is used is about 50 percent of the time, between 9:00 and 10:00 am. But note that, based on 15-minute intervals, the phones are used nearly 90 percent of the time around 3:30 in the afternoon.

This heavy usage occurs during the last hour of the shift when section foremen are making their end-of-shift reports on production status, supplies on hand, supply requests, and maintenance work requests. The fact that the phone system is used 90 percent of the time signifies that any other calls that could perhaps improve production efficiency must then be either delayed or not made at all.

Note that the North Mine, which has about the same number of phones and employees, has a peak phone use of only about 65 percent occurring during the same reporting period. Evidently communications in the North Mine is either not as essential or not as easily used as that for the South Mines.

The traffic density for this phone system in Erlangs is equal to the percentage of time the channel is used (seeing this is a single-channel system). In turn, this Erlang measure can be used to determine the probability of finding the line busy when another party needs the channel.

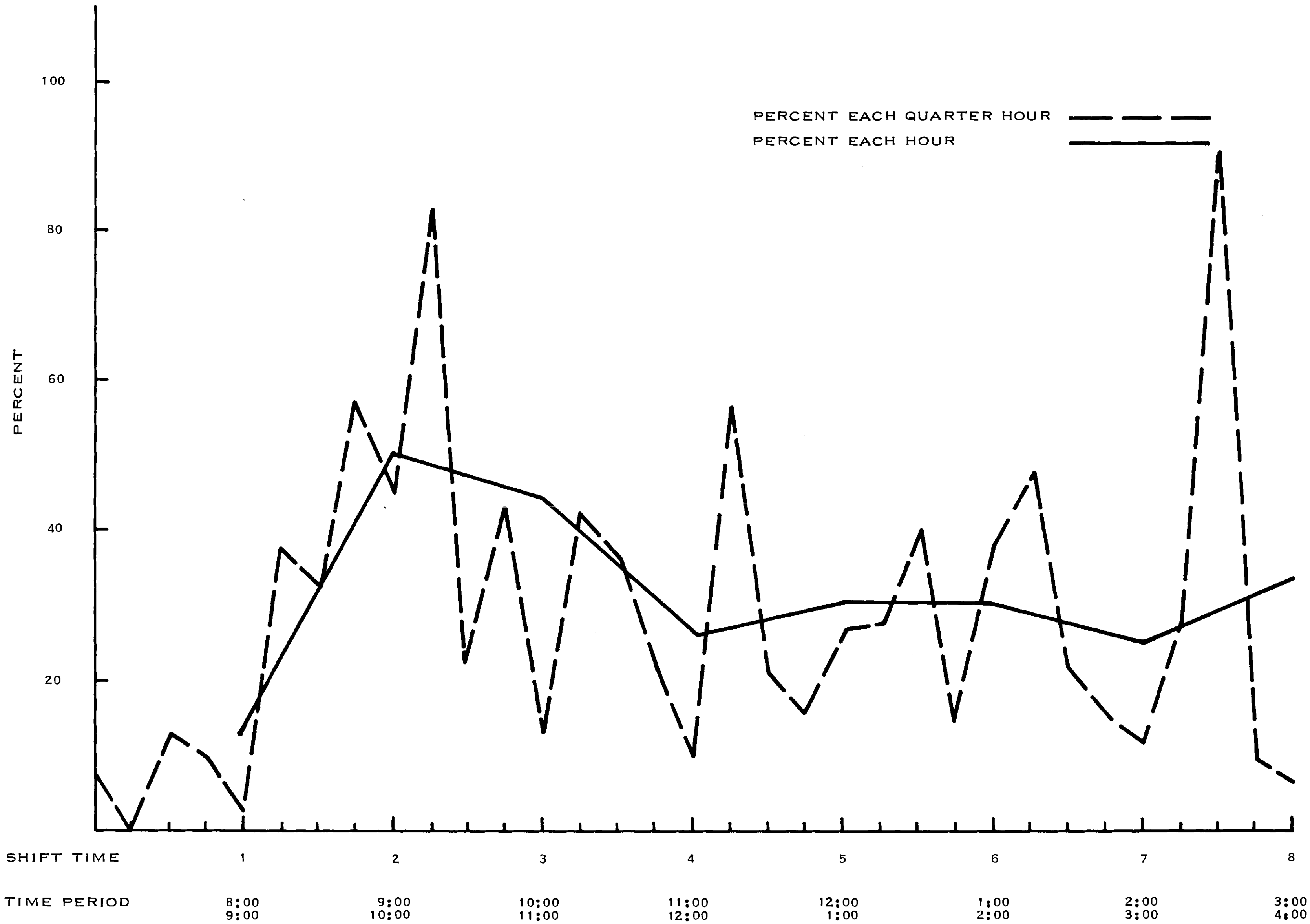


Figure 3-16. Percent of Time Phone Used - South Mine.

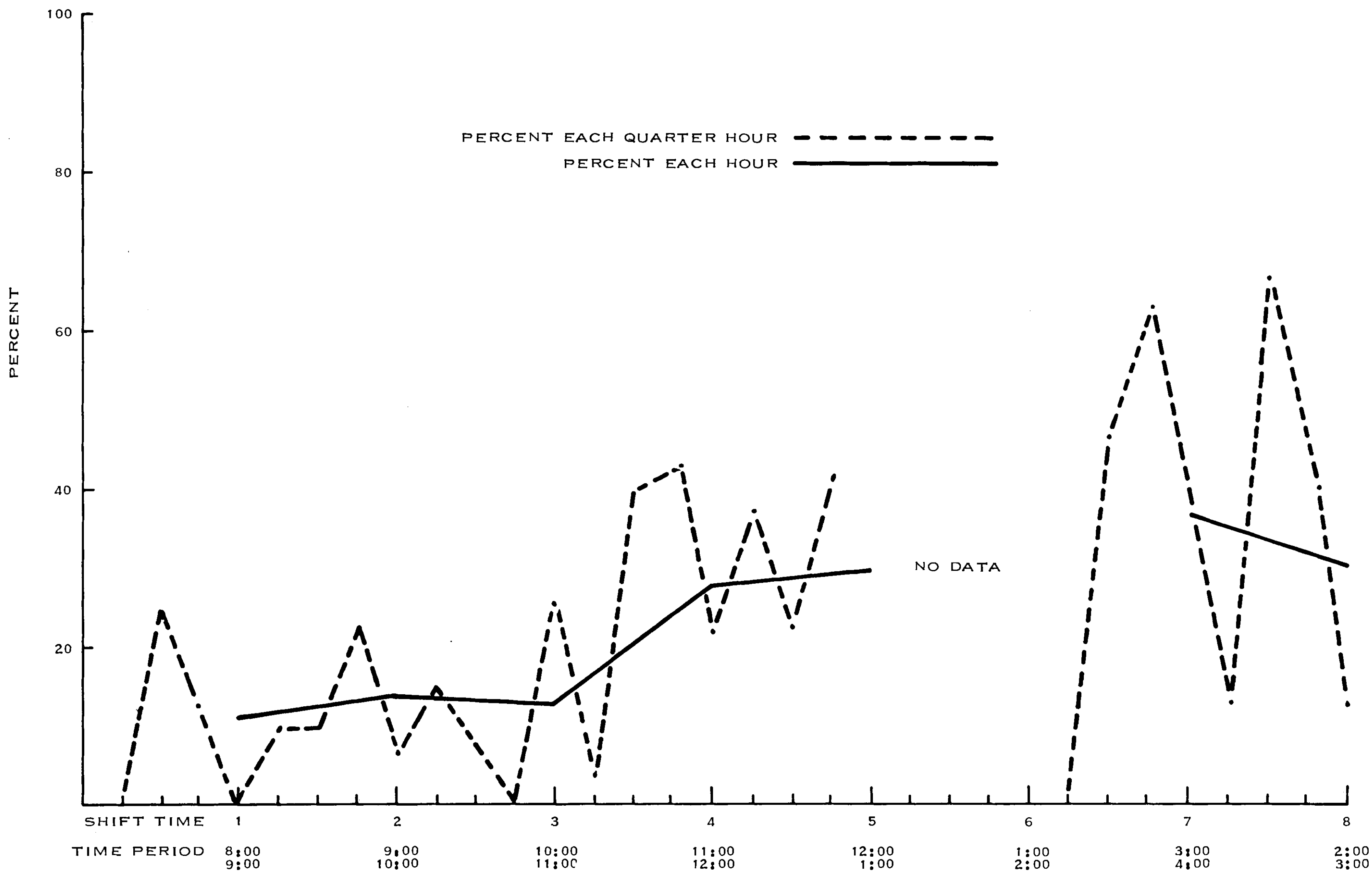


Figure 3-17. Percent of Time Phone Used - North Mine.

The South Mine, at times of peak communication, has a maximum single channel traffic density of approximately 0.85 Erlang. With this traffic density the percentage of time the line is busy is 45 percent, which is 450 times greater than some industries consider adequate. However, for the same situation, the North Mine traffic density is approximately 0.60 Erlang. With this density the percentage of times the line is busy is 35 percent, which is 350 times greater than industry will accept.

Figure 3-18 shows the time in minutes the phones are used during each hour of the first shift for both the South (solid line) and the North (dashed line) Mines. This is the same as the previous figure except time is given in minutes rather than percentages.

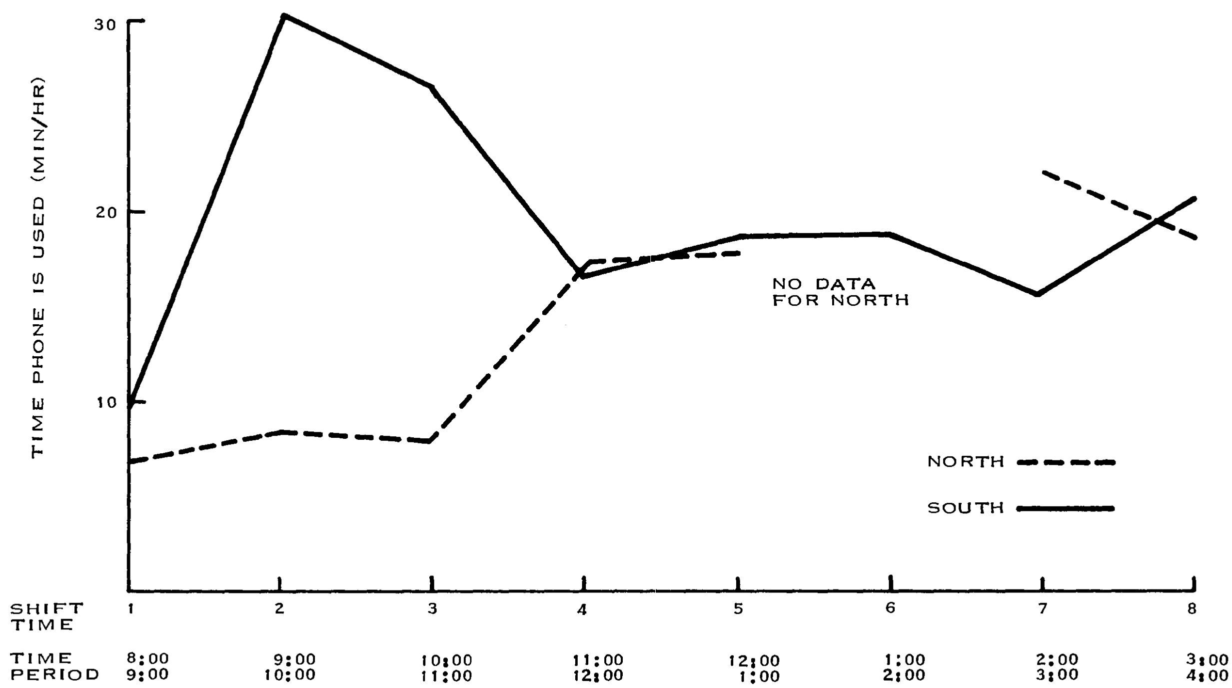


Figure 3-18. Total Time Phone Used.

Figure 3-19 presents the numbers of phone calls placed, figure 3-20 the number of calls completed, and figure 3-21 the composite of the two, the percentage of calls completed. The three figures present data independently for the South and North Mines.

The final curve for the phone system, figure 3-22, shows the cumulative distribution for the time it took for a person called to answer that call. This curve gives an indication of the time required to accomplish a successful call. For example, for 50 percent of the successful calls initiated, contact was established in under 10 seconds; and for 75 percent of the successful calls initiated, contact was established in under 24 seconds. A similar curve for the North Mine could not be drawn because so few calls were placed in the North Mine telephone system.

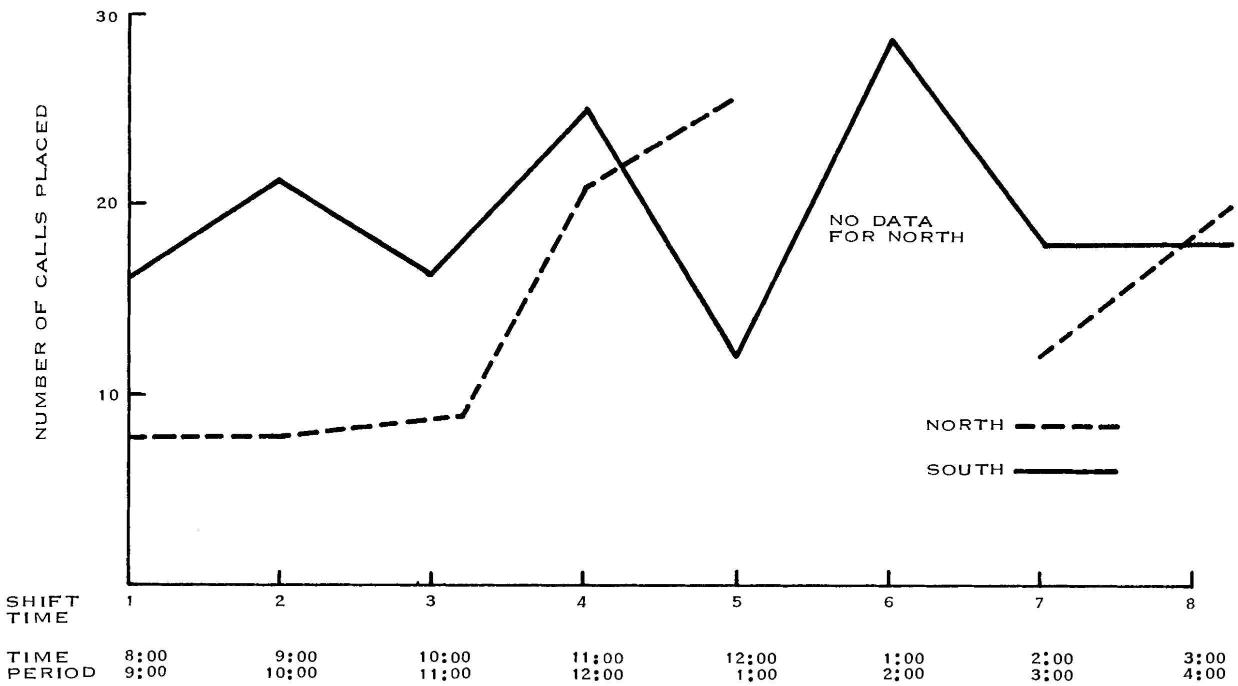


Figure 3-19. Number of Calls Placed.

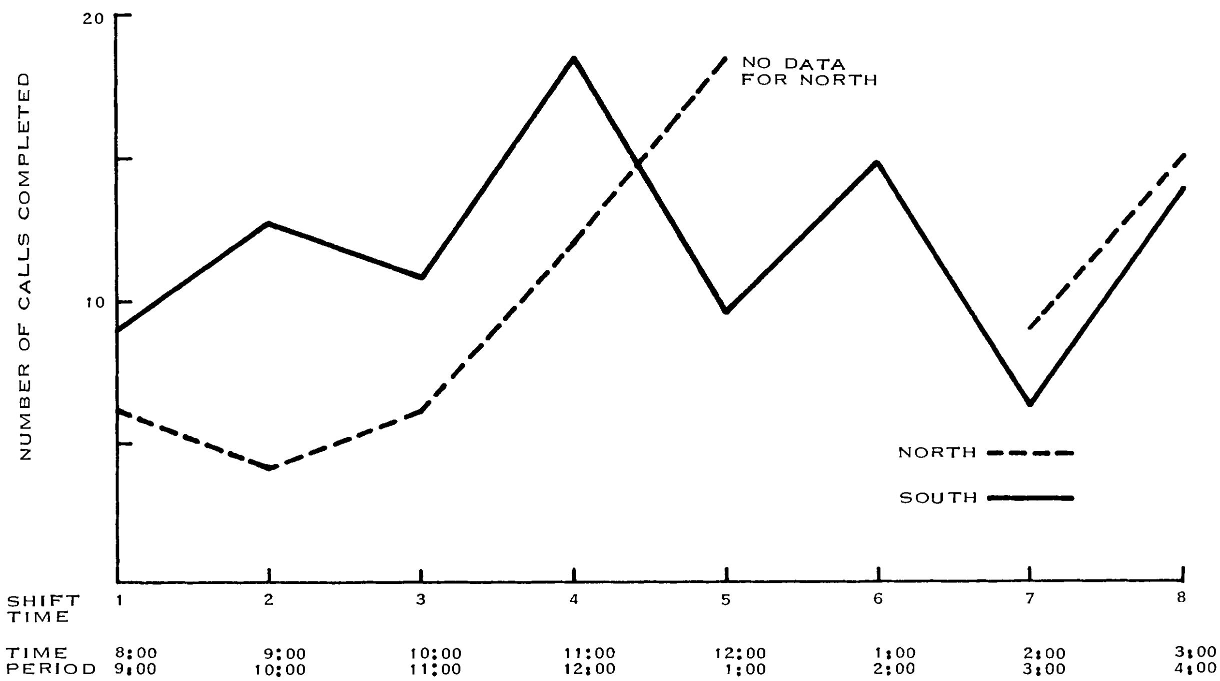


Figure 3-20. Number of Calls Completed.

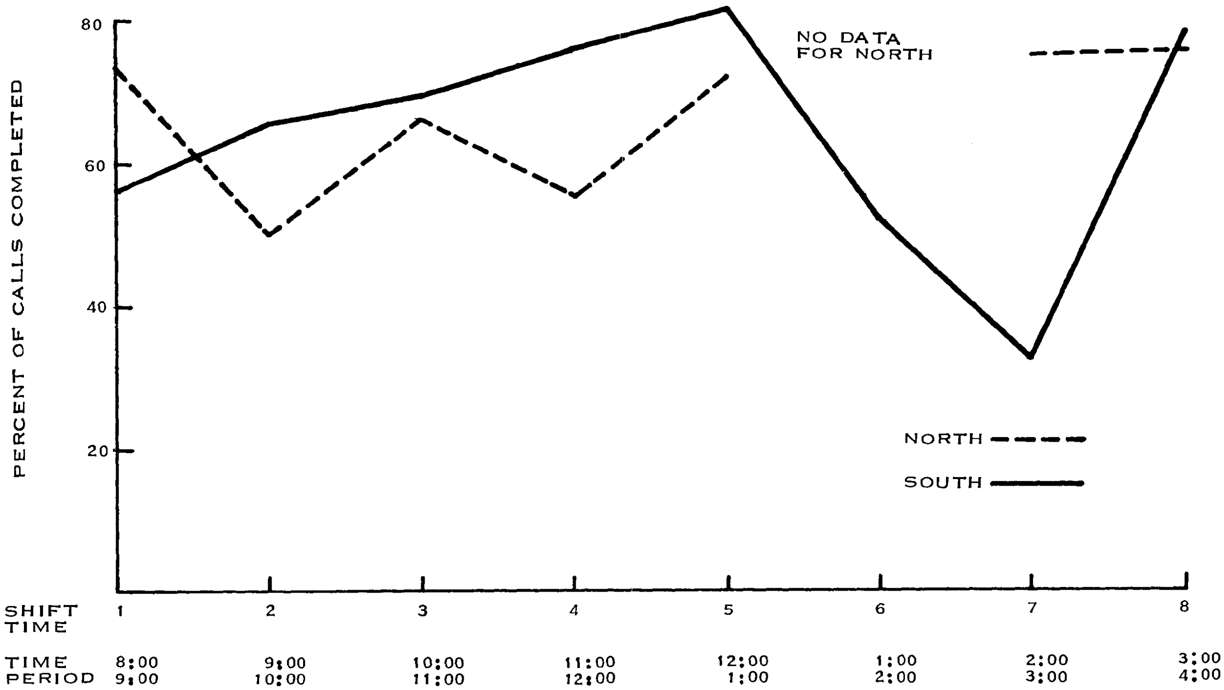


Figure 3-21. Percent of Calls Completed.

3.2.5.2 Telephone Transmission Lines

The lines used to connect the 31 underground and 7 surface telephones of the South Mine are conventional twisted pair phone lines having a cumulative length of about eight miles.

The excessive hum pickup on these lines is due to unbalance in terminal equipment rather than any deficiency of the transmission lines.

There was never an indication that extreme distance between phones was a communications limiting factor.

3.2.5.3 Trolley Phone System

A second means of voice communications is the trolley phone system that uses the dc trolley wire as a carrier of 88-kHz (South Mine) and 100-kHz (North Mine) FM. In each mine five loudspeaker trolley phones are used: one as a base station at the inside mechanics shanty, two on utility jeeps, and two on motors. Additional trolley phones will be obtained for the two mines.

One shortcoming of the present trolley system is that there is no way for personnel with trolley phones to communicate with working sections. Mine personnel would like some way of patching the trolley and phone systems together.

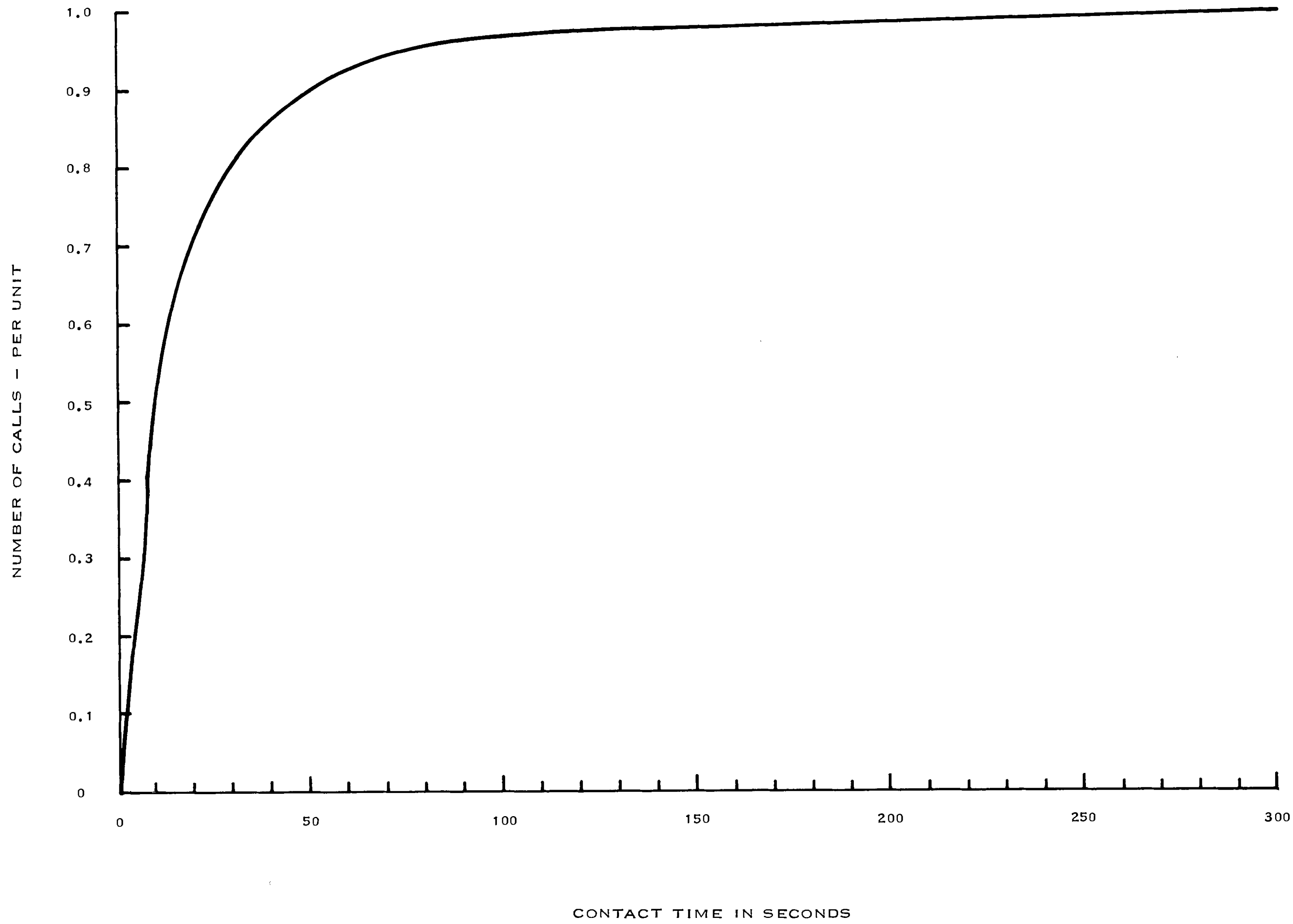


Figure 3-22. Phone Call Duration Distribution - South Mine.

Little was found about the usage of the trolley phone communications system because our tape recorder to phone hookup caused a hum that was usually much stronger than the phone calls. Figure 3-23 shows the number of calls placed on the South Mine trolley system (dashed line) and the South Mine phone system (solid line) for each hour of the first shift. The phone system's average of 20 calls per hour compared with the trolley system's average of 15 calls per hour might lead to a false conclusion unless it is realized there are 38 telephones compared to 5 trolley phones: the number of calls per phone is many times greater for the trolley phones.

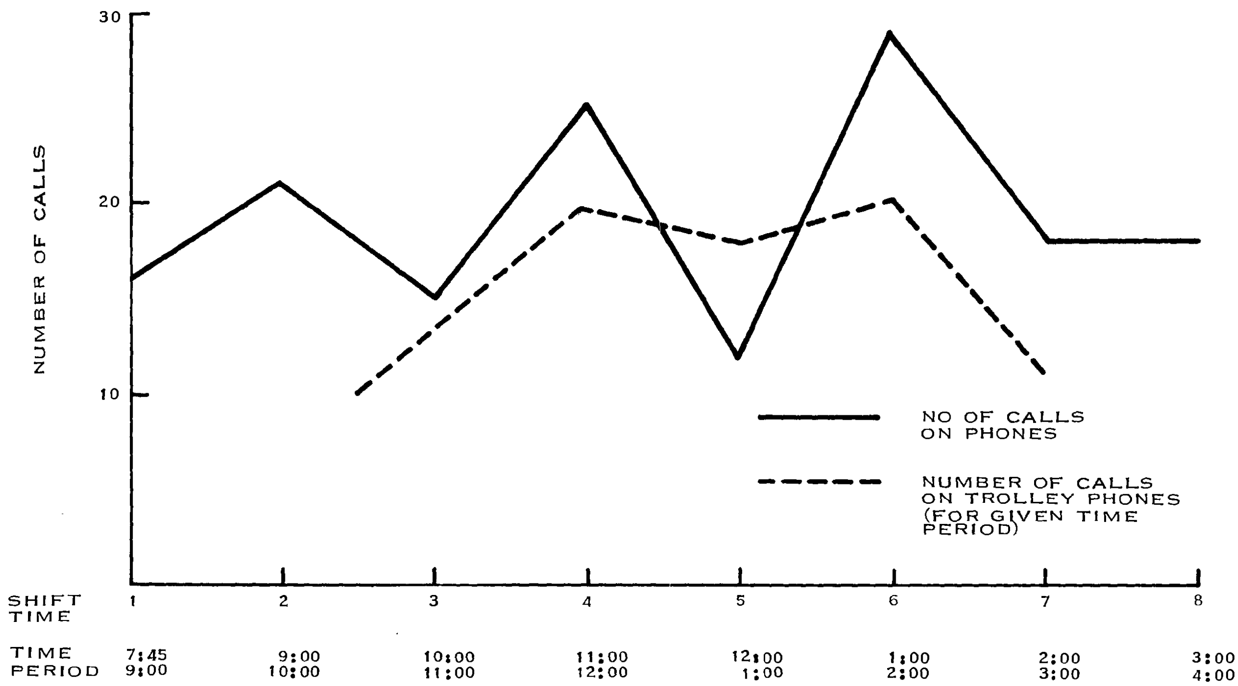


Figure 3-23. Number of Calls Placed for Phones and Trolley.

3.2.5.4 Longwall Communications

Five permissible loudspeaking telephones are spaced at 125-foot intervals along the 500-foot longwall system. These five phones are connected together to form an independent communications system. Near the phones at either end of the longwall system are phones of the overall telephone network. Though not interconnected, the two phone networks are at least physically close to each other.

The five phones are identical to those of the main telephone system except that the paging mode is permanently wired into all five phones as a safety measure. Anything said into any one of the five handsets will be broadcast over all five loudspeakers, thus alerting all nearby personnel of activity on the longwall section.

3.2.5.5 Belt Maintenance Communications

Along the belt lines, every 2000 feet at the belt heads, are located phones of the telephone communications system. The belt heads are the only spots where belt mechanism fires are likely to occur.

3.2.5.6 Belt Fire Alarm System

Although these Greenwich mines have never had a belt fire, their fire alarm system is better than required by law. A tape player is positioned underground and when activated will broadcast a warning over all telephone and trolley phone loudspeakers. The recorded message warns all personnel of the alarm condition, specifies the location of the tripped alarm, and advises personnel of safety precautions to be taken.

3.2.5.7 Fan-Stop Alarm

In event a fan stops, provision is made for utilizing the phone systems to ensure that proper action is taken. At the North Mine where there is a phone at the fan site, and where personnel are within earshot of an audible alarm, the person responding to the alarm can use the normal telephone system in seeking help. The fans for the South Mine are remote from any mine personnel so the alarm is automatically sent over a Bell System line to South Mine's Lamphouse.

3.2.6 Communications Requirements -- User's Viewpoint

Through the interviews and freewheeling discussions with those who use, plan, and maintain the communications systems, communications requirements were determined that would aid production with Greenwich's current mining procedures and methods. These requirements dealt directly with mine operations not using a dispatcher, with operations where coal haulage is by belt only, and with operations involving low-coal and longwall mining.

The first suggestion made by Greenwich personnel was that they needed someone to perform the communications and information center tasks often performed by the dispatcher in other mines. Presently they have no way of relaying messages between, or interlinking, the independent telephone and trolley phone systems. They also would like someone to monitor beltline sensors, from a center, in order to coordinate troubleshooting, maintenance, and repair of all belt-lines. Thus, a requirement for a Communications Center Operator (communications coordinator) would resolve the two immediate problems as well as many others.

Low-coal and longwall mining combine in determining a requirement for fixed communications terminals to be close to all classes of foremen, and a requirement for personal hands-off operation radios of insignificant weight and bulk. Coordinating the operation and repair of a 500-foot longwall miner is difficult, and in low coal it's almost impossible.

Mine personnel felt that having nothing would be better than having a simple pager where a section foreman might have to crawl 700 feet to the nearest phone to find out that it really wasn't that important. If the section foremen are given anything for mobile communications it must be small, light, and 2-way. In this mine they would like the section foremen to be able to easily contact a general assistant foreman for supplies and repairs. The need for small portable 2-way communications is shown by the case where someone at the Greenwich mine, on their own initiative, tried some 2-way units they had borrowed from a local hospital.

3.2.7 Communication Requirements - Based on Survey Analysis

An analysis of both the North and South Mine survey indicates that the communications systems noise levels are unacceptably high, and that communications capability is on the verge of becoming unacceptable. Credit must be given to employees for maintaining their effectiveness in spite of marginal communications, and to management for recognizing the need for improved communications. Therefore, improved communication and improved mining operation would result merely by improving signal to noise with the present communications systems.

Since the current phone traffic makes the chance of getting a busy signal between 350 and 450 times greater than most industries find acceptable, additional channel capacity is needed to reduce the chance of blocking to the 1-percent level. Although the 1-percent of blocking is still 10 times greater than industrial standards, it appears to be a reasonable selection for coal mine communication.

With the current peak single channel traffic density of 0.35 Erlang, additional channels could increase this peak density by 50 percent, bringing the total traffic density to 1.28 Erlangs. With a traffic density of 1.28 Erlangs, a minimum of 5 communication channels is needed to reduce the probability of blocking to just less than 1 percent.

Also, from observing the mine operation and talking to various personnel it appears that section foremen and select longwall personnel need some form of 2-way wireless communication of minimum size and weight. All personnel expressed a negative attitude toward any 1-way type of communication.

Furthermore, the mine personnel felt they needed a location where the daily production activity could be monitored. This location can evolve into a communication center since as the mine expands and more vehicles are equipped with trolley phones, a combination dispatcher, call monitor, and production monitor can be financially justified.

Specifically for the Greenwich Mines, the following represents a minimum for future communication requirements:

a. Reasonable communication channel signal-to-noise level
b. At least 5 independent voice channels to replace the present one channel
c. Small, lightweight wireless 2-way communicator units for foremen and select personnel
d. A communications center

3.3 SOMERSET COAL MINES, ON-SITE SURVEY OF JUNE 19 AND 20, 1973

3.3.1 Mine Contacted

US Steel Somerset Coal Mine
Somerset, Colorado 81434

3.3.2 Initial Mine Contact

Russ Ramey - Superintendent
(303) 929-5115

3.3.3 Personnel Interviewed

Russ Ramey	-	Superintendent
Terry Gunderson	-	General Mine Foreman
Dick Vance	-	District Electrical Engineer
Joel Phelps	-	General Maintenance Foreman
Bill Ward	-	Mine Inspector (Bureau of Mines)
Loyd Miller	-	Mine Inspector (Somerset)

3.3.4 General Mine Information

3.3.4.1 Mine Description

The Somerset coal mine is owned by US Steel and has been operational since 1903 with production originally estimated for 100 years. Coal is being mined in both a B and C seam, which have 36 to 60 feet of vertical displacement between each seam. The mine employs continuous mining techniques and personnel enter the mine through a slope entry. Coal production is approximately 1 million tons per year and is removed by a combination of belt and haulage cars. The B seam has two active working sections and each section transfers coal from shuttle cars to a small feeder belt. A longer mother belt then takes the coal to a main loader head. This loader head has the capacity for 18 cars and when 12 cars are filled, these cars will be assembled into a 12-car train 240 feet in length for main line haulage. The C seam has only one working section and coal is transferred by shuttle cars to a set of 6 haulage cars and two of these combinations of 6 are attached to make a 12-car train which removes the coal from the mine. Figure 3-24 and figure 3-25 show both the B and C seams together with the tracks, feeder belts, and main line belt.

3.3.4.2 Mine Size

The B seam is currently 1.7 miles north and south by 3.2 miles east and west with the C seam 0.35 mile north and south by 0.45 mile east and west. The overburden varies from 0 at the slope entry to 2,000 feet under Fire Mountain. All tunnels are typically 18 feet wide. The average C seam tunnel is 9 feet high and the typical B seam height is 15 feet. Since the B seam has coal 22 feet thick in some places, the top level is mined first and then they return to mine the bottom coal for maximum yield. Roof bolt length is typically 6 feet with variations from 4 to 12 feet. These bolts are positioned on 5-foot centers in the B seam and on 4-foot centers in the C seam.

The mine has 1 bore hole into the B seam which was used at one time for a phone line and another time for pumping water out of the mine. A second bore hole is in the C seam and it is used to pump methane out of the mine.

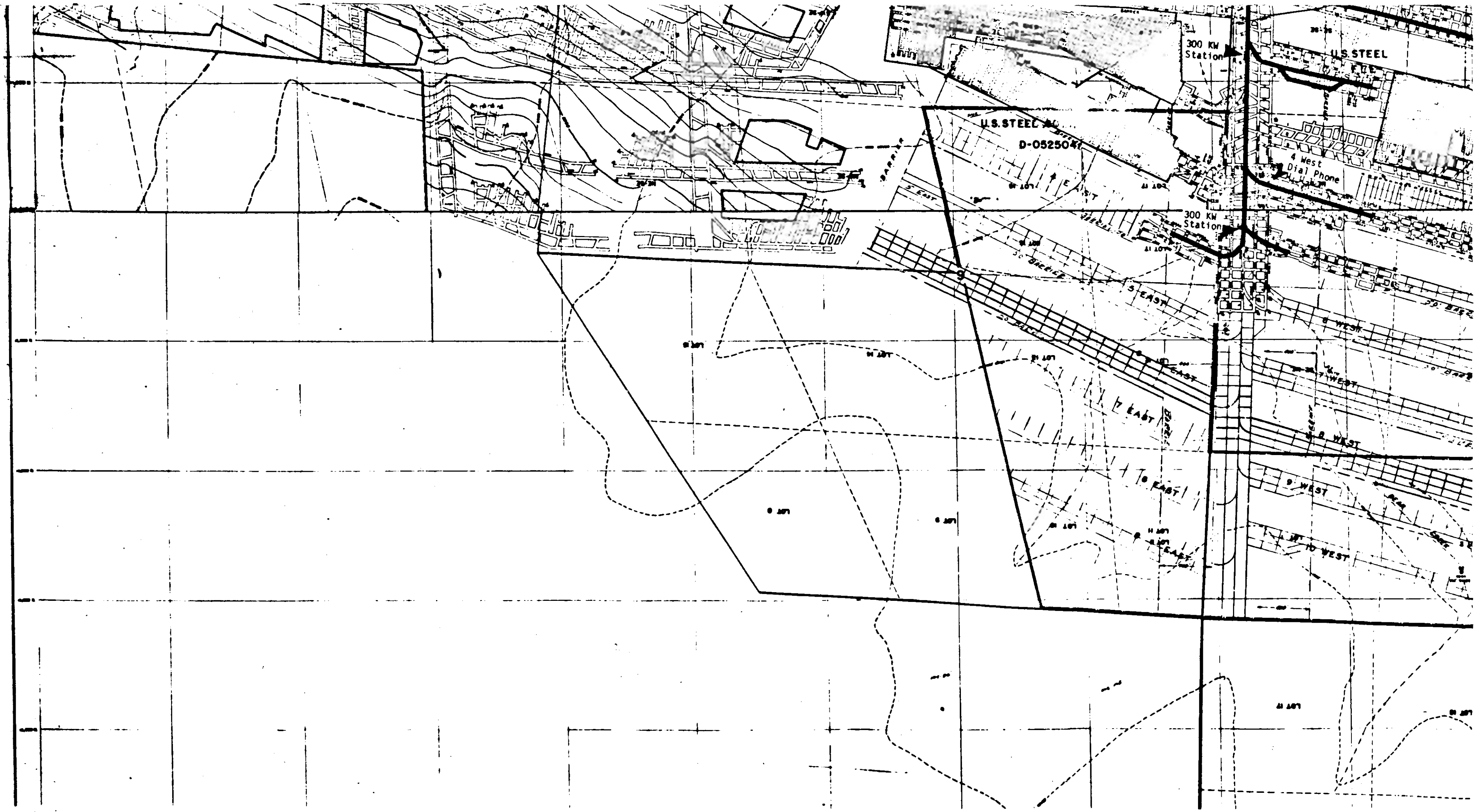
Currently the mine has 2 coal producing sections in the B seam and 1 coal producing section in the C seam. Furthermore, the B seam has 1 large cleanup section and 2 smaller cleanup or rehabilitation sections. A typical working section is 320 feet square. The mine has 2 production shifts and 1 maintenance shift, each 8 hours in length, and they run from 8:00 am to 4:00 pm, 4:00 pm to 12:00 midnight, and 12:00 midnight to 8:00 am.

3.3.4.3 Crew Composition

The mine has 71 men underground for the first production shift, 55 men underground for the second production shift, and 45 men underground for the last or maintenance shift. The following list shows the crew organization for an operating or production section and a cleanup section:

a. Operating (Production) Section Crew

Foreman (1)
Miner operator (1)
Miner operator helper (1)
Roof bolters (2)
Shuttlecar operators (2)
Utility man (1) (rock dust, ventilation, etc)
Section mechanic (1)


300 KW Station
U.S. STEEL
U.S. STEEL
D-05250
4 West
Dial Phone
300 KW Station
5 EAST
6 WEST
7 WEST
7 EAST
8 WEST
8 EAST
9 WEST
10 WEST
BARRIER

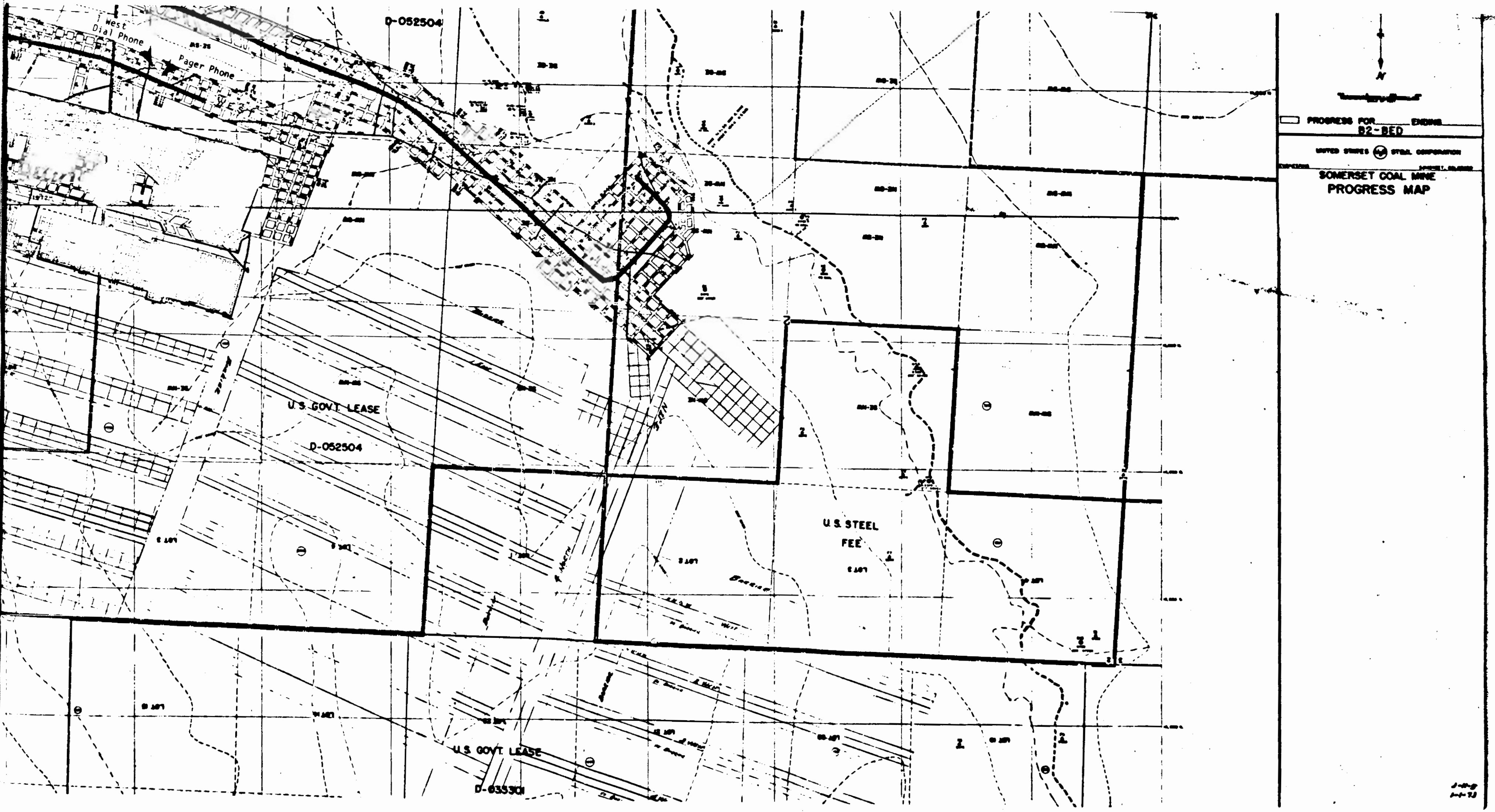


Figure 3-24. Somerset Mine (B Seam).

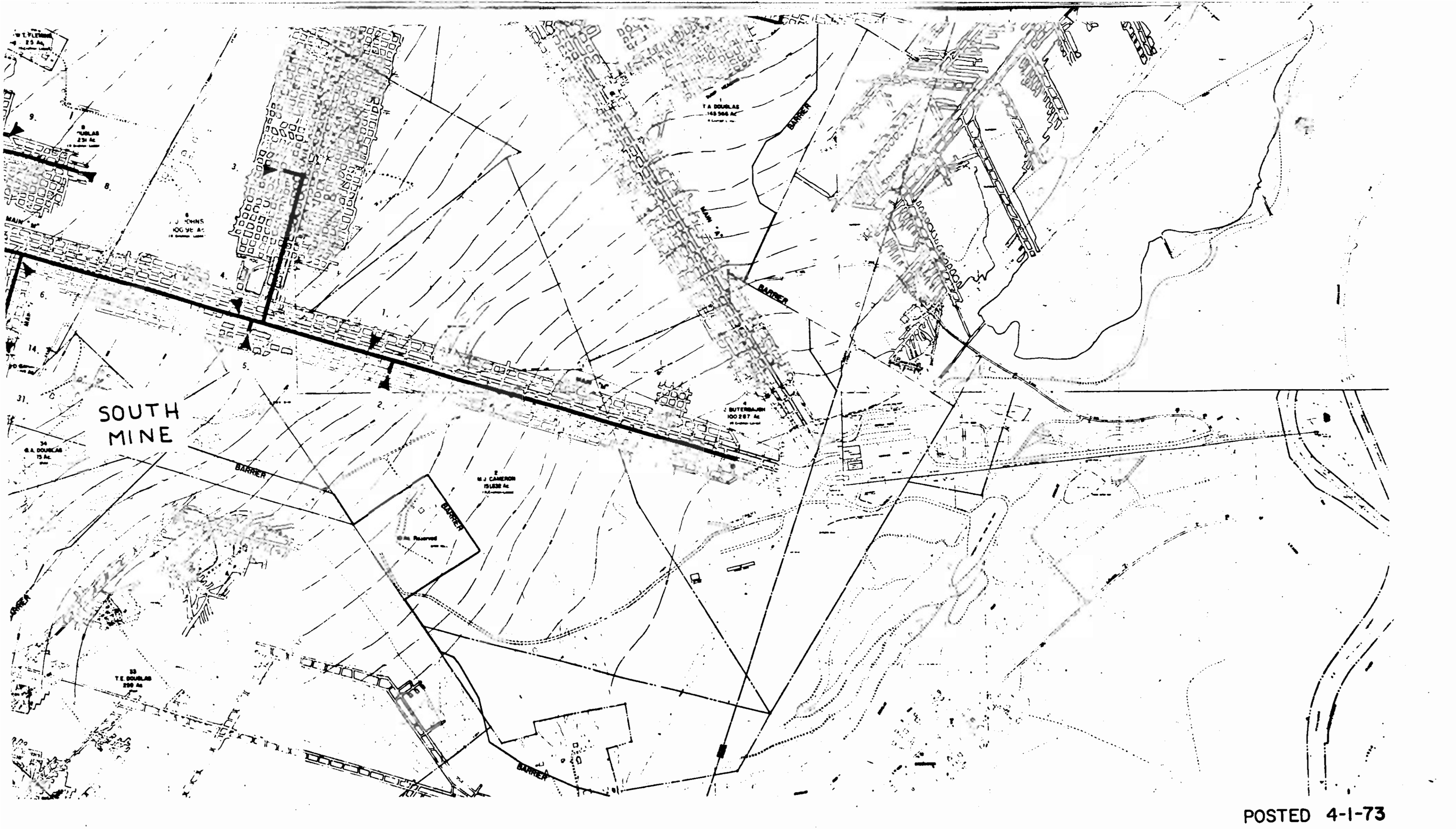
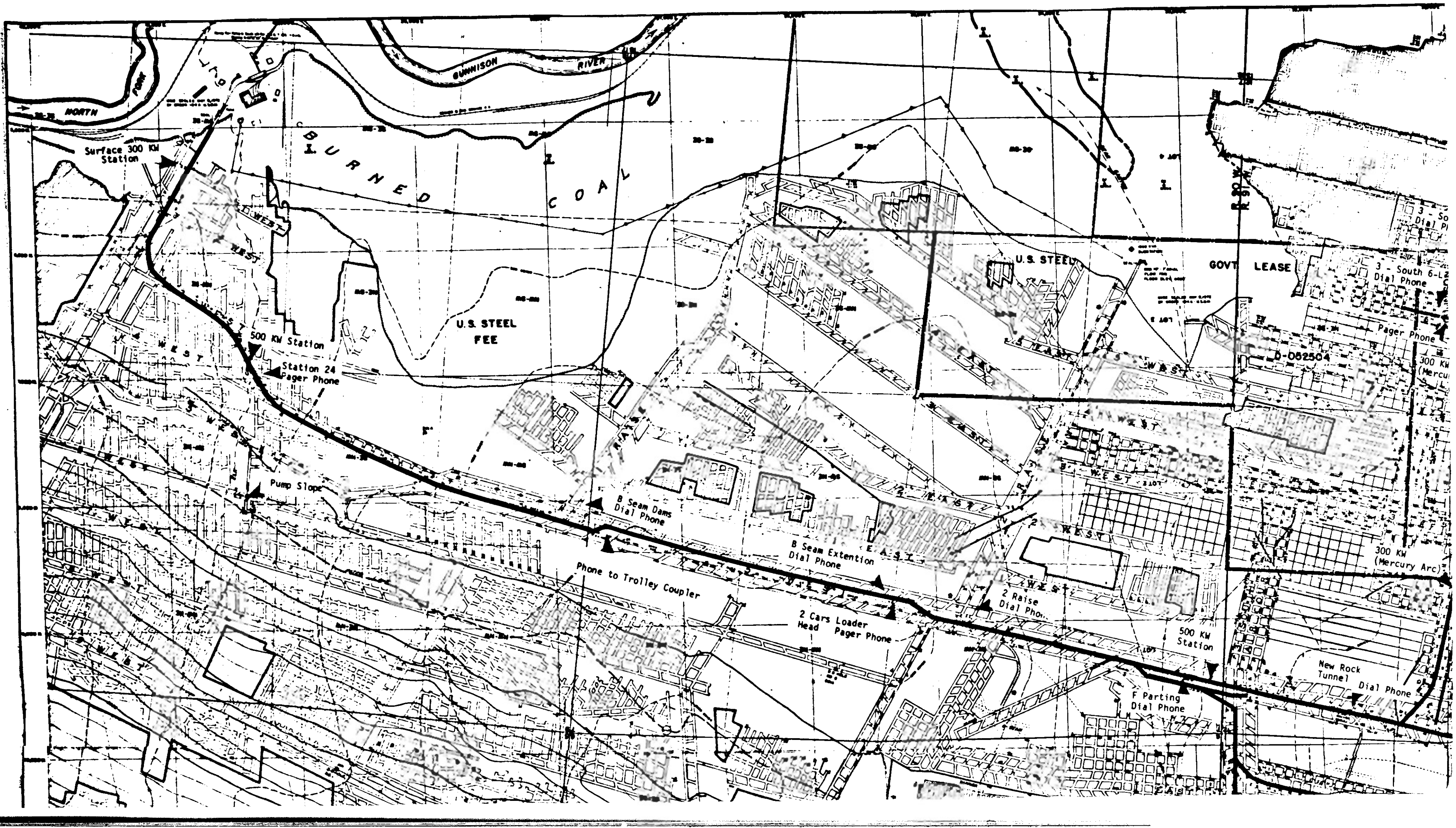
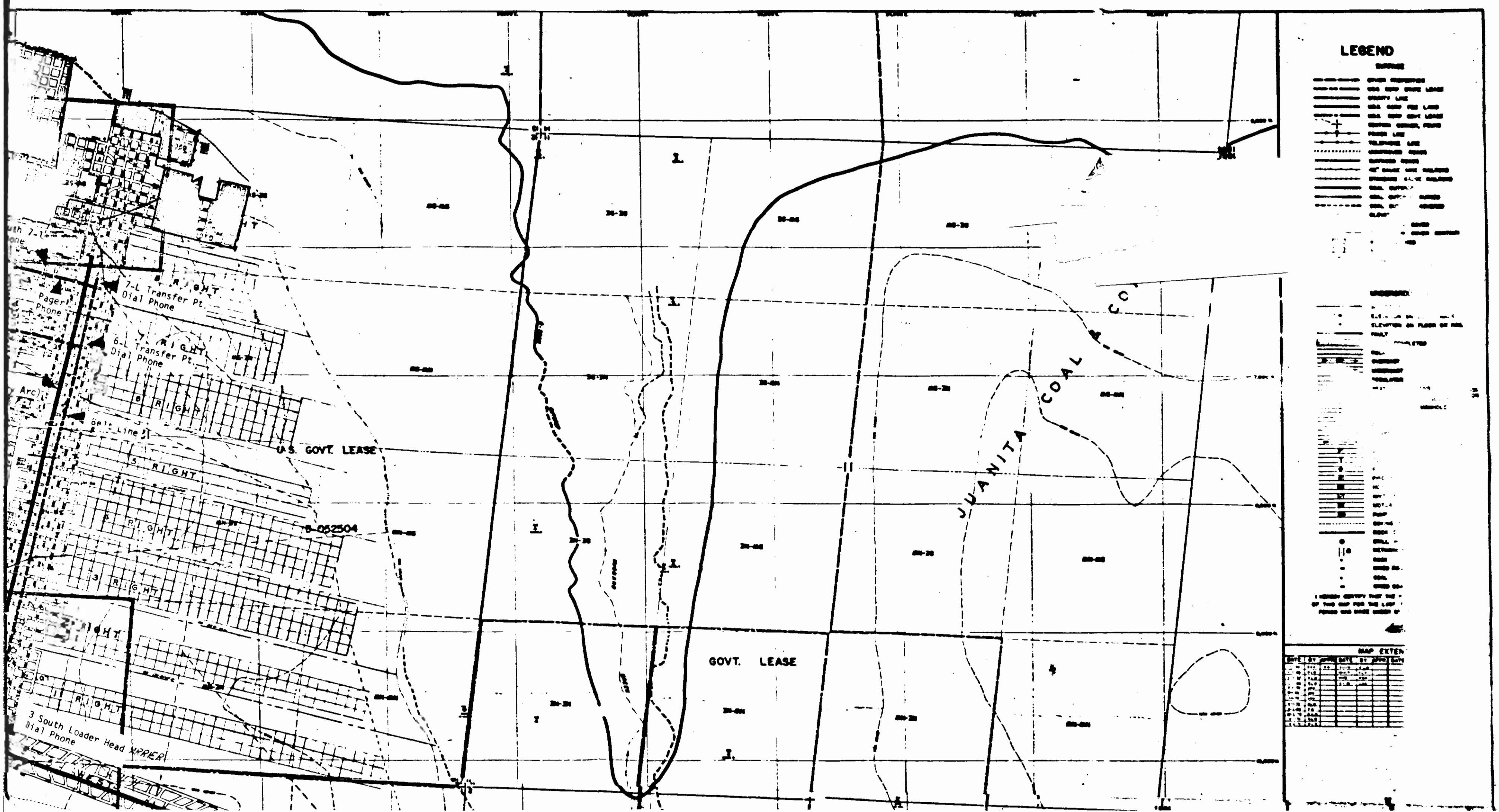
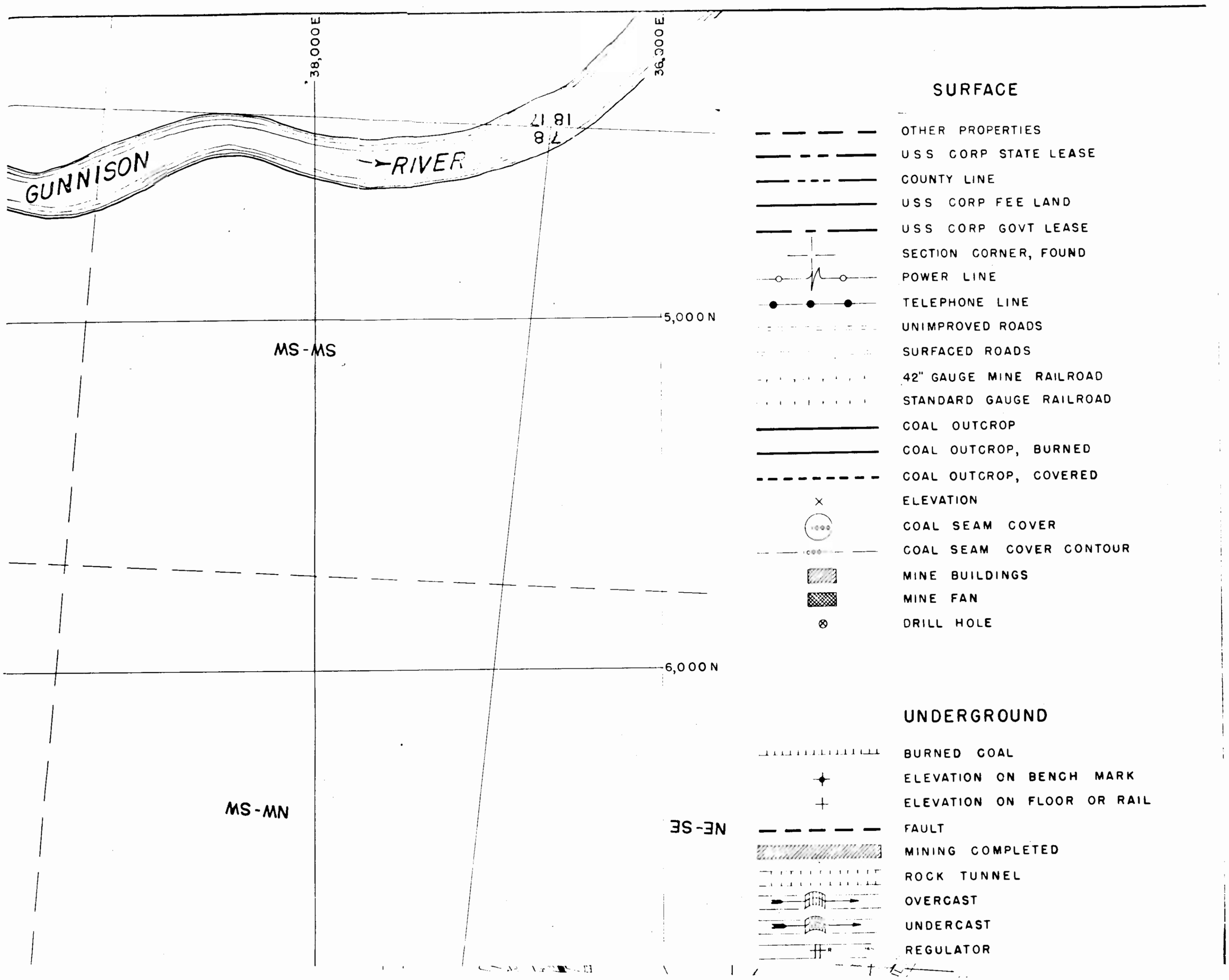


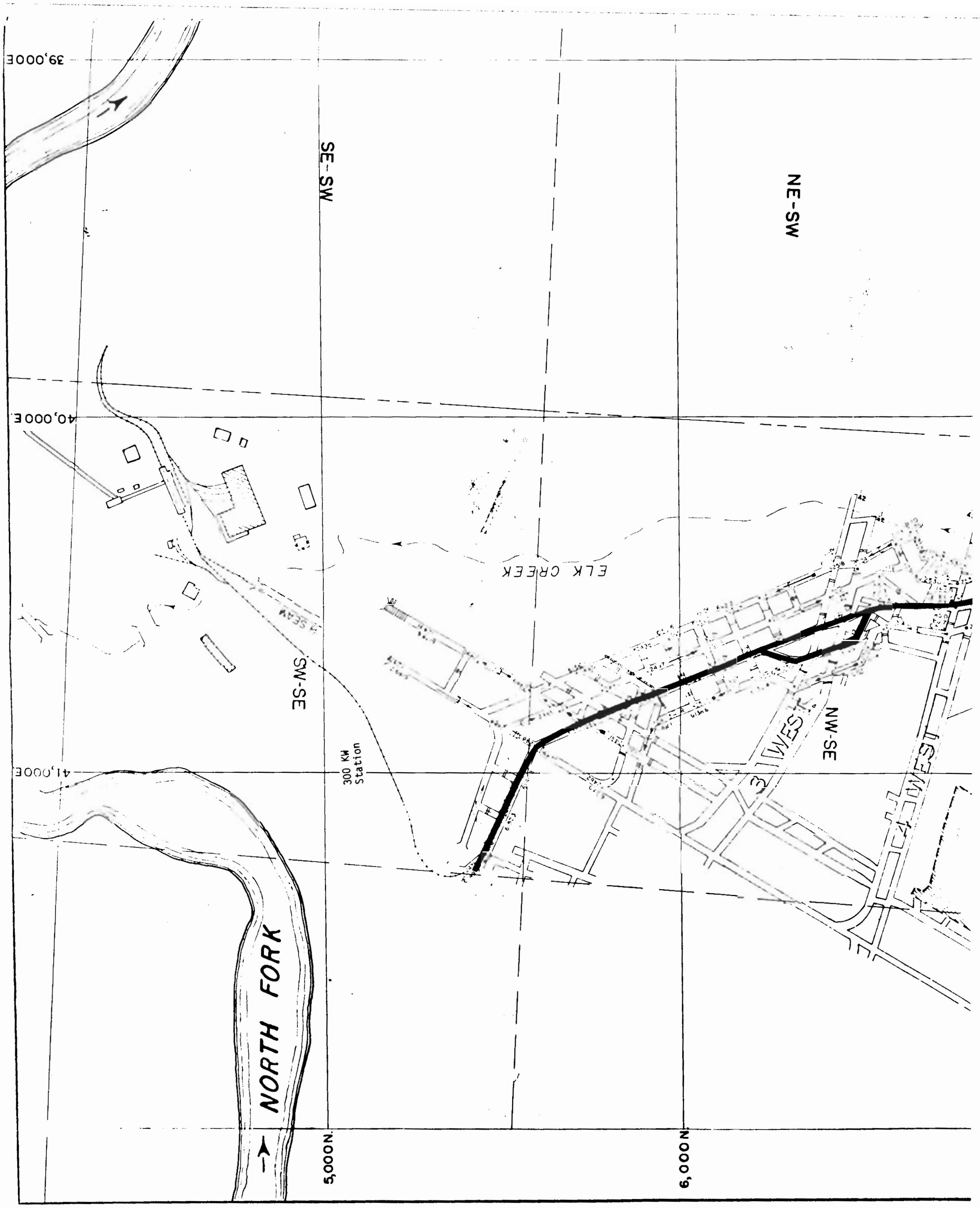
Figure 3-13. Map of Greenwich Mines.



NORTH FORK
GUNNISON RIVER
Surface 300 KW Station
BURNED COAL
U.S. STEEL FEE
U.S. STEEL
GOVT LEASE
D-052504
500 KW Station
Station 24 Pager Phone
Pump Slope
B Seam Dams Dial Phone
Phone to Trolley Coupler
B Seam Extention Dial Phone
2 Cars Loader Head Pager Phone
2 Raise Dial Phon
500 KW Station
F Parting Dial Phone
New Rock Tunnel Dial Phone
300 KW (Mercury Arc)
Pager Phone
3 South 6-L
Dial Phone


LEGEND
JUANITA COAL CO.
U.S. GOVT. LEASE
GOVT. LEASE
D-052504
7-L Transfer Pt.
Dial Phone
6-L Transfer Pt.
Dial Phone
Pager Phone
Belt Line
3 South Loader Head
Dial Phone
MAP EXTEN


GUNNISON
RIVER
38,000E
36,000E
5,000N
6,000N
18 17
7 8
SW-SW
NW-SW
NE-SE
SURFACE
OTHER PROPERTIES
USS CORP STATE LEASE
COUNTY LINE
USS CORP FEE LAND
USS CORP GOVT LEASE
SECTION CORNER, FOUND
POWER LINE
TELEPHONE LINE
UNIMPROVED ROADS
SURFACED ROADS
42" GAUGE MINE RAILROAD
STANDARD GAUGE RAILROAD
COAL OUTCROP
COAL OUTCROP, BURNED
COAL OUTCROP, COVERED
ELEVATION
COAL SEAM COVER
COAL SEAM COVER CONTOUR
MINE BUILDINGS
MINE FAN
DRILL HOLE
UNDERGROUND
BURNED COAL
ELEVATION ON BENCH MARK
ELEVATION ON FLOOR OR RAIL
FAULT
MINING COMPLETED
ROCK TUNNEL
OVERCAST
UNDERCAST
REGULATOR


39,000E
40,000E
41,000E
5,000N.
6,000N
SE-SW
NE-SW
SW-SE
NW-SE
ELK CREEK
NORTH FORK
300 KW
Station
3 WEST
4 WEST

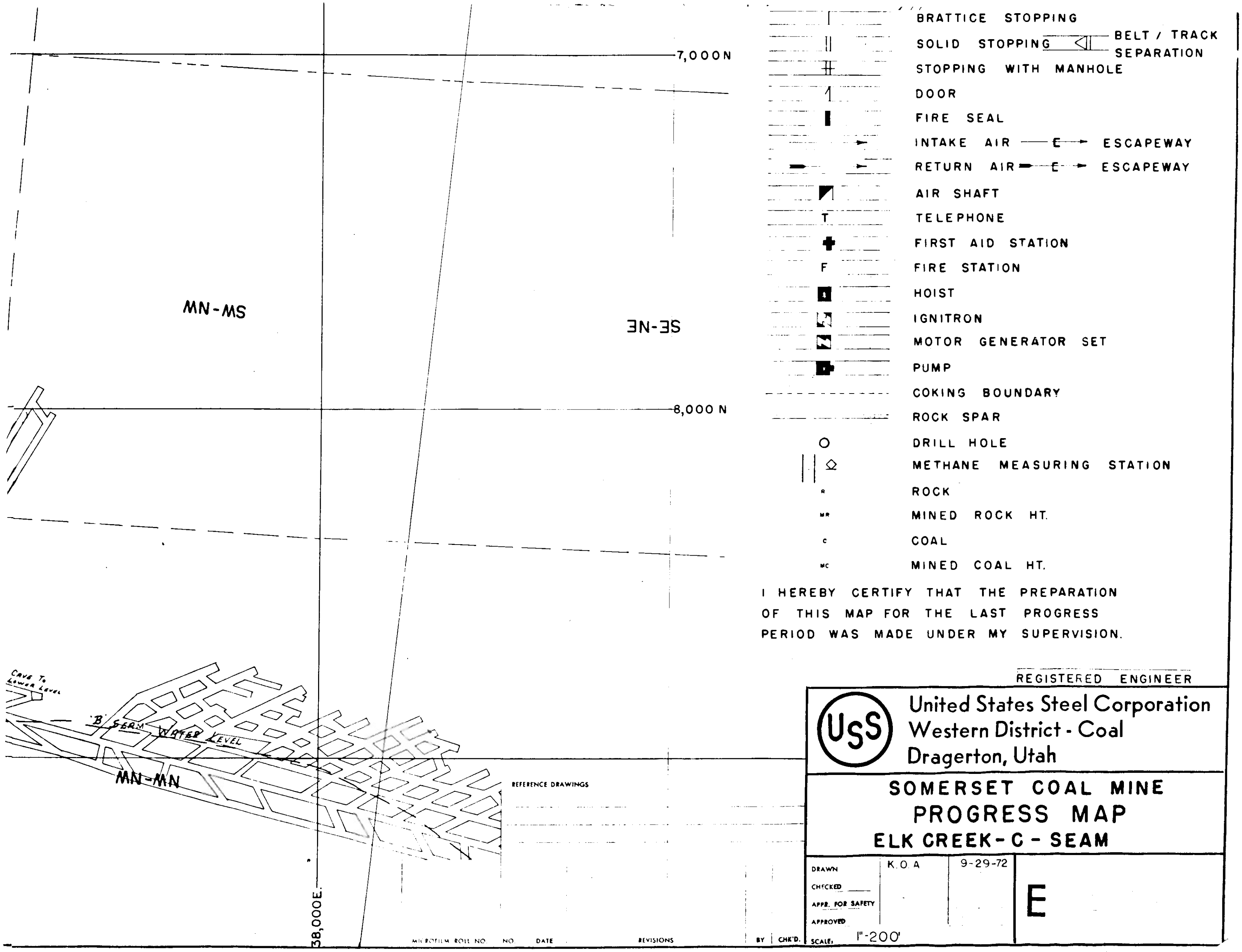
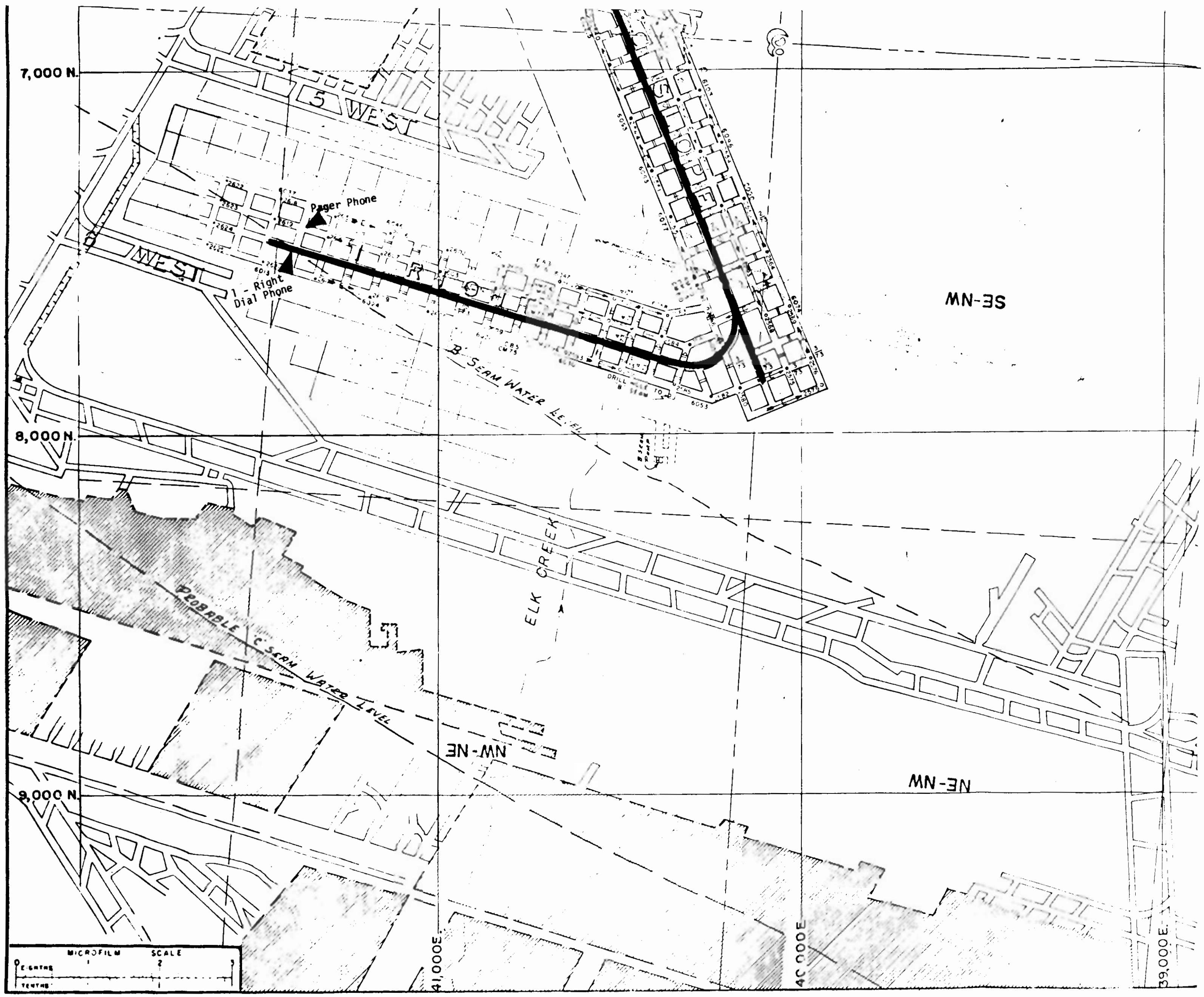


Figure 3-25. Somerset Mine (C Seam).


7,000 N.
8,000 N.
9,000 N.
41,000E
40,000E
39,000E.
5 WEST
WEST
Pager Phone
1 - Right
Dial Phone
B SEAM WATER LEVEL
ELK CREEK
PROBABLE C SEAM WATER LEVEL
SE-NW
NE-NW
NW-NE
MICROFILM SCALE

b. Cleanup Section Crew

Foreman (1)
Miner operator (1)
Miner operator helper (1)
Roof bolters (1 to 2)
Shuttlecar operator (1)
Utility man (1) (rock dust, ventilation, etc)
Section mechanic (0 to 1)

Mine personnel typically require 20 minutes to get from portal to their working sections and they take 30 minutes for lunch some time between 11:00 am and 1:00 pm. These lunch periods are staggered between working sections. On the B seam the work cycle starts with the continuous miner cutting coal and filling a shuttlecar. When the shuttlecar is full, the driver transfers the coal load to one of the 36-inch 550-foot/minute belts run to the section. The belts then remove the coal to the south loader head where the coal is loaded into cars that will make up the main line haulage train. While at the mine, we found that a shuttlecar round trip took approximately 7 minutes to complete a work cycle on the B seam. Except for the shuttlecars dumping directly into haulage cars, the C seam has the same type of work cycle. Furthermore, the C seam has no belt haulage, and uses tracked haulage for coal removal.

3.3.4.4 Mine Equipment and Power

Three surface substations convert 44,000 volts 3-phase to 4160 volts 3-phase, and the 4160 volts is carried underground to various 440 volts ac and 275 to 300 volts dc power stations.

At the working sections, the shuttlecars are either powered by 440 volts ac or 275 to 300 volts dc; the continuous miner is powered by 440 volts ac, and the roof bolting machines are powered by 275 to 300 volts dc. The dc voltage can be obtained by either a trolley nip point or an ac-dc load center.

All trolleys are powered by a 275- to 300-volt dc trolley-line which is a common ring bus, fed by 300-kW rectifiers and two 500-kW rectifiers seen in figure 3-24. The quantity and type of trolleys or vehicles are as follows:

Man trip cars (7)
Mechanics' jeeps (2)
27-ton motor (6)
13-ton motor (2)

3.3.5 Current Mine Communications

Somerset Mine currently has a combination of loudspeaking paging phones, dial telephones, and 88-kHz vehicle-mounted carrier phones. The carrier phone system is tied electrically to the loudspeaking paging phones by an MSA trolley coupler located at the B seam dams seen in figure 3-24. Also, figures 3-24 and 3-25 show the location of the loudspeaking phones, dial telephones, and trolley tracks. To improve communication coverage, auxiliary speakers are sometimes used with the loudspeaking paging phones. The following tabulation shows the number of phones and their general location:

PHONE TYPE	B SEAM	C SEAM	SURFACE	STORAGE	VEHICLE
Dial telephone	12	1	16	-	-
Loudspeaking paging phone	5	1	1	1	-
Carrier phone	1	-	1	-	17

In general, vehicle operators and supervisory personnel use the trolley or carrier phones, and mine section foreman, maintenance personnel, and supervisory personnel use the dial telephone and pager phone.

3.3.5.1 Dial Telephone

The Somerset Mine has purchased from the Delta County Co-Op Telephone Company dial telephones, telephone environmental enclosures, associated PABX, and 25 pair telephone cable with wire size number 19. All underground telephone equipment and wire was installed by mine personnel and has been in service for the last 10 years. Standard dial telephones are mounted in environmental enclosures manufactured by Automatic Electric located in Northlake, Illinois.

The biggest problem the mine had with the dial telephone was dust and moisture getting into the dial mechanism. However, this was explainable since we found that the majority of the underground telephone enclosures were wide open and liberally rock dusted. Of the 8 underground telephones that we checked, 7 were in good working order and one had rock dust in its dial mechanism contacts. Another problem, not related directly to the telephone equipment, was that of acoustic noise from mine machinery. For example, a telephone is required near the 3rd south loader head, and mine personnel find communication difficult when the loader head is in operation. Mine officials have considered the building of a telephone enclosure that will shield this telephone from external acoustic noise.

Other than leaving the door to the environmental enclosures open, the mine personnel appeared to operate the telephone system properly. The telephone was mostly used to call from underground stations to surface stations or call out of the mine. Figure 3-26 shows the results of analyzing a tape recording of the first shift conversations for what the mine officials thought was the most used telephone. This telephone, extension 223, is located on the surface in the maintenance office and is the hub of the underground to surface dial telephone conversations. Most calls were for supplies, maintenance, and location of personnel. This telephone system was also used as a backup system when communications were bad. For example, once personnel were contacted using the trolley or pager phone and extended conversation was needed, the person would be instructed to go to the nearest dial extension telephone and reestablish contact to complete the communication.

Figures 3-27 and 3-28 show the total time the dial telephone extension 223 is used and total number of phone calls placed or received each hour on this telephone respectively. Furthermore, since this location is apparently the communication hub of the mine, another telephone was installed to handle any communication overload that may occur. Figure 3-29 shows the percent of times the dial phone is used over the 8-hour shift. At the start of shift hour 6, a channel peak of 32 percent occurs. It appears from these figures and the fact that two extensions can be used at this location, there is no real channel capacity problem with Somerset's dial telephone system.

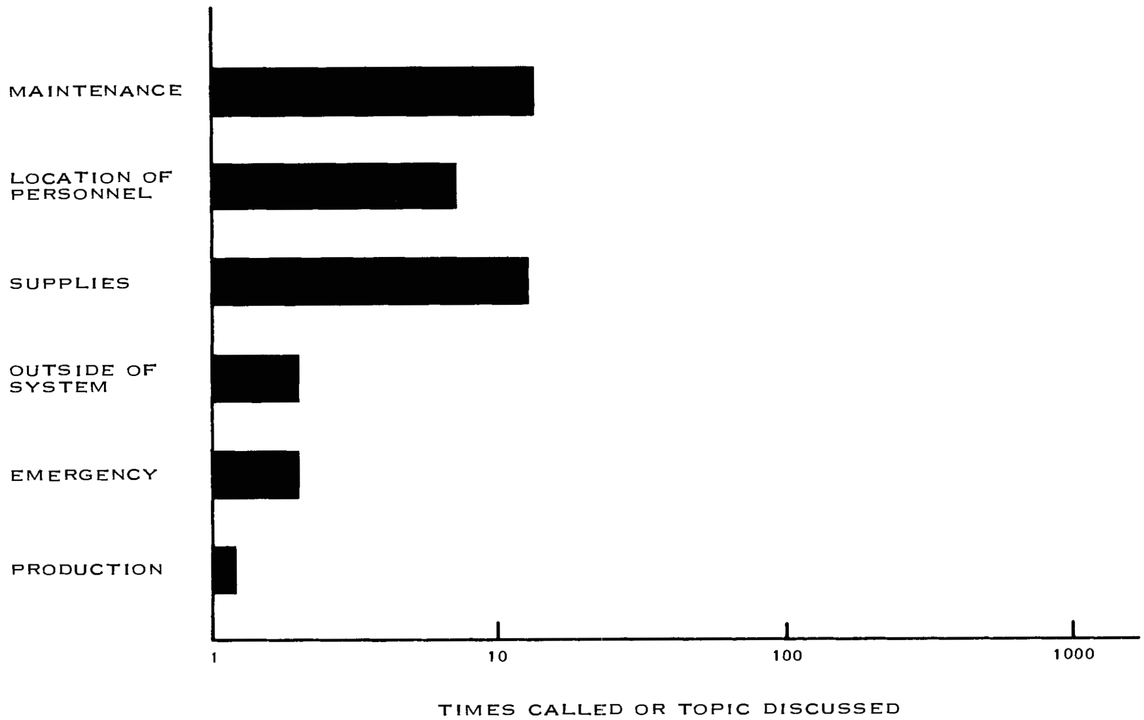


Figure 3-26. Extension 223 Call Categories.

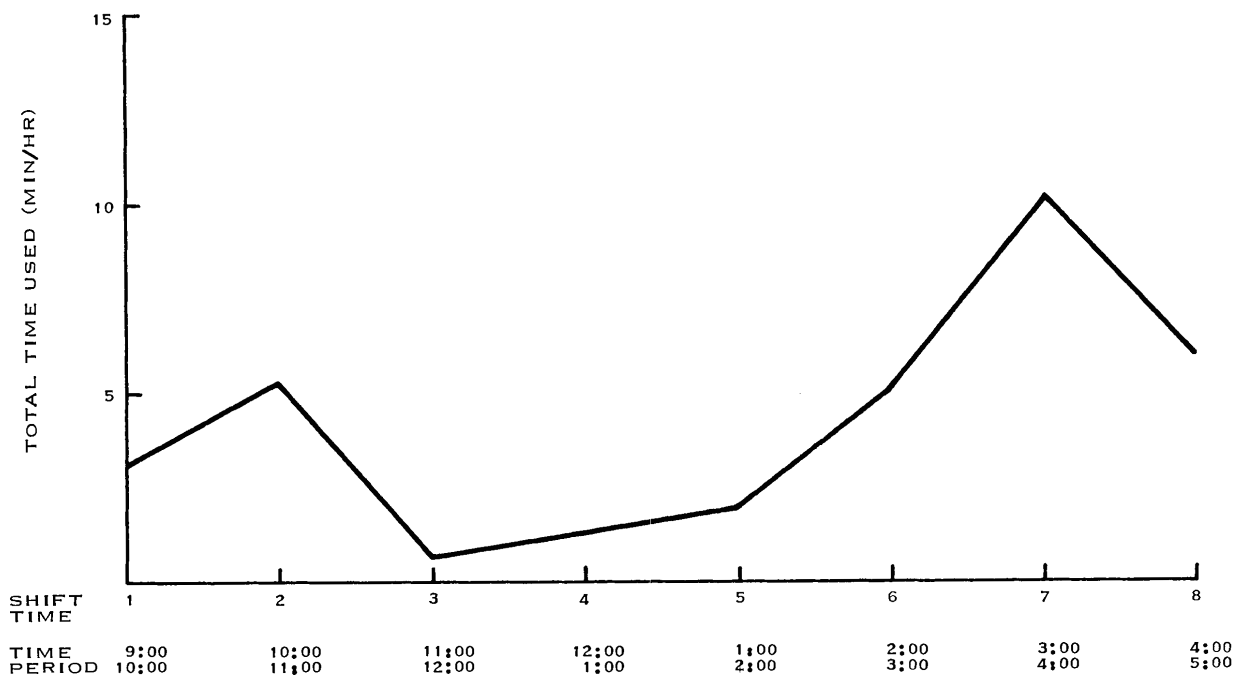


Figure 3-27. Total Time Extension 223 Is Used.

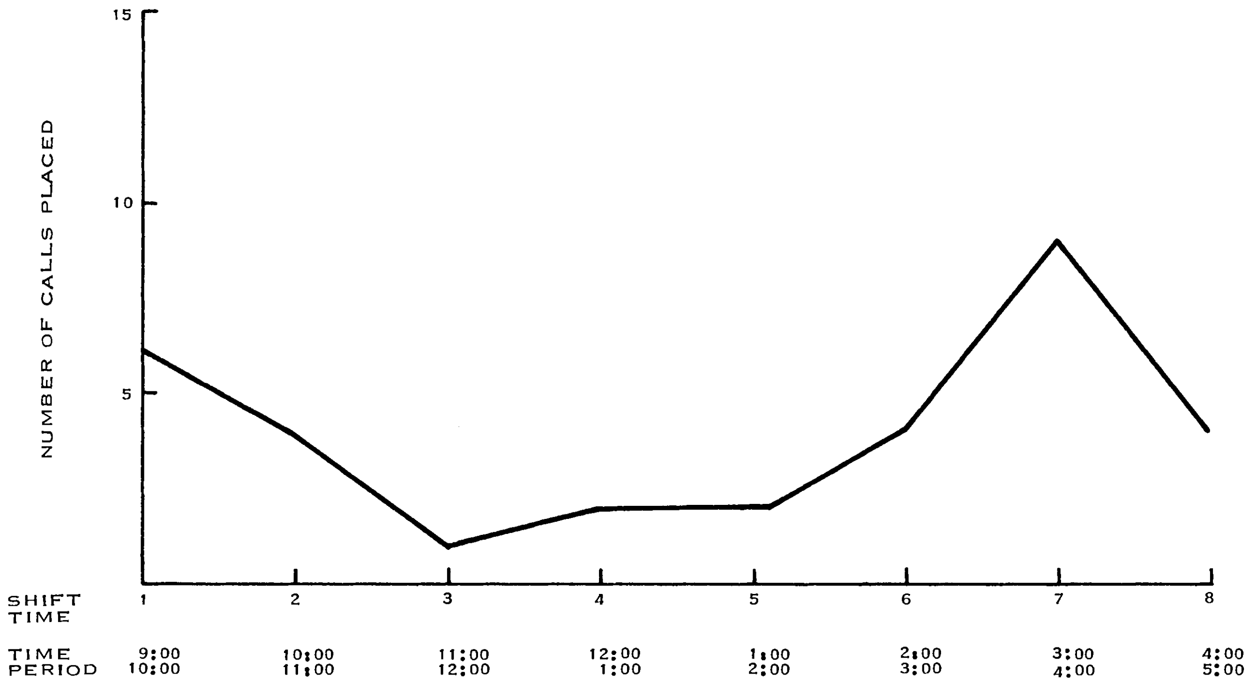


Figure 3-28. Number of Calls Placed on Extension 223.

Over the history of the mine only one major emergency has occurred and that was a destructive fire that started May 1972. This fire destroyed the telephone cable and the underground dial telephone system could not have been used for emergency personnel evacuation. This points out the basic weakness that multiple pair type of telephone systems have during a real disaster situation.

3.3.5.2 Loudspeaking Paging Phone/Carrier Phone

Both the loudspeaking paging phone and the carrier phone are manufactured by MSA. Somerset has two 6-year old Pager I phones and six 10-month old Pager II loudspeaking paging phones. Carrier phones installed at the mine include six 10-year old Model E-60 units with thirteen 14-month old Model 1601 units all with 88-kHz center frequency. The mine personnel plan to retrofit all E-60 models with the new 1601 models in the near future. The mine phone to loudspeaking paging phone coupler is manufactured by MSA and Universal Sound Model 1B-A8 (30W) auxiliary speakers are used with the paging phones where the need arises. The loudspeaking paging phones communicate through a pair of wires from the 25-pair telephone cable and the carrier phones use the dc trolley wires for their signal paths.

With the exception of service problems with the older E-60 models, all carrier and paging phones are of good quality, are holding up well, and are apparently being properly used by working personnel. However, there is a problem associated with the carrier phones communicating from certain dead zones in the mine to the surface.* We observed this problem and

*The same problem was solved at the Harris mine by having five or six couplers, throughout the mine, placed between the trolley line and the parallel telephone line pair.

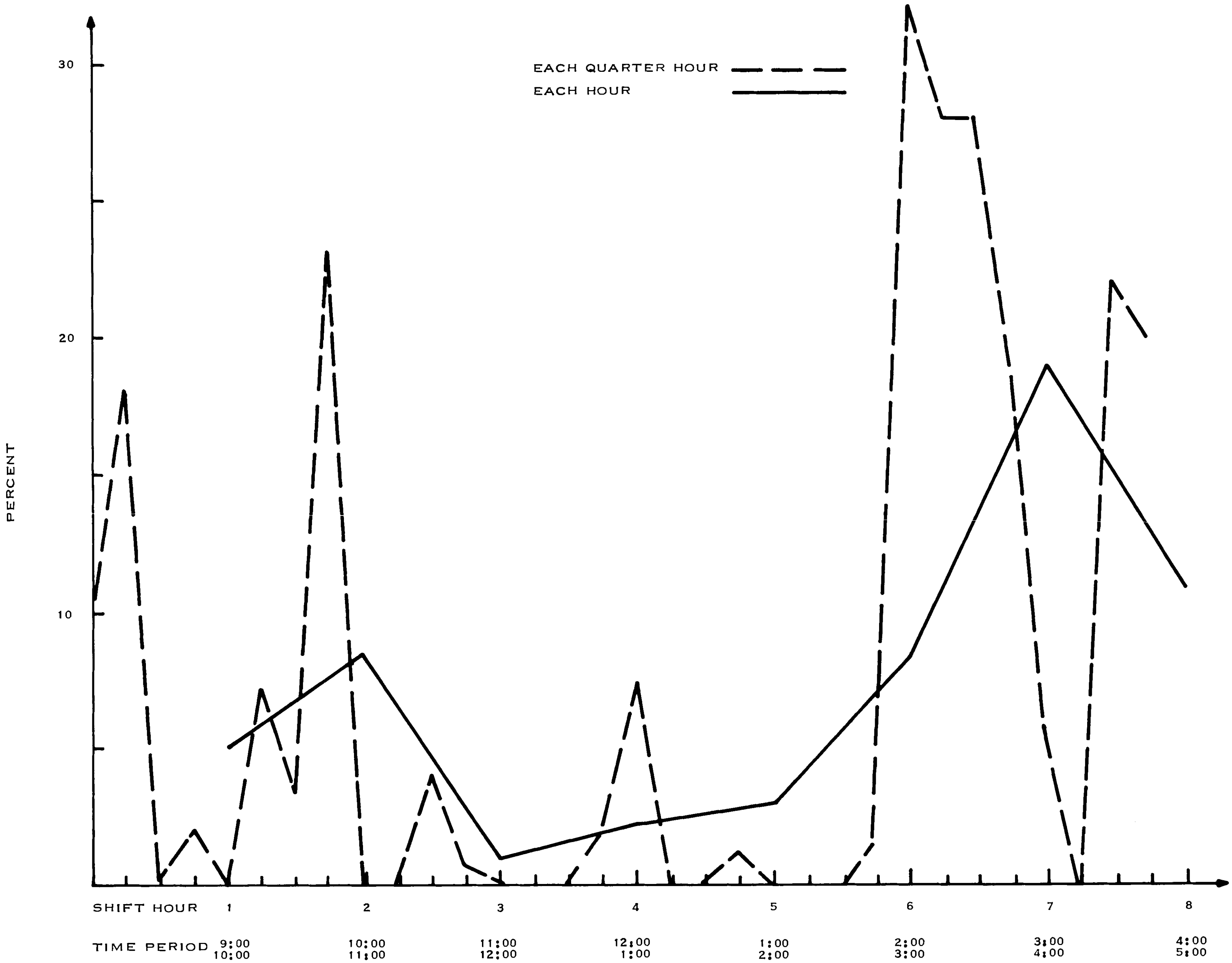


Figure 3-29. Percent of Time Extension 223 Is Used.

efforts were made to route some of the carrier signal over the telephone wires which, if successful, would have eliminated these dead zones. However, the efforts to eliminate this problem failed. The problem is probably caused by standing waves on the trolley line and our rerouting of the signal to the phone wire failed to improve communication because the phone wire length was possibly the same as the trolley wire and, therefore, would not increase the propagated signal. Another problem with the carrier phones was that the battery had to be serviced every 30 days and mine personnel said this was excessive. Also, the mine officials indicated that the ring-fed trolley rectifiers added receiver noise, and additional rectifier line filtering helped but did not eliminate the local problem when the trolley was near the rectifier stations.

External audio noise and replacing the internal battery approximately every 90 days were the most annoying problems associated with the loudspeaking paging phones.

Although the two systems are electrically tied together, the loudspeaking paging phone was primarily used to reach the working section and the trolley phone was used for right of way, placing loads and empties, personnel location, and requesting supplies. When the trolley-mounted carrier phone was used for self-traffic control, the operator would twice give his location and destination and then proceed to his final destination. Although the mine officials indicated this method of traffic control worked for their mine, we could see from our tour of the mine that an improvement could be seen using a dispatcher.

Figure 3-30 shows, for the first 8-hour work shift, the various conversation subjects and how many individual calls or times that particular subject was discussed for the trolley and pager linked communication system. The most frequent call made was concerned with right of way and the least frequent topic discussed was an emergency. It is important to remember that the data shown by this graph and figures 3-31, 3-32, and 3-33 relate to the sum of the conversations on the trolley and pager systems. Also, it should be noted that out of the total 296 calls on the

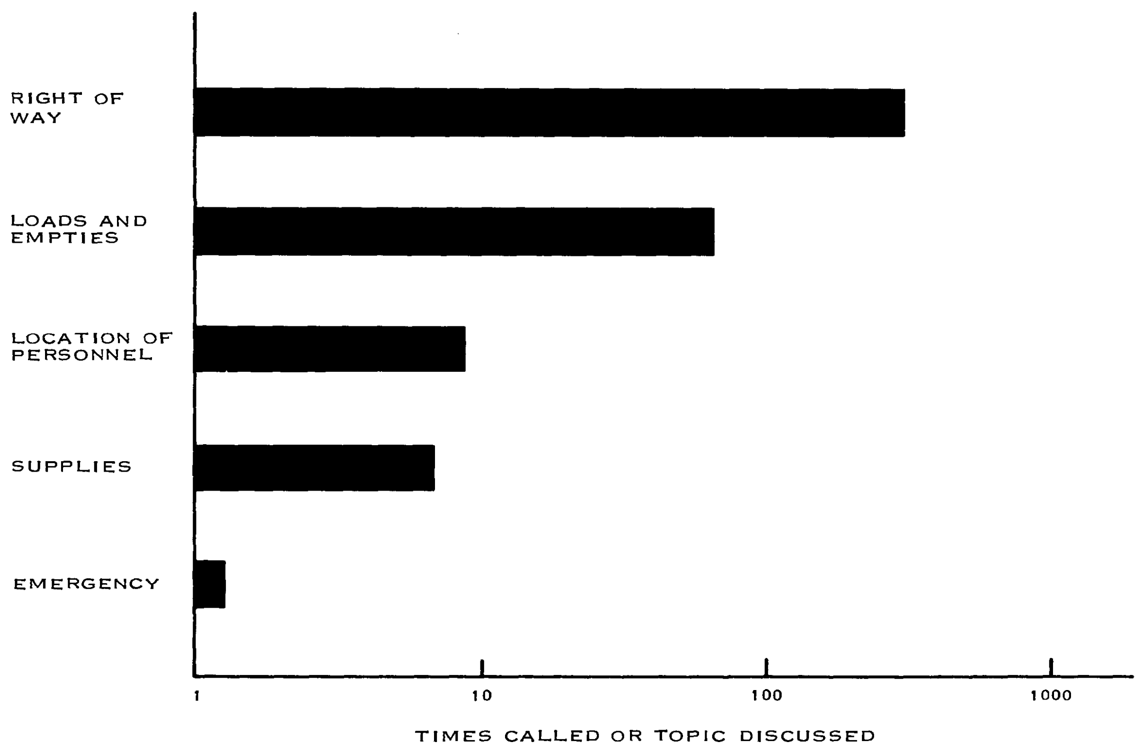


Figure 3-30. Trolley and Pager Call Categories.

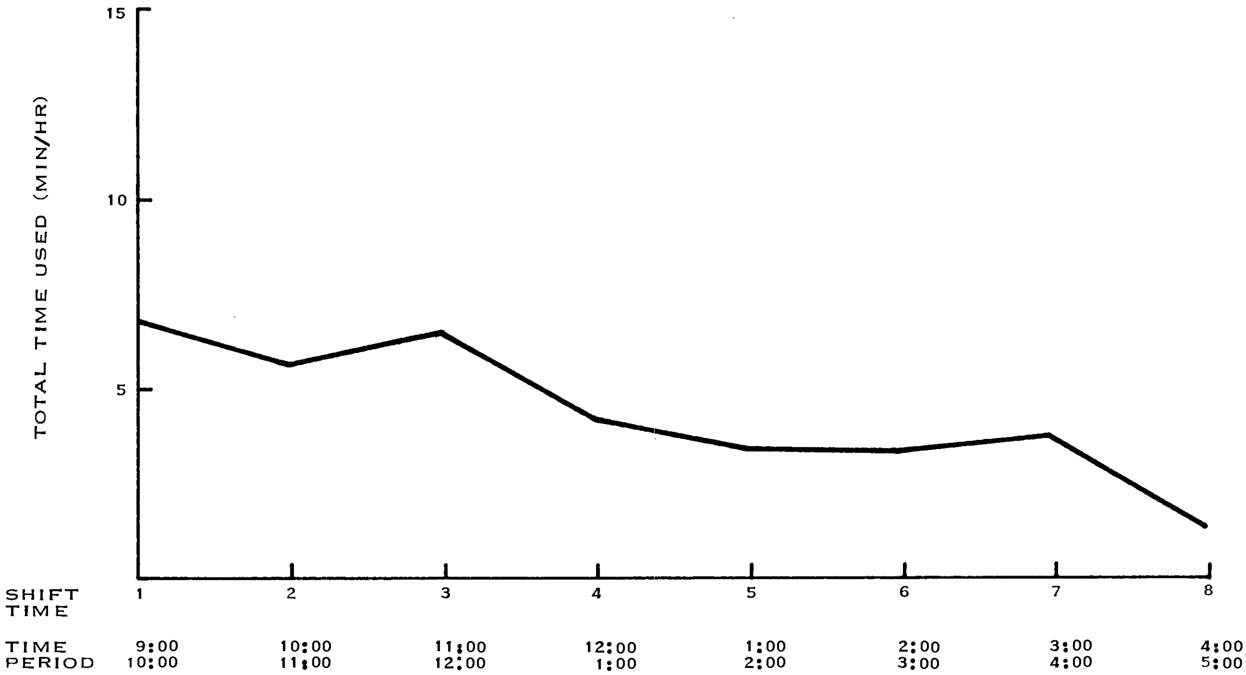


Figure 3-31. Total Time Trolley and Pager System Used.

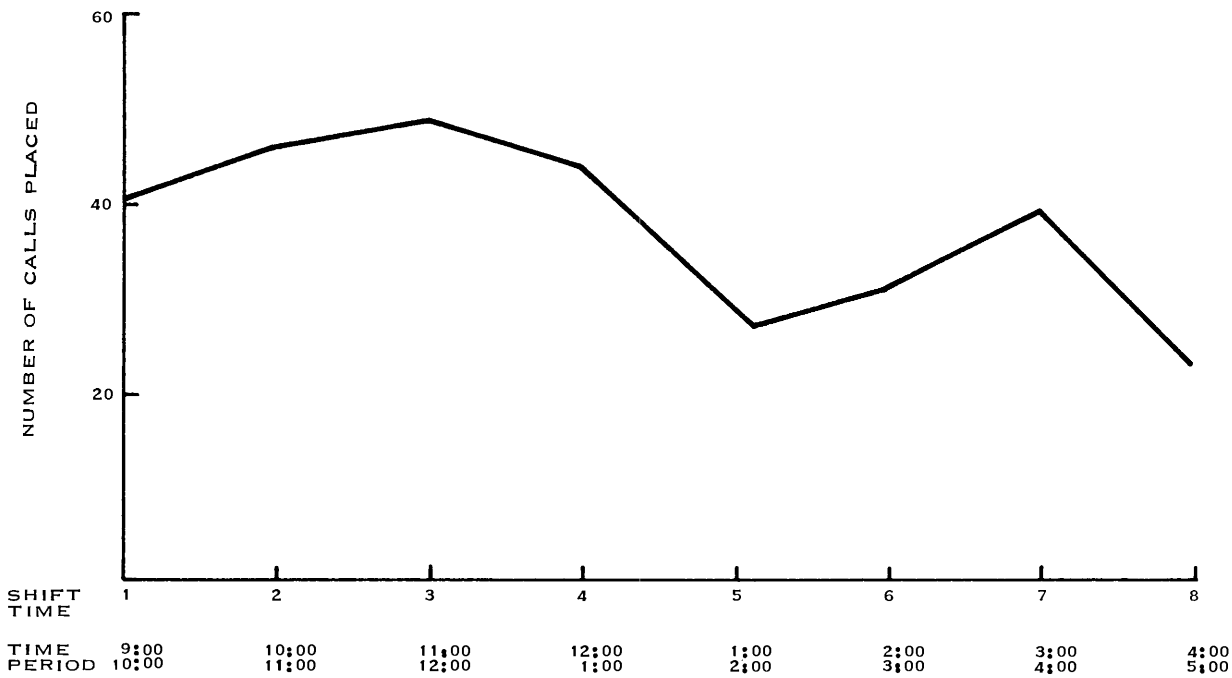


Figure 3-32. Number of Calls Placed on Trolley and Pager System.

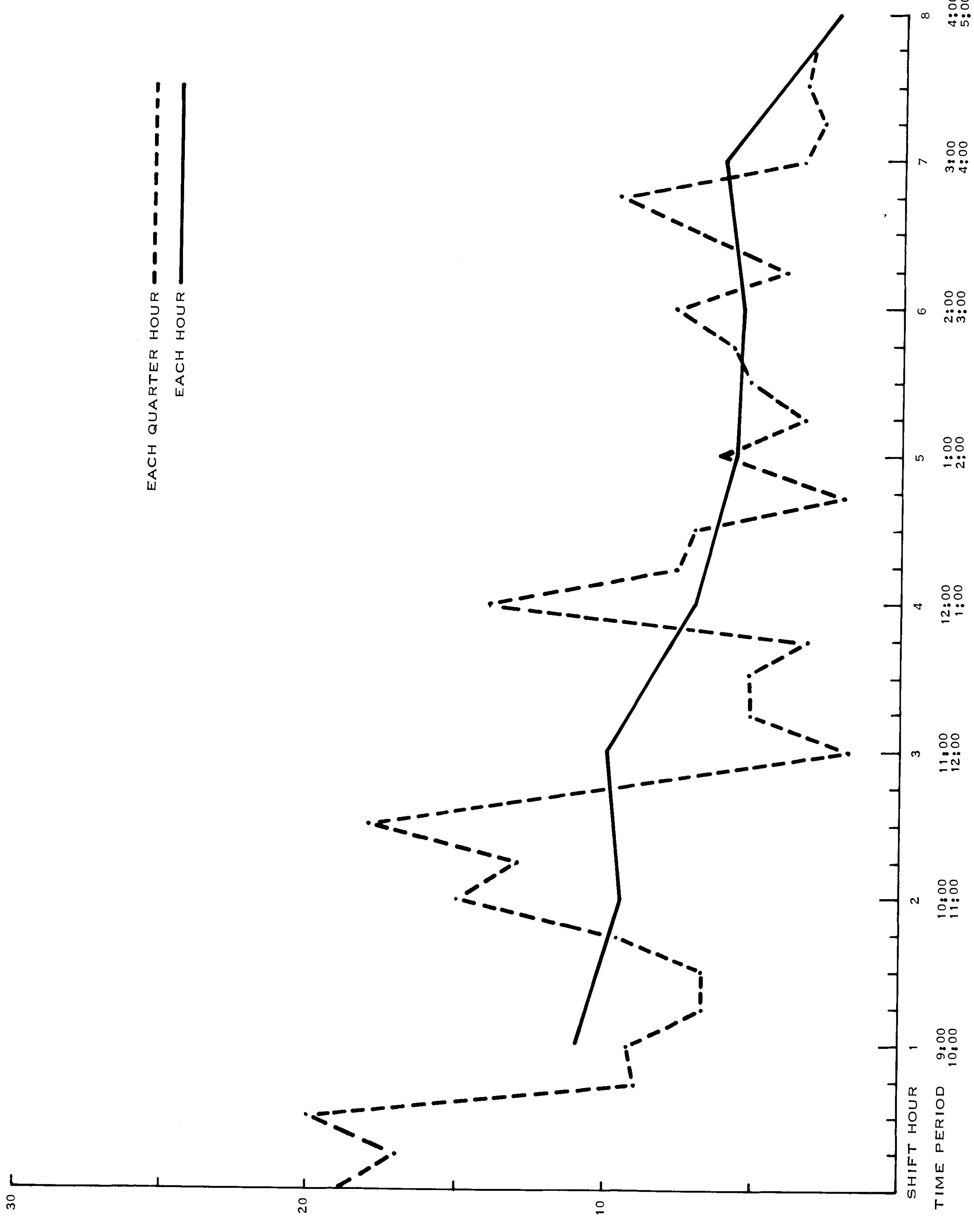


Figure 3-33. Percent of Time Trolley and Pager System Used.

trolley and pager system only 8 were on the pager. Therefore, the most frequently used communication was done on the trolley or carrier phone. By listening to tape recordings of both the pager phone and the carrier phone simultaneously, we discovered there were also 78 calls out of the 296 that were not heard on the outside trolley phone. It was also found that the trolley to pager hookup failed on 12 occasions. The actual failure of the coupler to function on sòme signals and the propagation dead zones were major problems associated with this system. Figures 3-31 and 3-32 show the total time and total number of calls placed on the trolley and pager system for the first shift as a function of shift hour. The percent of time this system was used is seen in figure 3-33 for hourly and 15-minute samples.

From figure 3-33, it can be seen that a peak in the conversation occurs during the first and third shift hours. Using a total maximum traffic density offered of 0.2 Erlang, we find that for a single channel the line will be busy 13 percent of the time. This is high when compared to our criteria of 1 percent; however, we find that 13 percent is much better than previously visited mines and may be attributed to the fact that the mine has only 3 production sections.

During the fire of May 1972, the trolley or carrier phones were the only communication that worked through the evacuation. As mentioned previously, the telephone wire was fused and communication was not possible using the dial system. However, the carrier phones can and did operate, using their internal batteries, through the fire. Although the loudspeaking phones were not in widespread service at the time of the fire, their line would have been fused making them inoperative if and when needed.

3.3.6 Communications Requirements - User's Viewpoint

Somerset's personnel indicated that the most urgent communication requirement was the elimination of dead zones in their trolley or carrier phone system. At present, they lose approximately 25 percent of the in-mine trolley to surface communication.

Communication between the shuttle cars and the shuttle cars to the continuous miner was also thought to be useful. However, there was apparently no great need or requirement for this type of communication.

Portable 2-way wireless communication for the maintenance foreman, fire boss, miners on weekend inspection, and working section foreman was noted as a possible requirement. If portable 2-way wireless equipment costs were high, the maintenance foreman, roving supervisors, and key personnel could use a 1-way pager. However, mine personnel did not consider equipping a working section with a 1-way pager since the working section foreman mostly communicated out from his location and is seldom called from other sections or surface locations.

A requirement existed for battery operated portable emergency communication that could be moved with the miners as the working section moved. This requirement came from the recent fire the mine had and would have been useful during the emergency and recovery efforts. Also noted was the fact that if the number of working sections increased, the mine may economically justify a dispatcher.

Physical requirements for equipment in this mine must include units that are moisture resistant and dustproof. Other than the trolley or carrier phones, most equipment in the mine would be relatively free of a constant vibration. Although there was no requirement for special case materials, there was àn interest in equipment that uses modular construction if the cost penalty was at a minimum. Current equipment durability with respect to handsets, speakers, and connection cords appears adequate if the moisture and dust problems can be solved. Equipment should be backplate timber mounted, using materials at hand like nails or spads. No equipment should be dependent on external power. Therefore, batteries should be included in all communications to power the unit in case of a disaster and its associated power-down condition.

3.3.7 Communication Requirements - Based on Survey Analysis

This mine is unique in that it has a dial telephone system, a pager system, and a trolley or carrier phone system. Somerset, as configured, has no need for additional channels, private channels, or the capability to interconnect to the public phone since the dial telephone has all these capabilities.

From the traffic density seen on the pager phone and trolley or carrier phone system, only 2 additional channels can be justified to get the probability of blocking to the 1-percent level. However, only 3 percent of this communication is from the pager phone system and the vehicle communication system must be single channel operation for safety reasons. Therefore, there exists no justification for additional channels for the pager phone. If it can be assumed, from the dial telephone data, that the total maximum nonvehicle communication traffic offered is 100 percent over the 0.33 Erlang seen on extension 223, then the maximum traffic offered is 0.66 Erlang and 4 channels are required to keep the probability of blocking below the 1-percent level.

Using this analysis and the needs generated by the mine personnel, the following list was developed to represent the minimum communication requirements for the Somerset Mine independent of their current system:

a. Reliable 2-way vehicle communication.
b. At least 4 independent voice channels whether they are from a dial telephone or an FDM system.
c. At least 1 channel that can be secure.
d. A dispatcher with communication center if the mine increases appreciably in size.
e. Portable 2-way wireless communication for working section foreman.
f. Portable 1-way voice pager for maintenance foreman and key personnel.
g. Portable battery operated communication equipment for mine-to-surface emergency 2-way communication.

3.4 KEYSTONE NO. 1 COAL MINE ON-SITE SURVEY (JULY 16-17, 1973)

3.4.1 Mine Contacted

Eastern Associated Coal Corporation
Keystone No. 1
Keystone, West Virginia

3.4.2 Initial Company Contact

T. A. Salvati - Division Manager
J. J. Higgins - Vice-President-Production

3.4.3 Personnel Interviewed

John D. Kirby - Mine Foreman
E. Bert Charles - Chief Electrician
Philip G. Formica - Master Mechanic
Terry Wells - Mining Engineer

3.4.4 General Mine Information

3.4.4.1 Mine Description

The Keystone No. 1 Mine is one of a group of four mines carrying the same name. Keystone No. 1 and No. 2 are the only mines that are connected. The mine is owned and operated by Eastern Associated Coal Corporation which is a subsidiary to Eastern Gas and Fuel Company. The mine is removing coal from Pocahontas Coal Seam No. 3. There was mining at Keystone in 1892, but the drifts used now were built in 1914. Even though the mine is old, they are still developing in some areas. At the present they have eight sections on development and five on retreat. It is estimated that there are 15 years of mining left in Keystone.

The mine is entered through one of two drift mouths. A vertical shaft is available but is seldom used.

Coal is extracted by conventional, continuous, and longwall mining methods. The mine produces approximately 4,500 tons of coal a day. The following numbers represent the percent of a total day's production produced by each method on the first shift:

Conventional	- 18 percent
Continuous	- 35 percent
Longwall	- 10 percent
Other shifts	- 37 percent
Total	100 percent

This was for the day preceding our visit, when one of their two longwalls was not in operation.

The coal is removed from the mine by track to the cleaning plant about two miles from the mine. The mine has an annual production of about 1,300,000 tons.

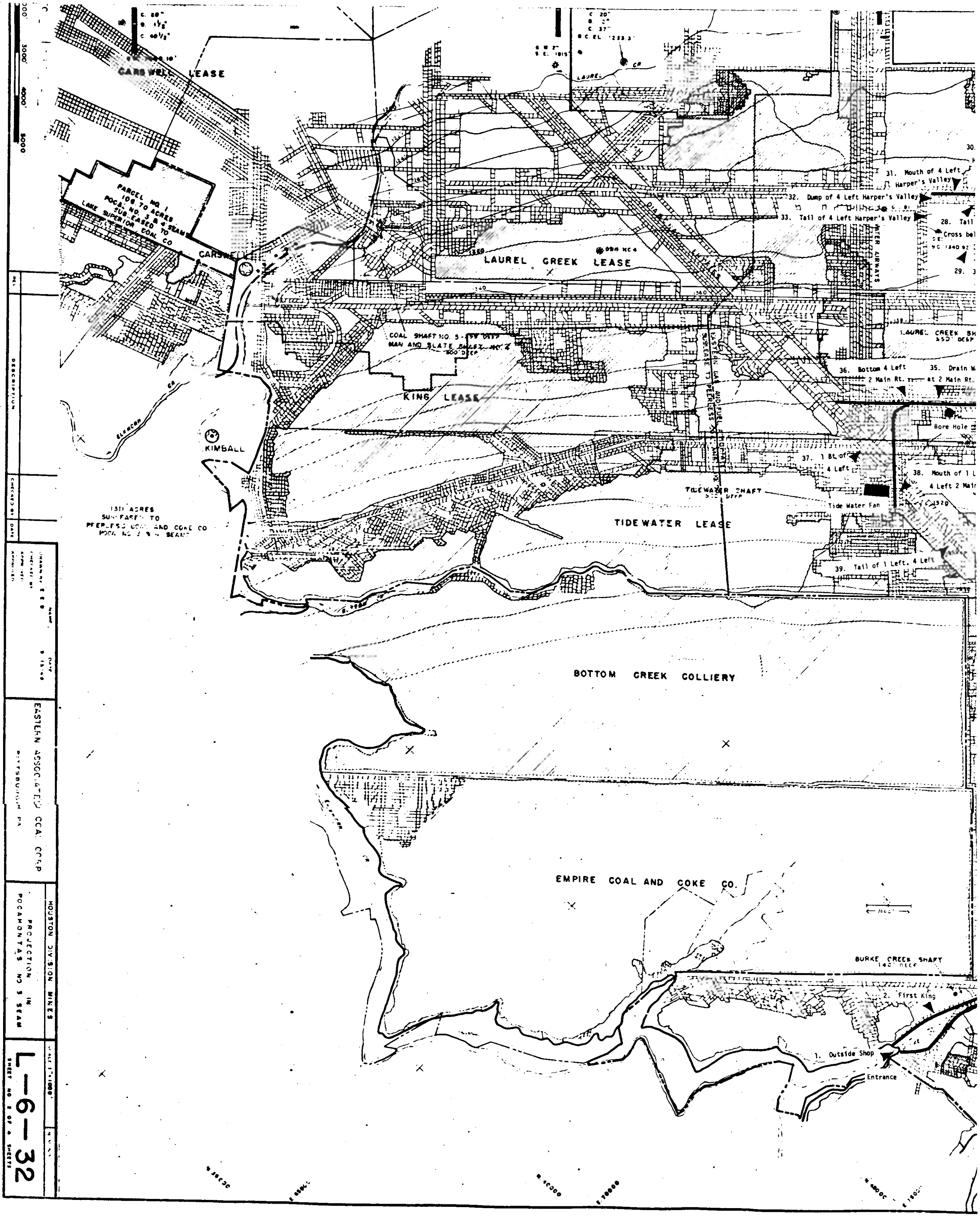
3.4.4.2 Mine Size

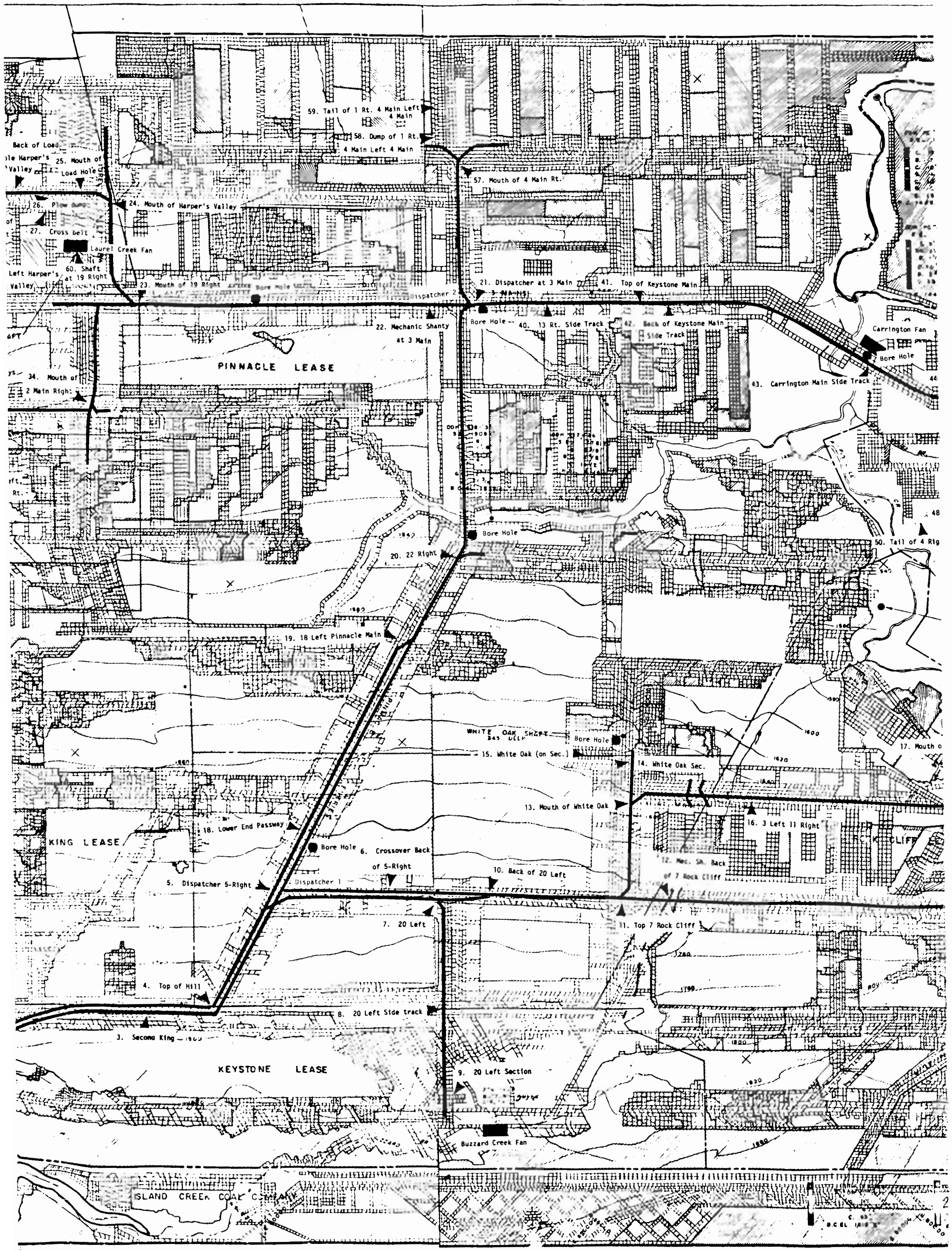
The mine is 7 miles by 5 miles and has overburden from 300 feet to 800 feet. The mine covers approximately the same amount of area as the capitol of West Virginia. All haulage tunnels are at least 6 feet high by 18 feet. There is no average size for a working section, but some are as much as 3,000 feet in length. This requires that coal be removed from the working face to the track by belt. The belt is 36 inches in width, and the mine has approximately 25,000 feet of belt. If the distance is short (less than 500 feet), it is possible to dump coal from the shuttle car directly into the coal car.

There are eight 37-ton locomotives that are used to remove the coal. The mine has 30 miles of track underground at present.

Figure 3-34 is a map of the mine. The heavy lines show the location of track. There are 8 bore holes (dots) shown, which are used to provide access for 13,800 volts ac, 3 phase, cables to the mine. A mine of this size requires a large ventilation system. The map shows the locations of the 5 fans (rectangles) used to pull air through the mine.

Roof control is obtained by the use of roof bolts ranging in length from 42 inches to 8 or 9 feet. The length depends on the condition of the overburden in the area.


CARSWELL LEASE
PARCEL NO. 1
106.70 ACRES
POCA. NO. 3 & 4 SEAMS
SUB-LEASED TO
LAKE SUPERIOR COAL CO
CARSWELL
LAUREL CREEK LEASE
COAL SHAFT NO. 5
MAN AND SLATE SHAFT NO. 2
KING LEASE
KIMBALL
1311 ACRES
SUB-LEASED TO
PEERLESS COAL AND COKE CO
TIDEWATER SHAFT
TIDEWATER LEASE
Tide Water Fan
Bore Hole
LAUREL CREEK SHAFT
31. Mouth of 4 Left Harper's Valley
32. Dump of 4 Left Harper's Valley
33. Tail of 4 Left Harper's Valley
36. Bottom 4 Left 2 Main Rt.
35. Drain
37. 1 Rt. of 4 Left
38. Mouth of 1 L 4 Left 2 Main
39. Tail of 1 Left, 4 Left
BOTTOM CREEK COLLIERY
EMPIRE COAL AND COKE CO.
BURKE CREEK SHAFT
2. First King
1. Outside Shop
Entrance
EASTERN ASSOCIATED COAL CORP
HOUSTON DIVISION MINES
PROJECTION IN POCAHONTAS NO 3 SEAM
L-6-32



59. Tail of 1 Rt. 4 Main Left 4 Main
58. Dump of 1 Rt. 4 Main Left 4 Main
Back of Load
25. Mouth of Load Hole
57. Mouth of 4 Main Rt.
26. Plow dump
24. Mouth of Harper's Valley
27. Cross belt
Laurel Creek Fan
60. Shaft at 19 Right
23. Mouth of 19 Right
Bore Hole
21. Dispatcher at 3 Main
41. Top of Keystone Main
22. Mechanic Shanty at 3 Main
Bore Hole
40. 13 Rt. Side Track
42. Back of Keystone Main Side Track
Carrington Fan
Bore Hole
43. Carrington Main Side Track
PINNACLE LEASE
34. Mouth of 2 Main Right
Bore Hole
20. 22 Right
19. 18 Left Pinnacle Main
WHITE OAK SHAFT
Bore Hole
15. White Oak (on Sec.)
14. White Oak Sec.
13. Mouth of White Oak
16. 3 Left 11 Right
18. Lower End Passway
KING LEASE
Bore Hole
6. Crossover Back of 5-Right
5. Dispatcher 5-Right
Dispatcher 1
10. Back of 20 Left
12. Mec. Sh. Back of 7 Rock Cliff
11. Top 7 Rock Cliff
7. 20 Left
4. Top of Hill
8. 20 Left Side track
3. Second King
KEYSTONE LEASE
9. 20 Left Section
Buzzard Creek Fan
ISLAND CREEK COAL

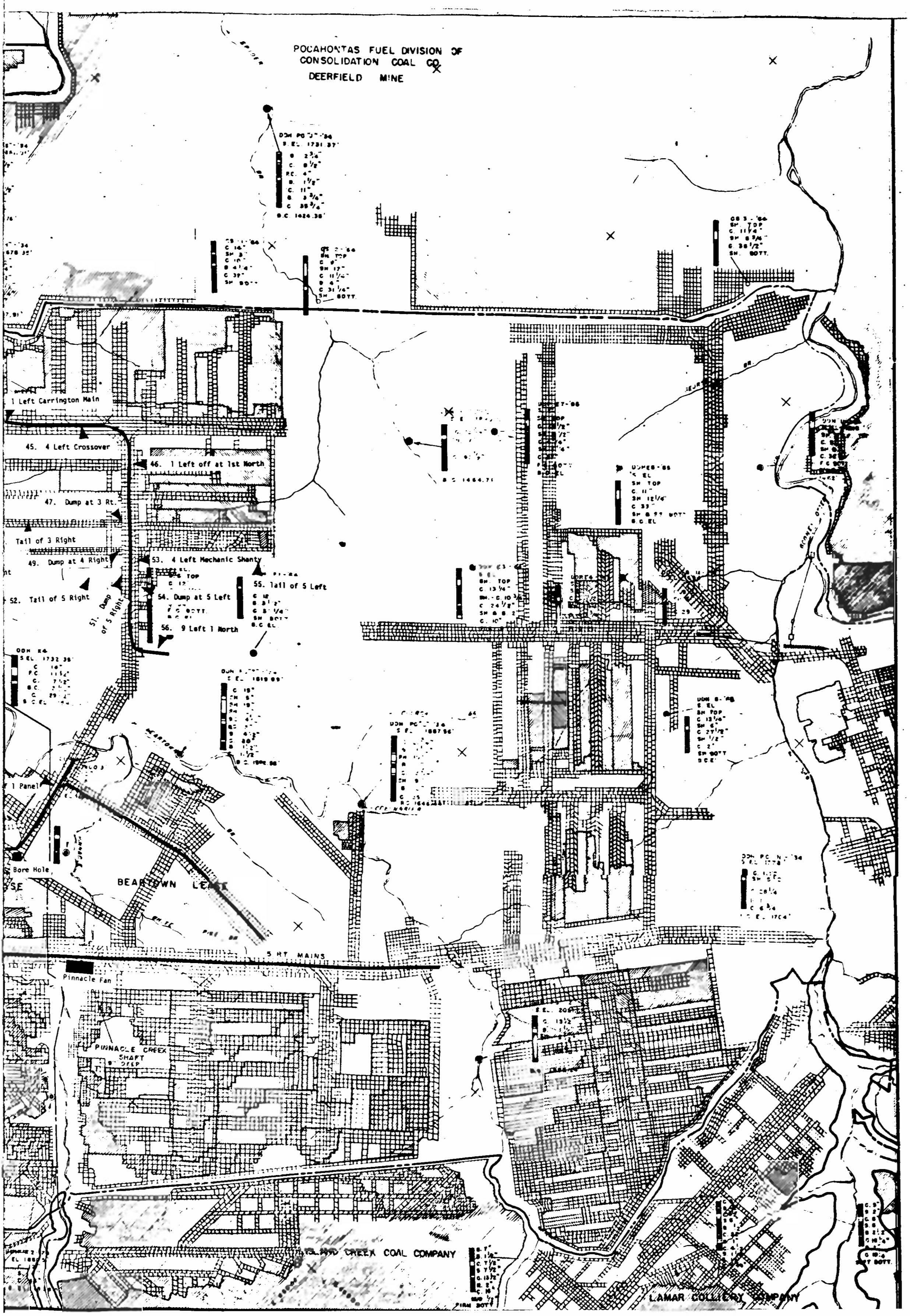


Figure 3-34. Keystone Mine No. 1.

Due to the amount of track and the layout of the mine, it is necessary for them to have two dispatchers. Figure 3-34 shows the locations of both dispatchers, one at the Y one-third up from map bottom, just to the left of center, the other at the T crossing at the top center of the map.

This mine is also engaged in strip mining at various locations directly above the mine. This coal is taken to the same cleaning plant as the coal mined underground. This requires that dispatcher 1 dispatch right-of-way outside as well as underground.

3.4.4.3 Crew Composition

Keystone No. 1 employs a total of 665 men with an average of 580 of them working each day. The mine works three 8-hour shifts each day, with the major production done on the first shift. The start and end of each shift and the total men working is as follows:

First shift:	6:45 am to 3:00 pm	- 308 men
Second shift:	3:30 pm to 11:45 pm	- 216 men
Third shift:	12:15 am to 8:30 am	- 151 men

The number of men required on a coal producing section varies according to the method of mining being used. The average requirements for the 3 methods are as follows:

a. Working Section -- Longwall

Foreman (1)
Shear or plow operator (1)
Roof support operator (7)
Mechanic (1)

b. Working Section -- Continuous Mining

Foreman (1)
Miner operator (1)
Miner operator helper (1)
Shuttlecar operators (2)
Mechanic (1)

c. Working Section -- Conventional

Foreman (1)
Loader operator (1)
Shuttlecar operators (2)
Roof bolter (1)
Cutting machine operator (1)
Face drill operator (1)

The mine also has mechanics that travel between sections to assist the section mechanics and deliver supplies.

There are also 33 supervisory personnel at the mines. This includes all foremen and the superintendent.

3.4.4.4 Mine Equipment and Power

Power is provided by Appalachian Power Company at 138,000 volts ac. This is then stepped down to 13,800 volts ac and distributed to 8 bore holes where it is taken underground. At some point underground this is converted to 250 volts dc, or 550 volts dc and/or 440 volts ac 3 phase. This is dependent on the equipment being used on the section and location in the mine. One of the reasons for this is that from the outside to dispatcher 2 (figure 3-34) the mine used 550 volts dc on the trolley. Then branching out from dispatcher 2, the mine used 250 volts dc on the trolley. The 440 volts ac is used in both areas.

Figure 3-35 is a map of the electrical system at the mine. It shows the locations of all rectifiers and power centers. The mine uses Westinghouse, General Electric, Ensign, and HeWettic (Mercury-Arc) rectifying equipment. Two of the stations are rated at 1,800 amperes while the others are rated 2,000 amperes-750 kVA.

The power provided to sections varies according to the type of equipment used. There are cases where, on the same section, 250 volts dc or 550 volts dc must be provided for the shuttlecars, and 440 volts ac provided for the miner.

The mine at the present, uses the following equipment:

Continuous miners (8)
Loading machines (5)
Longwalls (1 plow, 1 shear) (2)
Cutting machines (3)
Shuttlecars (29)

The equipment varies according to the type of mining being used. On a conventional section there will be the following:

Loader (1)
Cutting machine (1)
Roof bolter (1)
Shuttlecars (2)
Face drill (1)

The equipment on a continuous mining section will be as follows:

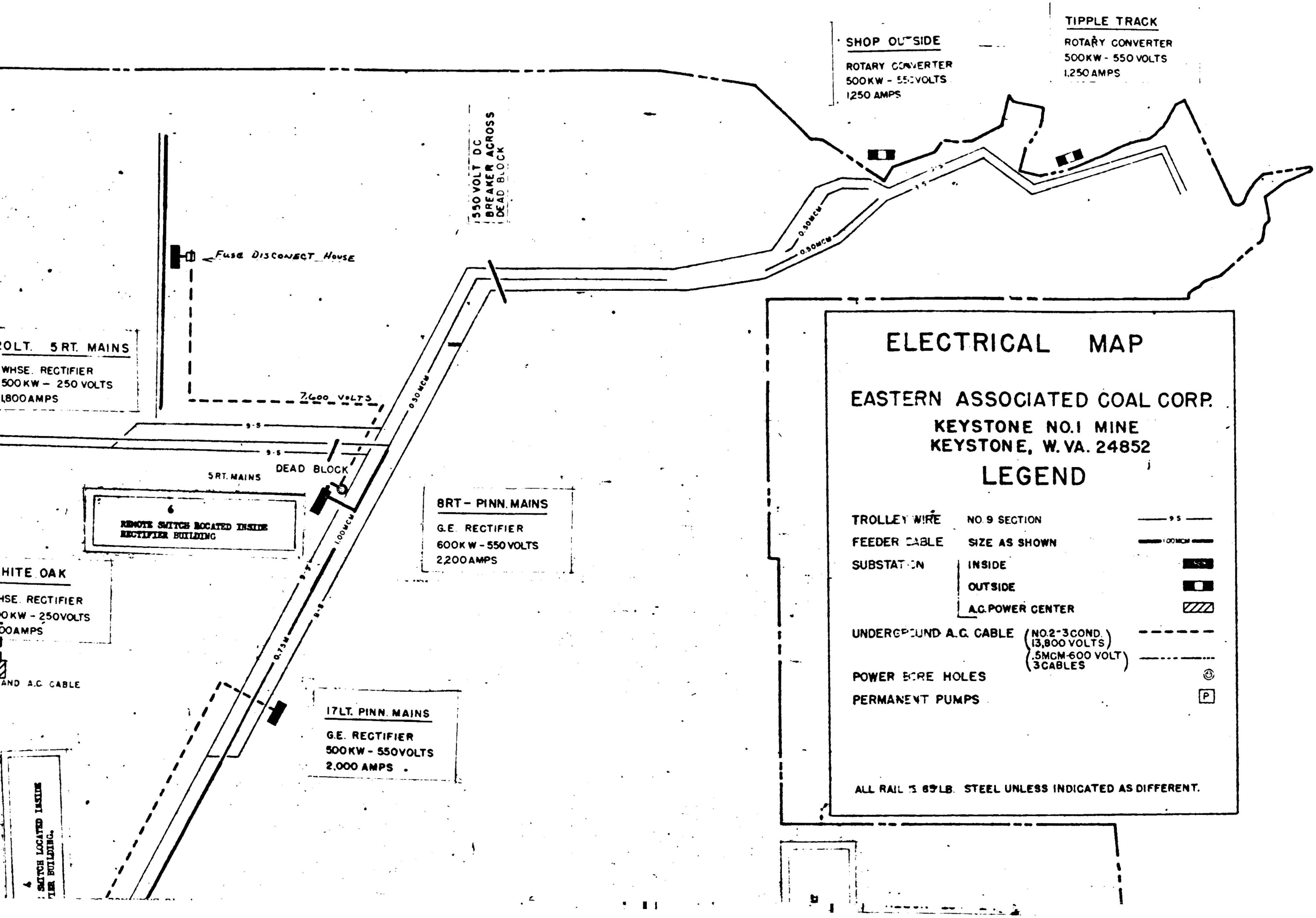
Continuous miner (1)
Shuttlecars (2)
Roof bolter (1)

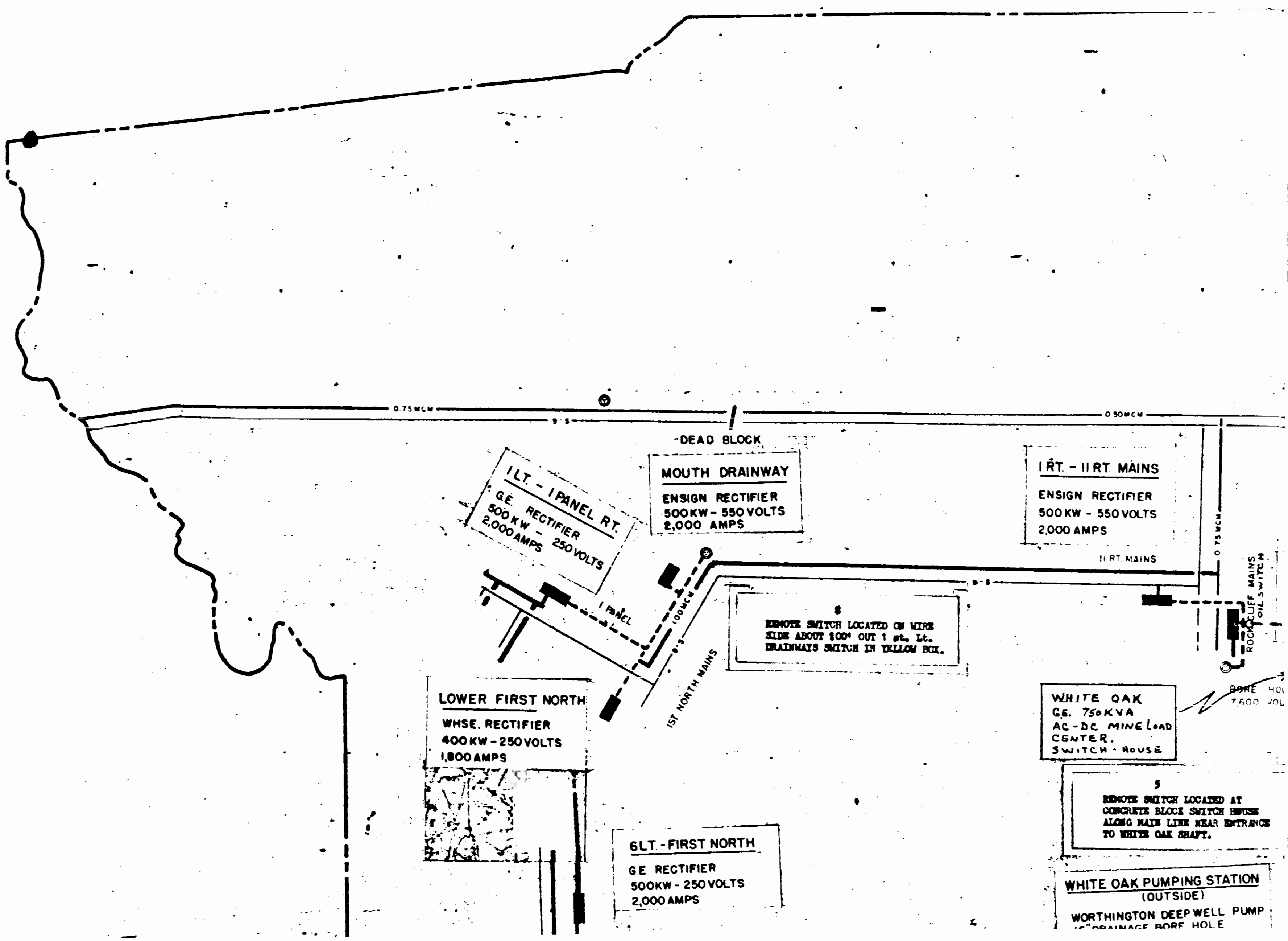
Both longwalls require 440 volts ac as do some of the newer continuous miners. There are also some battery powered "Scoops" on some sections. They are used for cleaning the section and hauling supplies.

3.4.4.5 Current Mine Communications

At the present, the mine communication system consists of a Magneto phone system, carrier phone (trolley phone) system and loud speaking phones.

The loud speaking phones are used only on the longwalls. Carrier phones are placed on most of the track vehicles. At the cleaning plant they use a 60-watt amplifier as a public address system calling 14 stations, each of which has a microphone and speaker.


ELECTRICAL MAP
EASTERN ASSOCIATED COAL CORP.
KEYSTONE NO.1 MINE
KEYSTONE, W. VA. 24852
LEGEND
TROLLEY WIRE — NO. 9 SECTION
FEEDER CABLE — SIZE AS SHOWN
SUBSTATION — INSIDE
OUTSIDE
A.C. POWER CENTER
UNDERGROUND A.C. CABLE (NO.2-3 COND. 13,800 VOLTS) (.5MCM-600 VOLT 3 CABLES)
POWER BORE HOLES
PERMANENT PUMPS
ALL RAIL IS 85 LB. STEEL UNLESS INDICATED AS DIFFERENT.
TIPPLE TRACK
ROTARY CONVERTER
500KW - 550 VOLTS
1,250 AMPS
SHOP OUTSIDE
ROTARY CONVERTER
500KW - 550 VOLTS
1250 AMPS
550 VOLT DC
BREAKER ACROSS
DEAD BLOCK
Fuse Disconect House
7,600 VOLTS
0.50 MCM
1.00 MCM
0.75 M
9-5
5 RT. MAINS
DEAD BLOCK
8RT - PINN. MAINS
G.E. RECTIFIER
600KW - 550 VOLTS
2,200 AMPS
17LT. PINN. MAINS
G.E. RECTIFIER
500KW - 550 VOLTS
2,000 AMPS
6
REMOTE SWITCH LOCATED INSIDE
RECTIFIER BUILDING
OLT. 5 RT. MAINS
WHSE. RECTIFIER
500KW - 250 VOLTS
1,800 AMPS
HITE OAK
HSE. RECTIFIER
0KW - 250 VOLTS
00 AMPS
AND A.C. CABLE
4
SWITCH LOCATED INSIDE
TER BUILDING.



0 75 MCM
0 50 MCM
-DEAD BLOCK
MOUTH DRAINWAY
ENSIGN RECTIFIER
500 KW - 550 VOLTS
2,000 AMPS
1 RT. - 11 RT. MAINS
ENSIGN RECTIFIER
500 KW - 550 VOLTS
2,000 AMPS
11 RT. MAINS
1 LT. - 1 PANEL RT.
G.E. RECTIFIER
500 KW - 250 VOLTS
2,000 AMPS
1 PANEL
100 MCM
1ST NORTH MAINS
REMOTE SWITCH LOCATED ON WIRE SIDE ABOUT 100' OUT 1 st. Lt. DRAINWAYS SWITCH IN YELLOW BOX.
ROCKCLIFF MAINS OIL SWITCH
WHITE OAK
G.E. 750 KVA
AC-DC MINE LOAD CENTER.
SWITCH - HOUSE
LOWER FIRST NORTH
WHSE. RECTIFIER
400 KW - 250 VOLTS
1,800 AMPS
6LT. - FIRST NORTH
GE RECTIFIER
500 KW - 250 VOLTS
2,000 AMPS
REMOTE SWITCH LOCATED AT CONCRETE BLOCK SWITCH HOUSE ALONG MAIN LINE NEAR ENTRANCE TO WHITE OAK SHAFT.
WHITE OAK PUMPING STATION
(OUTSIDE)
WORTHINGTON DEEP WELL PUMP

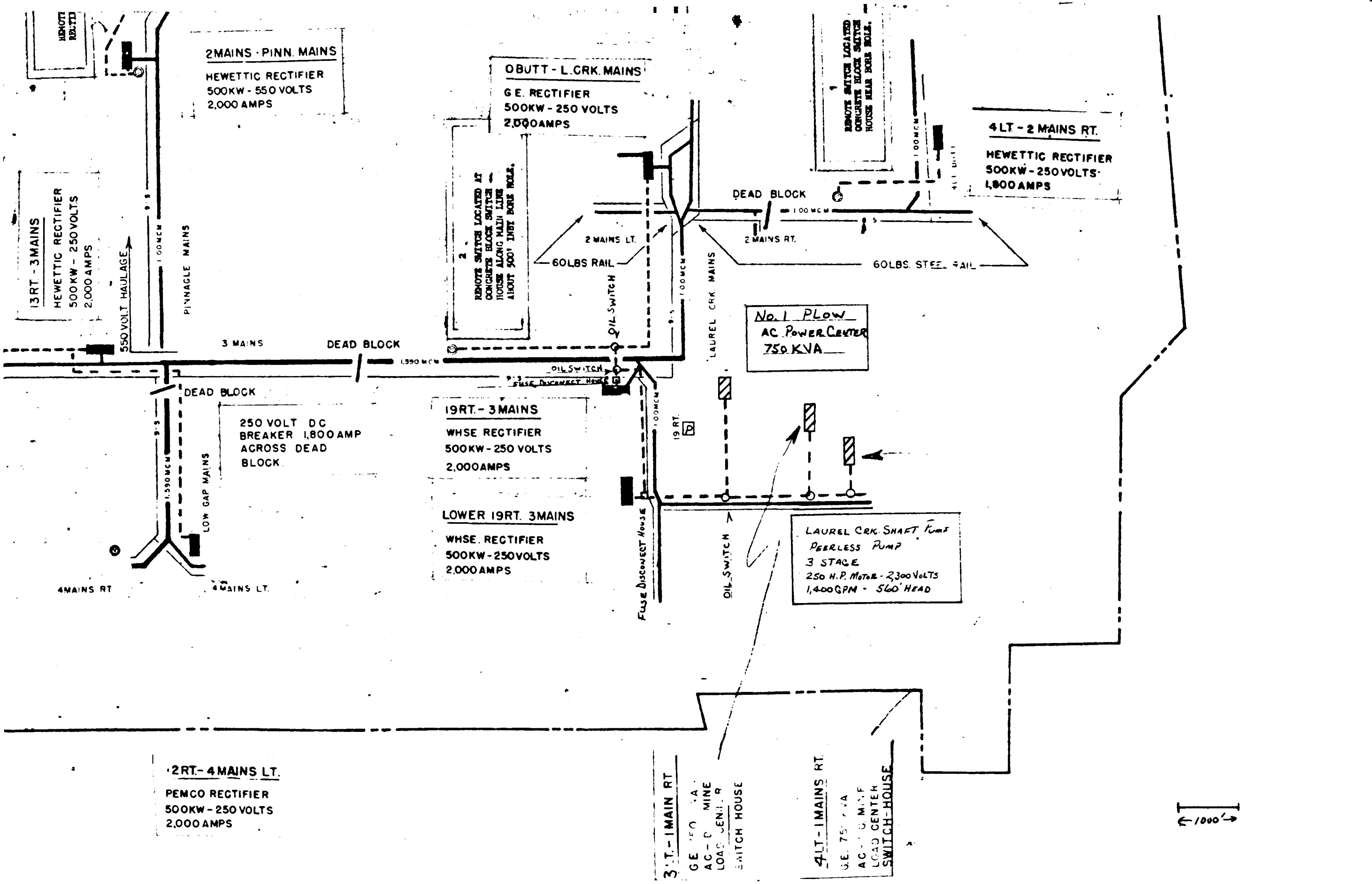
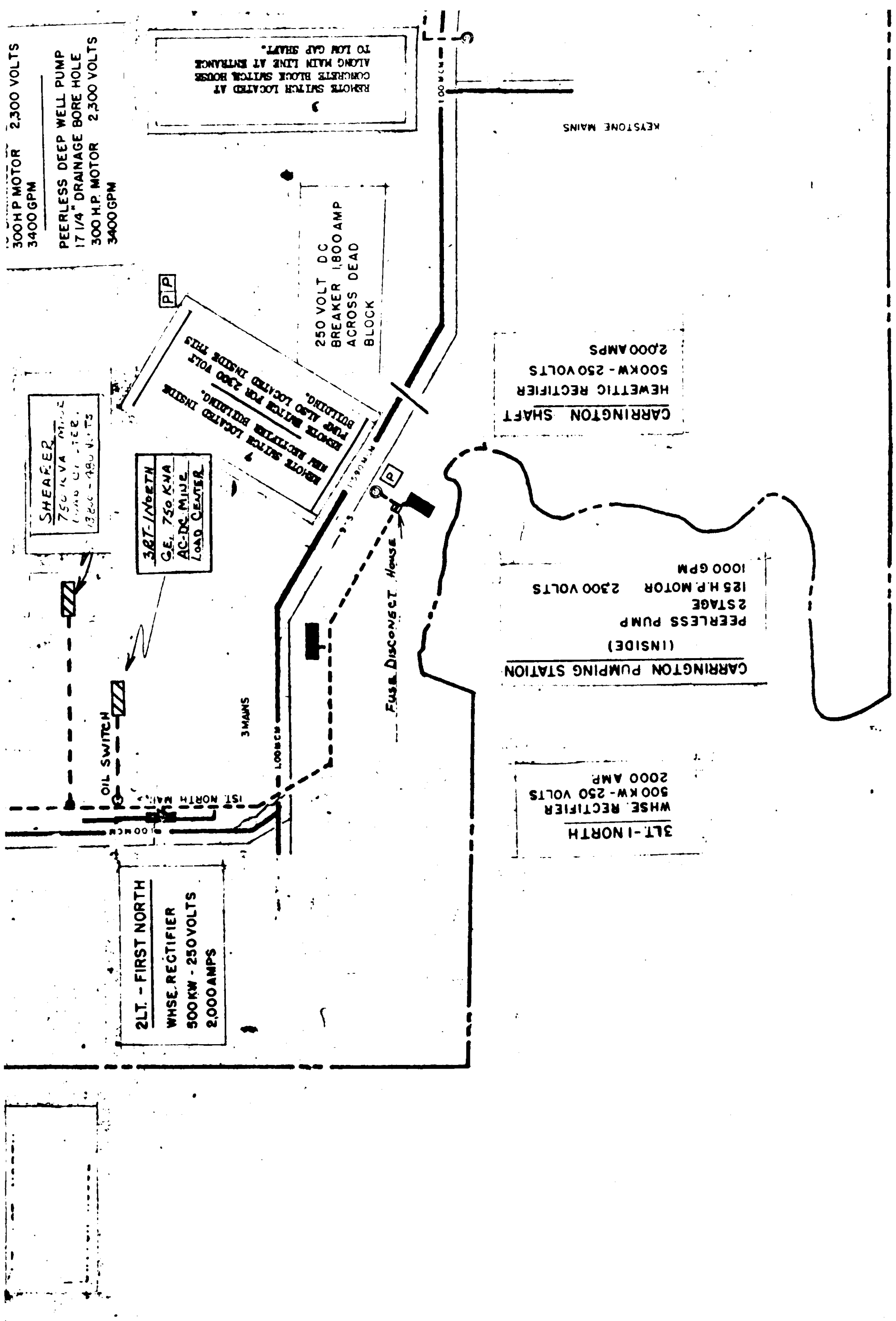


Figure 3-35. Keystone Electrical Map.



300 H.P MOTOR 2,300 VOLTS
3400 GPM
PEERLESS DEEP WELL PUMP
17 1/4" DRAINAGE BORE HOLE
300 H.P. MOTOR 2,300 VOLTS
3400 GPM
REMOTE SWITCH LOCATED AT CONCRETE BLOCK SWITCH HOUSE ALONG MAIN LINE AT ENTRANCE TO LOW GAP SHAFT.
KEYSTONE MAINS
250 VOLT DC BREAKER 1,800 AMP ACROSS DEAD BLOCK
P P
REMOTE SWITCH LOCATED INSIDE NEW RECTIFIER BUILDING.
REMOTE SWITCH FOR 2300 VOLT PUMP ALSO LOCATED INSIDE THIS BUILDING.
CARRINGTON SHAFT
HEWITTIC RECTIFIER
500KW - 250 VOLTS
2,000 AMPS
SHEARER
750 KVA
3RT-1NORTH
G.E. 750 KVA
AC-DC MINE
LOAD CENTER
P
FUSE DISCONECT HOUSE
CARRINGTON PUMPING STATION
(INSIDE)
PEERLESS PUMP
2 STAGE
125 H.P. MOTOR 2300 VOLTS
1000 GPM
OIL SWITCH
3 MAINS
1ST NORTH MAINS
3LT-1 NORTH
WHSE. RECTIFIER
500 KW - 250 VOLTS
2000 AMP
2LT. - FIRST NORTH
WHSE. RECTIFIER
500KW - 250 VOLTS
2,000 AMPS

Due to the size of the mines there are two dispatchers (figure 3-34). Each is responsible for carrier phone and magneto phone control in his area of the mines. The two dispatchers must consult with each other when routing traffic toward each other.

Typically, the telephone network having dispatcher 2 as its control point has heavier traffic of a more varied nature than that of dispatcher 1.

As with the other mines visited, the statistics are based on the measured traffic on the busier of the two trunks. Traffic on the second bus is assumed to be somewhat less than that on the first.

During the busiest period of the shift, the fourth hour, the busier trunk was used 70 percent of the time. The total traffic density thus becomes:

Measured or recorded trunk	- 0.7 (E)
Estimated for second trunk	- 0.4 (E)
Estimated traffic within a circuit	- 0.3 (E)
	1.4 (E)

This 3-channel traffic intensity implies that there is a 30-percent chance of getting a busy signal on any given call. This is considerably worse than the one chance in a thousand of commercial telephone standards. A 6-channel network would be required to bring the system to commercial standards.

There have been no major emergencies at Keystone No. 1 to test the existing system. It is possible that a roof fall could break the phone line and cut off communications to the outside for some areas of the mine. In the case of accident the section notifies the dispatcher who in turn calls mine management on the outside.

The phones are 30 years old and not in the best of condition, a consequence of the length of time they have spent in the mine.

3.4.4.6 Telephone System

The mine has 77 Magneto telephones, sixty of which are underground. Their position and name of location are marked on figure 3-34. The phones were manufactured by Western Electric and are approximately 30 years old. They use simple twisted pair, No. 14 wire for the phone circuit.

The phones are usually mounted on wood that is connected, in some manner, to the roof. They are placed at locations along the main haulage. Phones on the section are located at the head and tailpiece of the belt.

Since the phones are not permissible, the closest they can be to the face is 15 feet in by the last open crosscut. The maximum distance a man on a section may have to walk to get to a phone is 500 feet.

The dispatchers are the heart of the phone system. Dispatcher 1 is responsible for the phones outside and all the phones to the right of phone 5 (marked dispatcher 5-right). Dispatcher 2 has all phones from number 20 to 60.

Dispatcher 1 is responsible for the following circuits and phones:

Outside to 5-Right

1. Outside shop
2. First king
3. Second king
4. Top of hill
5. Dispatch at 5-right

5-Right

6. Crossover back of 5-right
7. 20-left
8. 20-left side track
9. 20-left section
10. Back of 20-left
11. Top of Rock Cliff
12. Mechanic shanty back of 7-Rock Cliff
13. Mouth of White Oak
14. White Oak section
15. White Oak (on section)
16. 3-left 11-right
17. Mouth of 1-panel

Pinnacle Main

18. Lower end passway
19. 18-left
20. 22-right
21. Dispatcher at 3-main

The following is a list of circuits and phones for which dispatcher 2 is responsible:

Laurel Creek and 19-right

22. Mechanic shanty at 3-main
23. Mouth of 19-right
24. Mouth of Harper's Valley
25. Mouth of load hole
26. Plow dump
27. Cross belt
28. Tail of cross belt
29. 3-left Harper's Valley
30. Back of load hole Harper's Valley
31. Mouth of 4-left Harper's Valley
32. Dump of 4-left Harper's Valley
33. Tail of 4-left Harper's Valley

2-Main Right

34. Mouth of 2-main right
35. Darin ways at 2-main right
36. Bottom 4-left 2-main right

37. 1-right off of 4-left
38. Mouth of 1-left, 4-left
39. Tail of 1-left, 4-left

Carrington Main

40. 13-right sidetrack
41. Top of Keystone main
42. Back of Keystone main sidetrack
43. Carrington main sidetrack
44. 1-left Carrington main
45. 4-left crossover
46. 1-left off of 1st North
47. Dump at 3-right
48. Tail of 3-right
49. Dump at 4-right
50. Tail of 4-right
51. Dump at 5-right
52. Tail of 5-right
53. 4-left mechanic shanty
54. Dump at 5-left
55. Tail of 5-left
56. 9-left 1-north

4 Main

57. Mouth of 4-main right
58. Dump of 1-right, 4-main left
59. Tail of 1-right, 4-main left
60. Shaft at 19-right

If a person wished to call outside from say phone 57, mouth of 4-main right, he would have to ring dispatcher 2. Dispatcher 2 would then call dispatcher 1, who would ring outside, then connect the lines. There is no other way for the caller to place the call. That call would be about 5-3/4 miles from the outside. The longest signal path, that from (56) 9-left North to outside (1), is about 9 to 10 miles.

Since the phones are a ringer type, a station must have a certain ring. The following is a list of the rings and the name of the station. It should be kept in mind that the circuits for the two dispatchers are separated. Therefore, each dispatcher could use the same ring combinations:

1L	Dispatcher 1
1L 2S	Dispatcher 2
1L 2S	White Oak
2S	Attention to anyone
6S	Mine foreman or assistant mine foreman
3S	3-right - Carrington main
4S	4-right - Carrington main
5S	Four
2L	Five
2S 1L	5-left
1L 1S 1L	9-left
3S	4-main
4S	2-left 2-main right

3S	1-right 2-main right
1L 1S	Plow dump
2L	Plow section
1L 1S 1L	3-section Harper's Valley

Recordings and corresponding analysis were made of the calls at number 2 dispatcher's location. Figure 3-36 shows the total time the phone was used during a shift. Figure 3-37 shows the corresponding number of calls that were placed each hour. It should be noted that even though the maximum and minimum values may change from day to day; the relationship between peaks and lows to certain time periods may hold everyday.

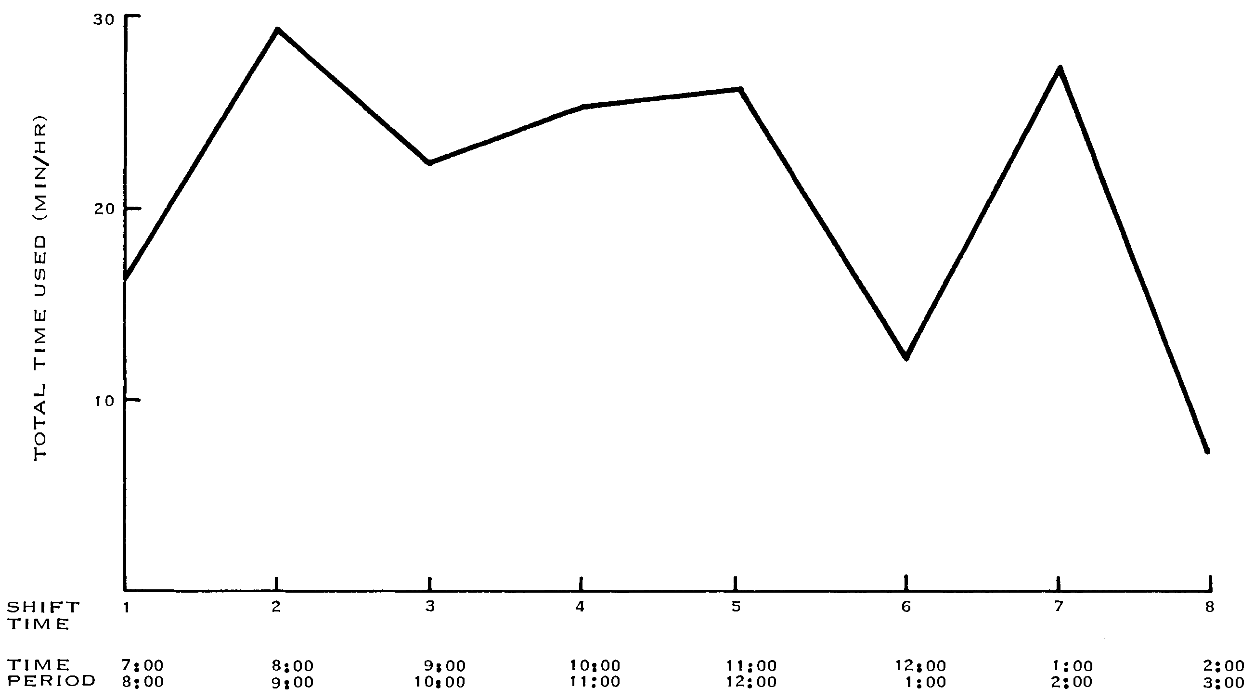


Figure 3-36. Total Time Phone Is Used.

Figure 3-38 shows the percent of time the phone is used with respect to the time period.

If one were to observe only the percent of each hour the phone is in use, the maximum value would be 49 percent. Yet, the graph for each quarter hour shows that there are times when the system is used 71 percent of the time. This seems to indicate that there are times when the system is overloaded.

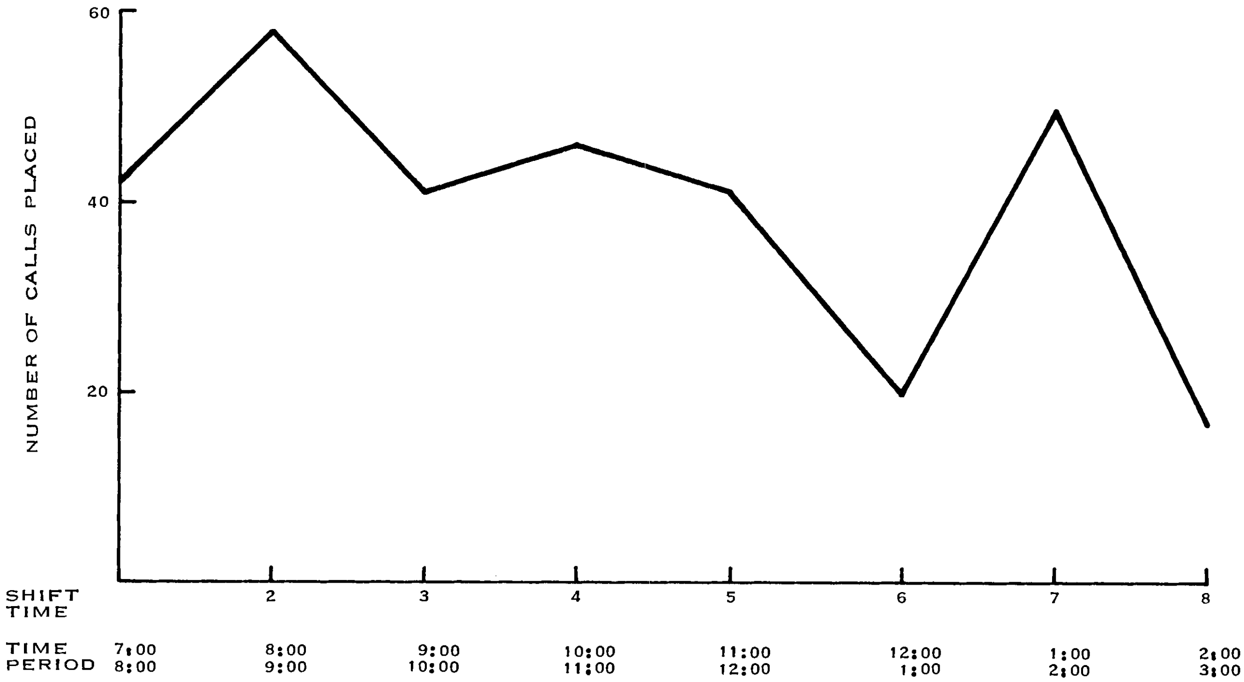


Figure 3-37. Number of Calls Placed.

The data was taken at dispatcher 2 July 16, 1973. Information depended on which circuit he had switched in. Therefore, the calls recorded were placed to him and there were no unanswered calls recorded. It is possible that calls on a line placed at another station on the same line were not answered. Calls from the tail of a belt to the head of a belt or a section are calls of this type.

Figure 3-39 is a bar graph showing the relationships between the telephone call categories. It can be seen that the phone system is used mostly for dispatching right-of-way to track vehicles that do not have carrier phones. The absolute value of these calls may change from day to day, where the relationships to each other will change little.

Calls to and from supervisory personnel could be important in showing who may need portable pagers. Table 3-1 shows as accurate as possible the matrix of calls. The matrix shows that more calls were placed to the mechanic foreman, and the master mechanic.

The table shows that 25 percent of the calls went to the mechanic foreman and 26 percent to the master mechanic. It should be noted that there are two mechanic foremen and only one master mechanic. Approximately 19 percent were placed to assistant mine foremen, and there are two of them also. Therefore, on an individual basis the master mechanic is called for more than any supervisory personnel.

All data was taken at dispatcher 2, because the mine personnel felt that the phone at dispatcher 1 was not used enough to give additional data.

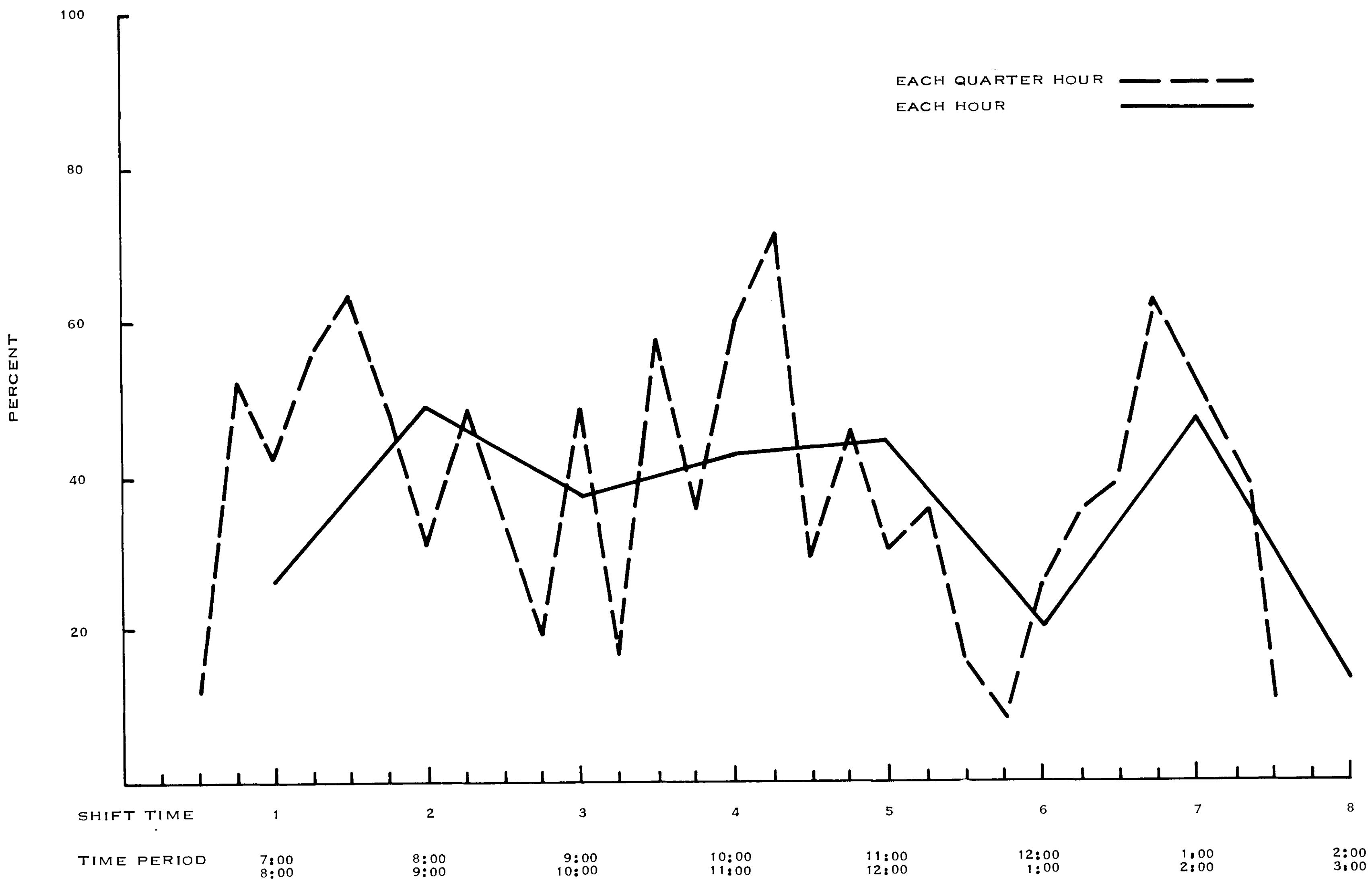


Figure 3-38. Percent of Time Phone Used.

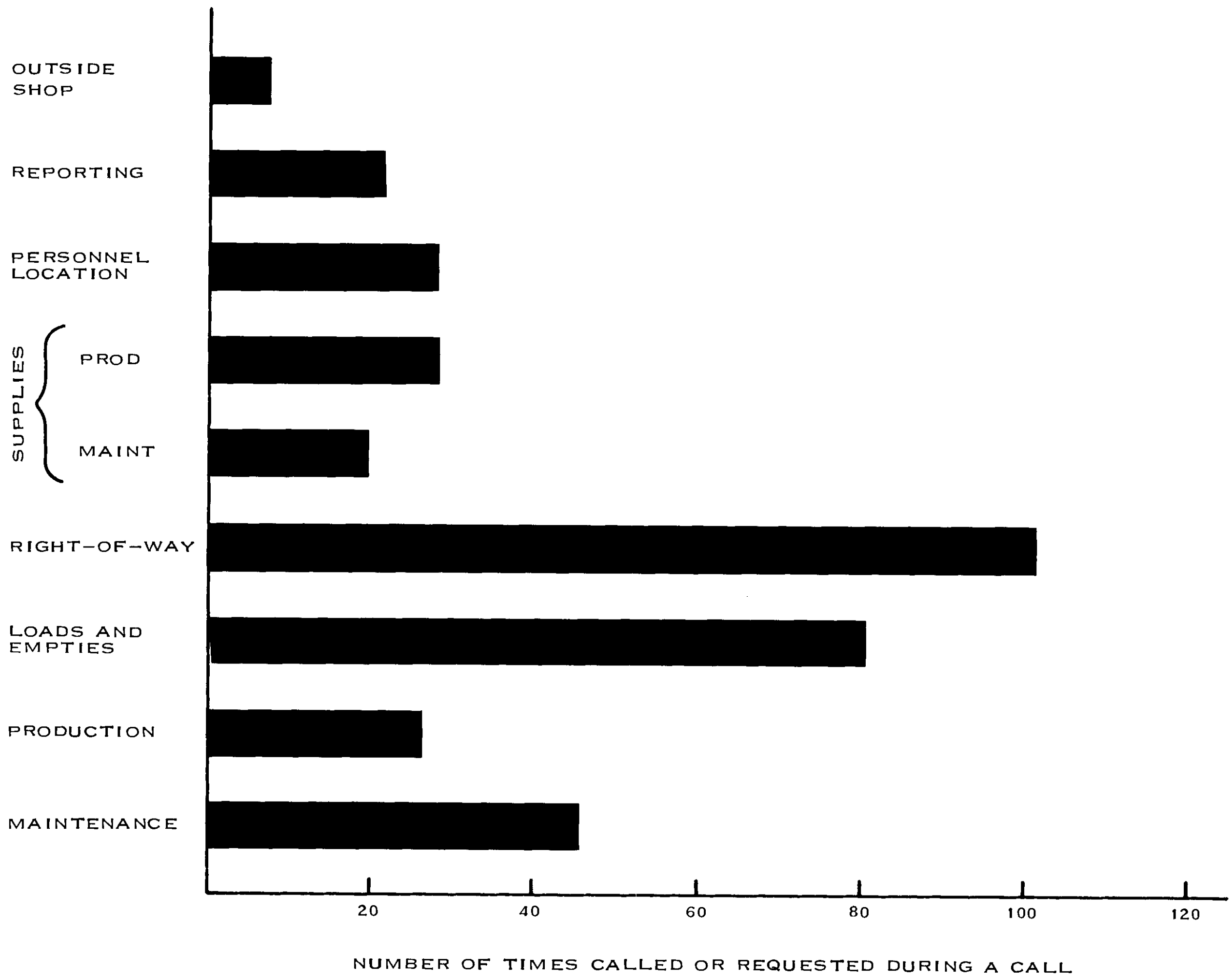


Figure 3-39. Telephone Call Categories.

3.4.4.7 Trolley Phone System

The carrier phones are mounted on most of the track vehicles. The fact that Keystone uses 250 volts dc and 550 volts dc on the trolley requires the use of two different carrier phones. They have twelve 250-volt, 163-kHz trolley phones and twenty-eight 550-volt, 100-kHz phones. The trolley phones are made by Femco, model numbers TP3000 (tube) and TP3000-T (transistorized). The tube type is 20 years old and the transistorized type is 12 years old. The TP-3000-T is operated by a 12-volt battery. So that, should the power in the mine go off, they will still have some communications.

Figures 3-40 and 3-42 show the total time the 250 volt and the 550 volt systems were used. Figures 3-41 and 3-43 show the total number of calls placed on each system. The number of calls and total time may increase as production increases. This is because the dispatchers must get the loaded cars out and empty cars to the sections at an increased rate.

Figures 3-44 and 3-45 show the percent of time the trolley system is used. Again, the quarter hour graph shows duty cycles greater than the hourly graphs.

Table 3-1. Calls To and From Supervisory Personnel.

PERSON PLACING CALL	PERSON RECEIVING CALL						
	SECTION FOREMAN	MECHANIC FOREMAN	MASTER MECHANIC	SECTION MECHANIC	MINE FOREMAN	ASSISTANT MINE FOREMAN	UNKNOWN
Section foreman							
Mechanic foreman			1	1			
Master mechanic		1		1			
Section mechanic		1					
Mine foreman	1		1			1	
Assistant mine foreman			1				
Unknown	3	12	12	1	1	9	

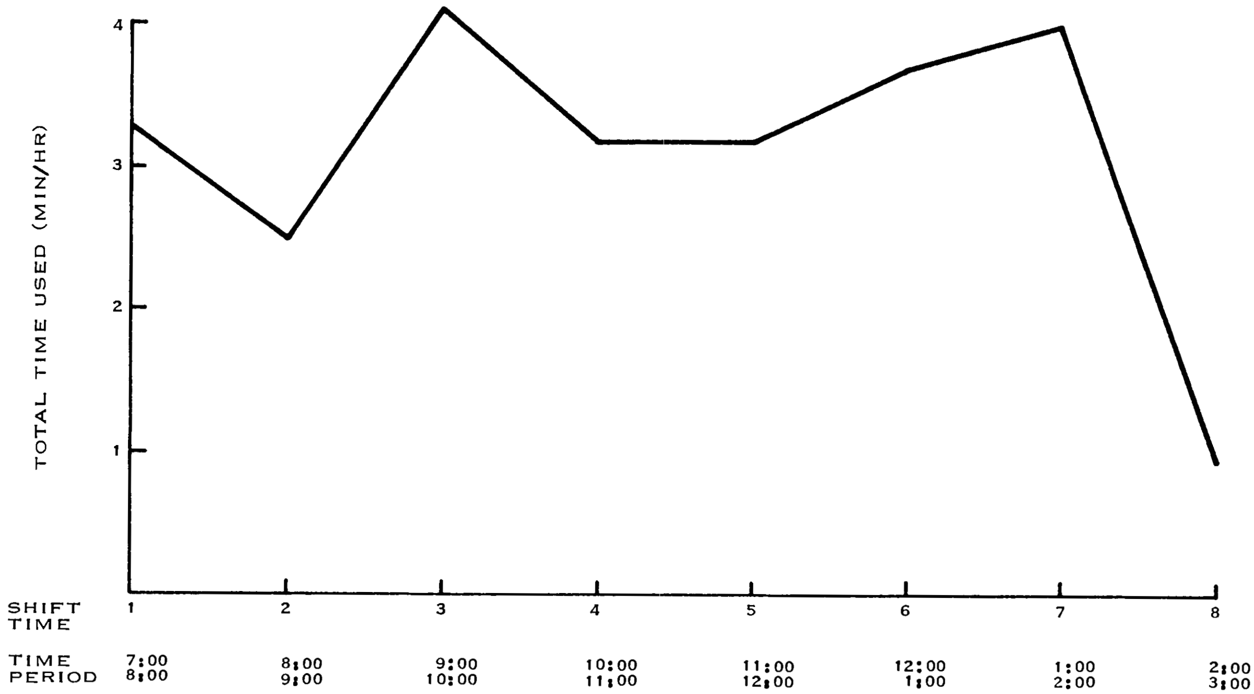


Figure 3-40. Total Time Trolley Phone Used (250 Volt).

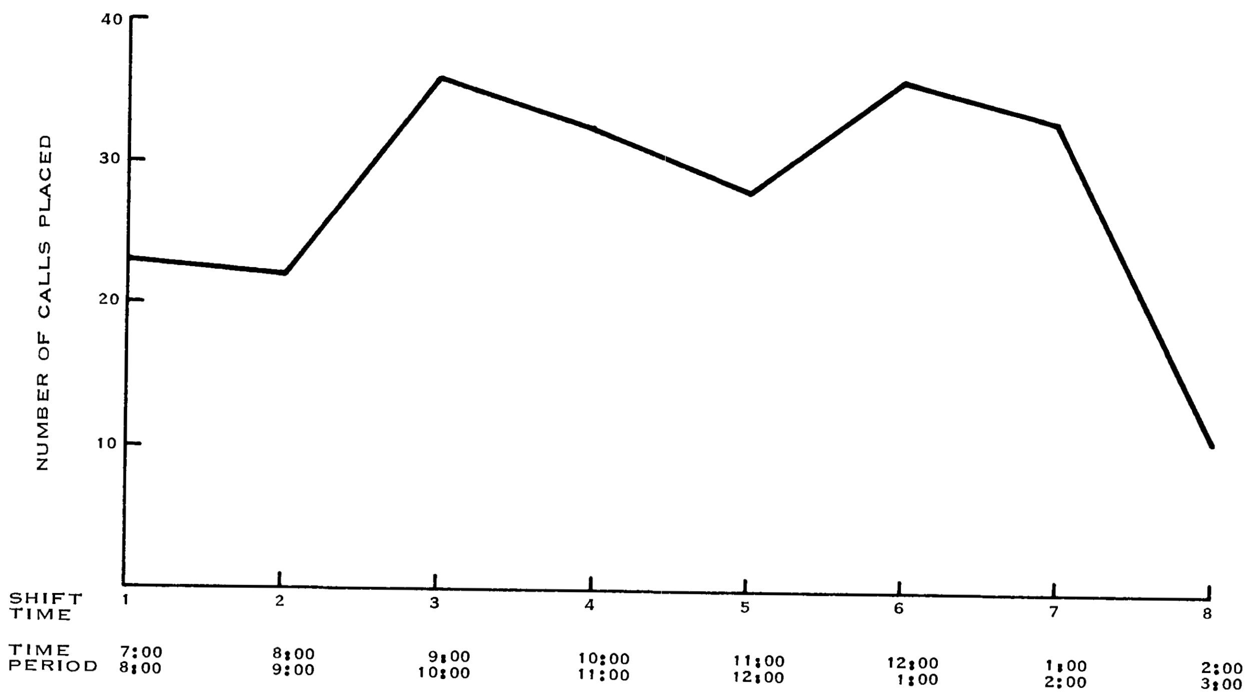


Figure 3-41. Number of Calls Placed on Trolley Phone (250 Volt).

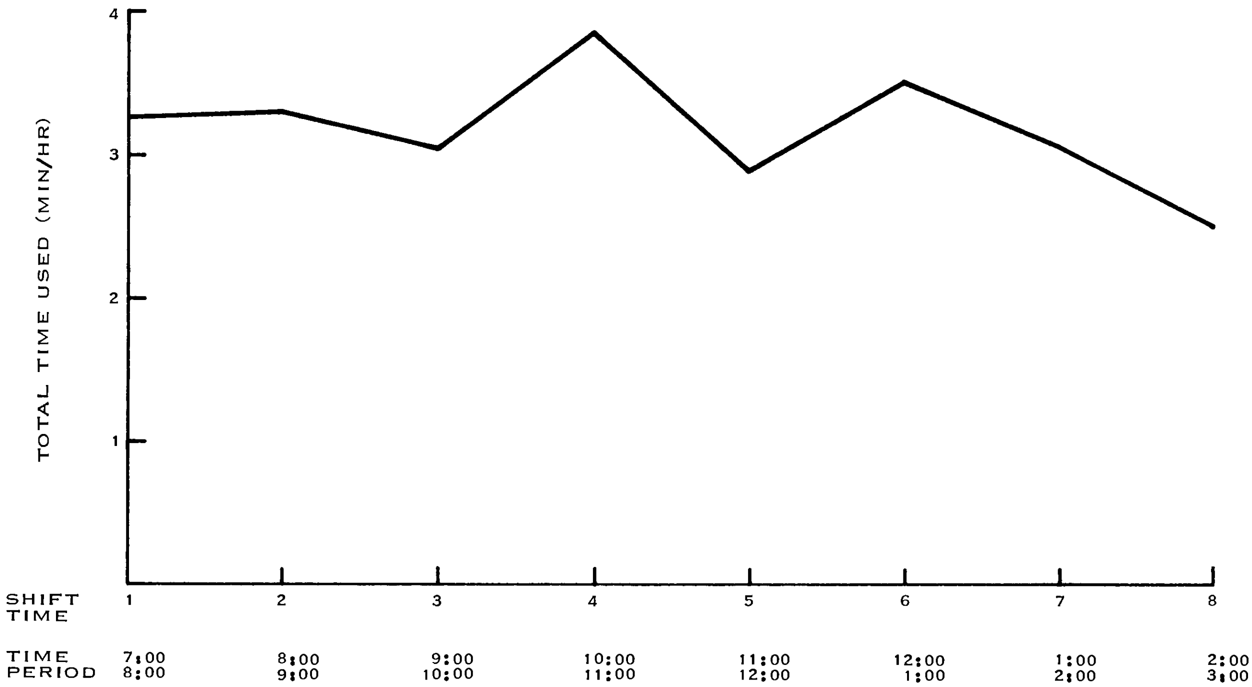


Figure 3-42. Total Time Trolley Phone Used (550 Volt).

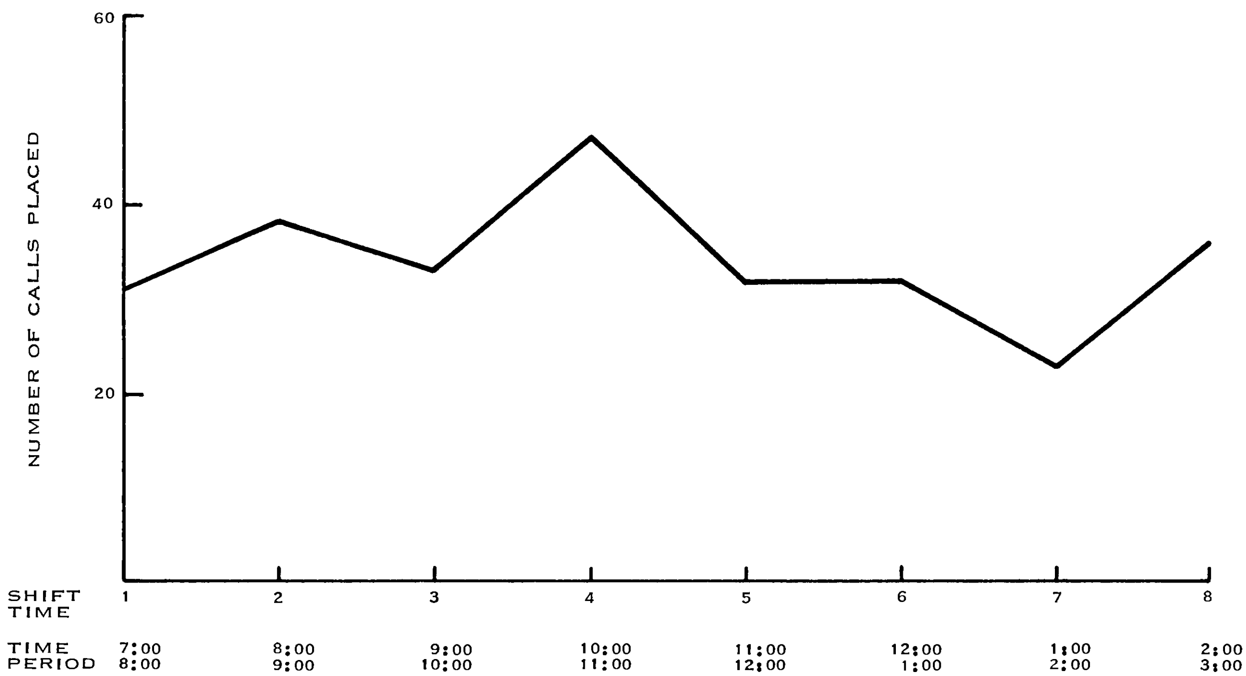


Figure 3-43. Number of Calls Placed On Trolley Phone (550 Volt).

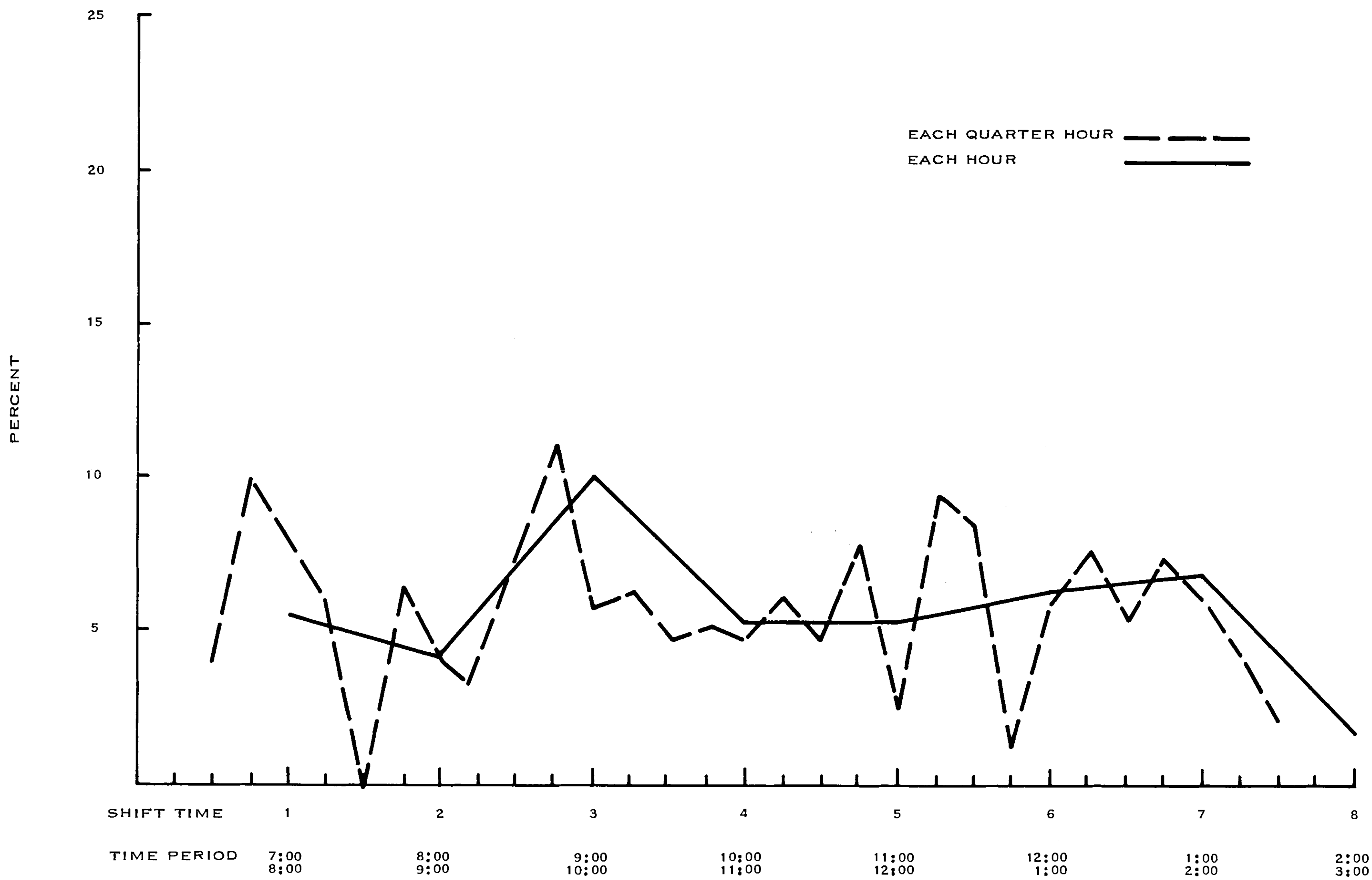


Figure 3-44. Percent of Time Trolley Phone Used (250 Volt).

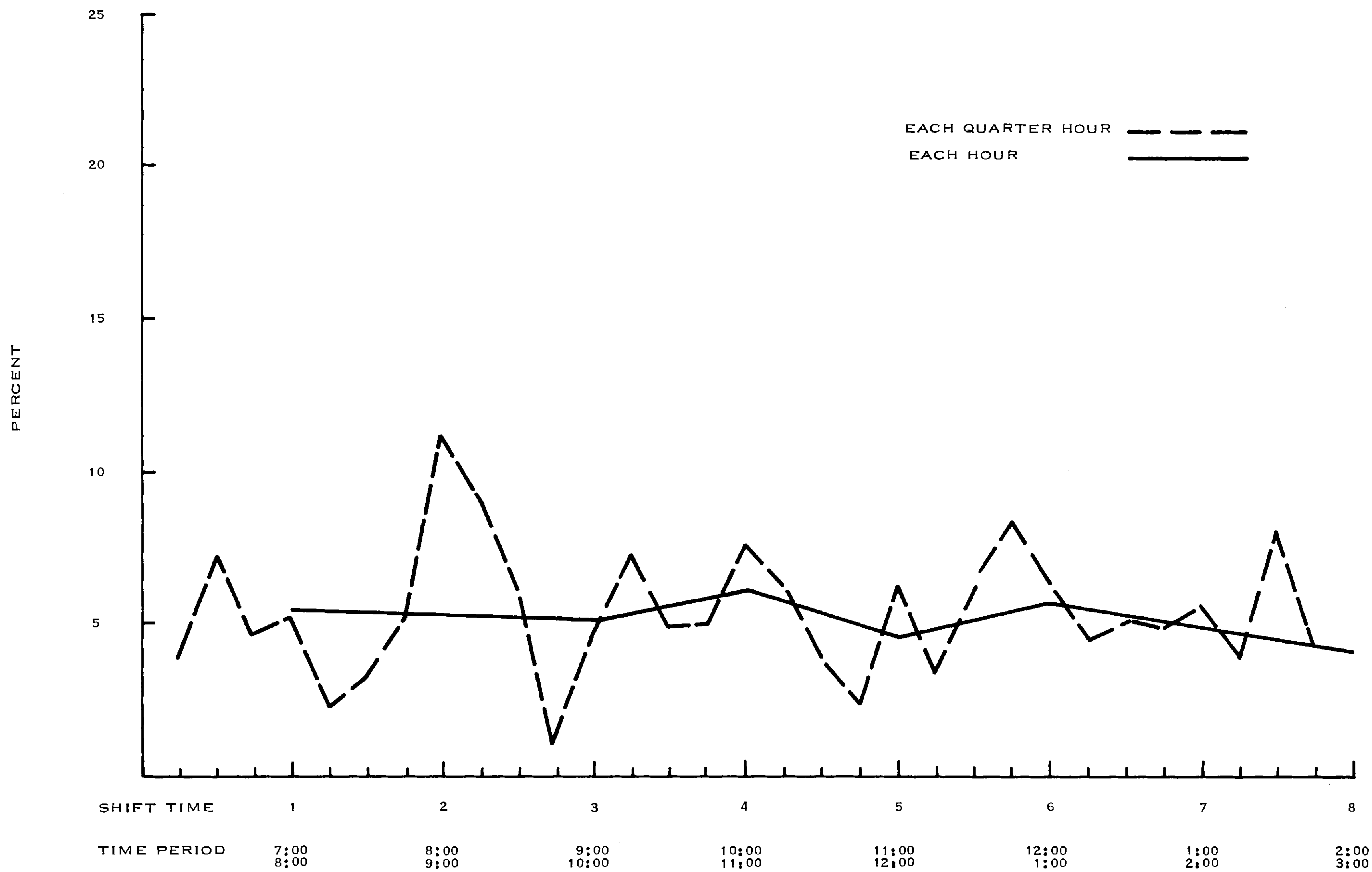


Figure 3-45. Percent of Time Trolley Phone Used (550 Volt).

There were no unanswered trolley calls. This should be expected because figure 3-46 indicates the largest number of calls are between the dispatcher and the motor operator. Therefore, the majority of calls are from the dispatcher or to the dispatcher.

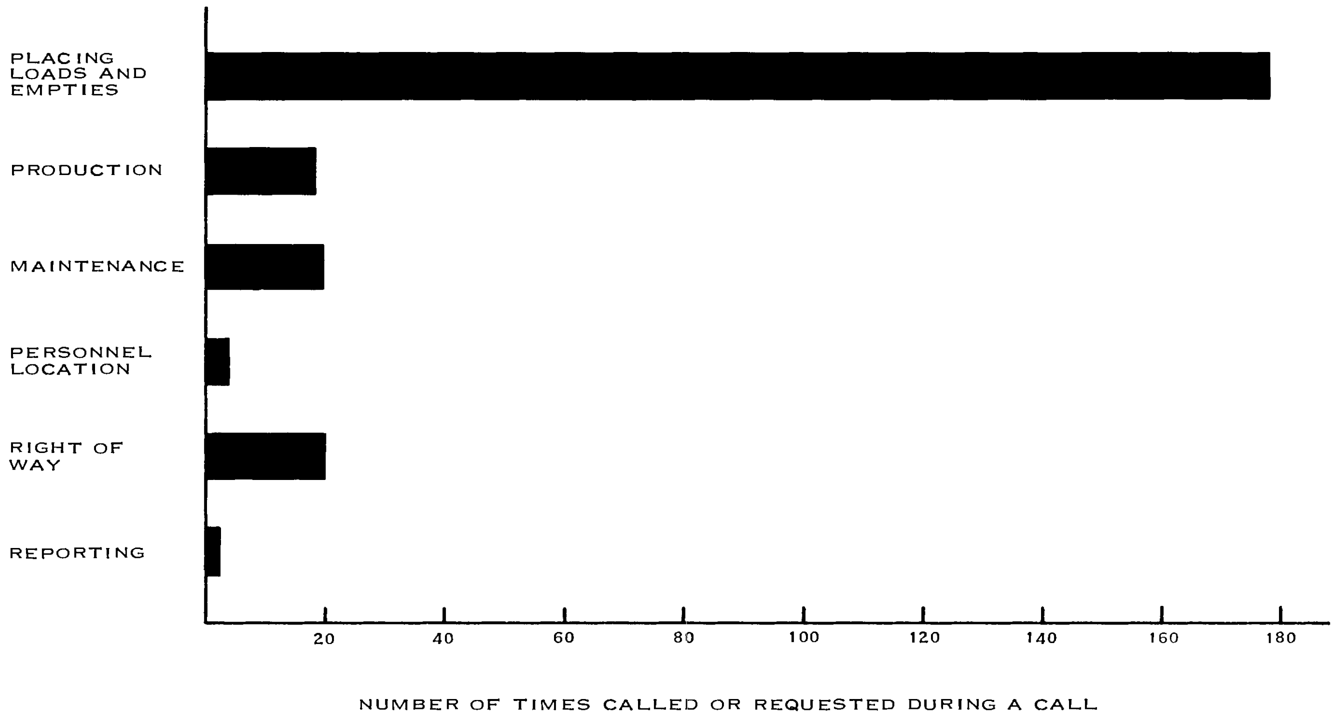


Figure 3-46. Trolley Phone Call Categories (250 Volt).

The trolley phone call categories are shown in figures 3-46 and 3-47. The graphs show that the trolley system is very much related to getting coal out and empties in. Most of the mining now takes place on the 250-volt system. This is the reason for an increase in production and maintenance calls on the 250-volt system. It turns out that the dispatchers are more than just traffic controllers. They take messages, locate personnel, hunt supplies, take reports, and so on. They are more like an information center.

The average traffic on the 250-volt system is a little greater than that on the 550-volt system, but they both have peak densities of about 11 percent. Because they are independent, each is a single channel system. A single channel with a traffic density of 0.11 Erlang has a busy signal probability of 10 percent.

However, the safety factors associated with having all communications traffic on one channel outweigh the desire for a lower traffic density.

3.4.4.8 Pager Phones

Pager phones are used on the longwalls and on the outside of the mine. The pages used on the longwalls are MSA pagers model 8U-85441. They are permissible phones. The pager phones are mounted on "J" hooks from the roof support jacks. Wires are hung from the roof

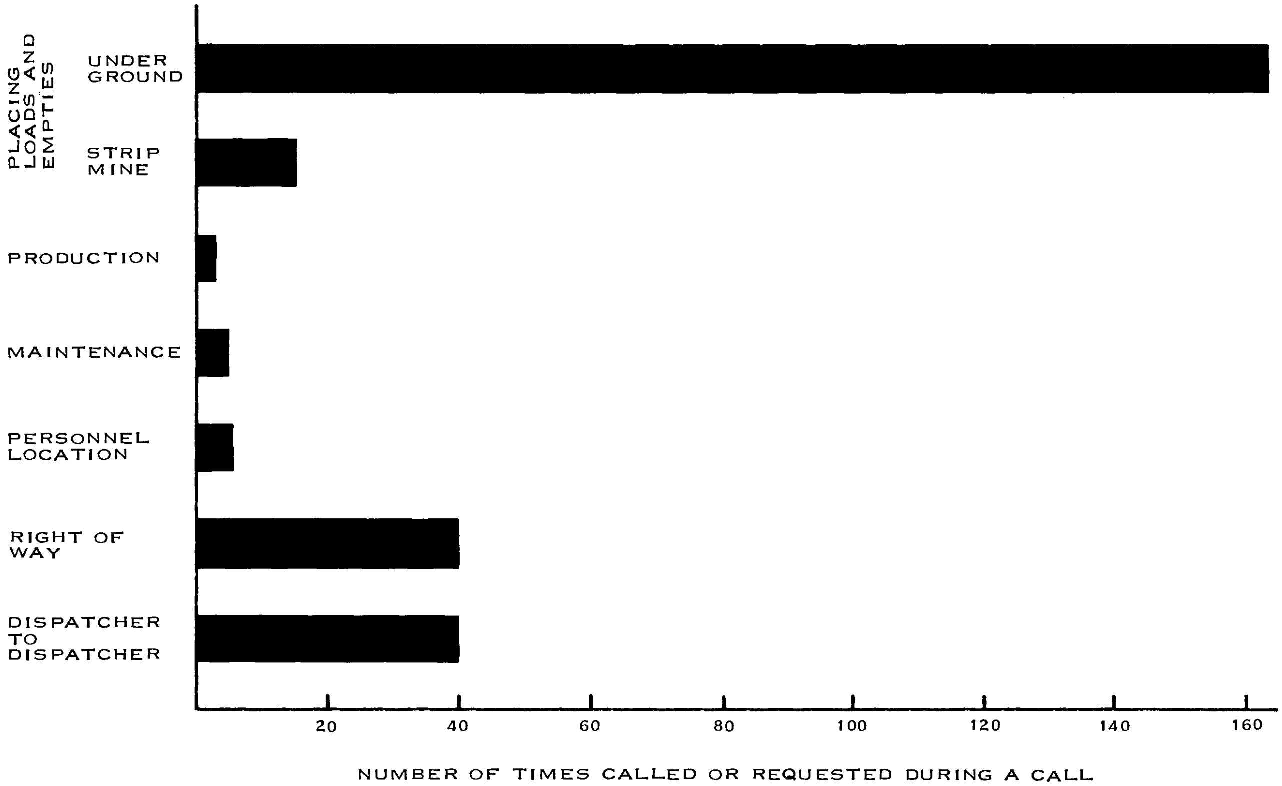


Figure 3-47. Trolley Phone Call Categories (550 Volt).

supports for the phones. Rocks falling between the jacks have caused the line to break, causing a potential safety hazard due to interrupted communication. It is possible to talk from the pager to the telephone system. The connection is made by the dumpman, where the telephone bells are located. The reason for this is there is no way of hearing a ring on the pager system. There are 10 pagers on the plow and 5 on the shear. The phones are 10 years old. The mine personnel felt that the phones were mistreated by man and environment, and that was the reason for failures.

3.4.4.9 Fan Monitors

The size of Keystone would indicate that the fans would be located at great distances from the maintenance shop. The fans are monitored by sending a signal over the high voltage lines, which is monitored at the outside shop. There are 5 fans. The 5 frequencies used are 39, 116, 47, 61, and 33 kHz. The monitors were built by Femco. They were installed 15 years ago and have caused the mine a lot of maintenance trouble.

3.4.5 Communication Requirements - User's Viewpoint

The phone system in Keystone No. 1 performed very well considering the age of the system. We were told that the changes in humidity caused a lot of problems. There was also a problem with having to talk long distances. This is not uncommon considering the size of the mine. Western Electric made the phones and they are not permissible. This limits how close to the working face they can be placed, and often requires that an individual walk as much as 500 feet.

Mine personnel felt that wireless communications of some type would be of help on a section. The foreman and the mechanic are the two most sought after individuals on the section. The mine personnel were of the opinion that communications to those two men would be desirable.

The maintenance foreman and master mechanic felt that portable 2-way communications would decrease the time needed to locate them. This equipment, they feel, should be small and easy to carry because of the number of things they must carry at the present time.

Portable communications are desired for the supervisor personnel (superintendent, mine foremen, and maintenance foremen). At the same time a private line was requested for the phone system for the supervisory personnel.

The safety department personnel suggested that remote monitoring of the mine conditions would help to increase safety for the entire mine. It was suggested that a private channel directly to the outside for emergency would decrease the time required to get help from the outside. This private channel would also ensure that the occurrence of an accident would not be heard by men on other sections.

There should be a secure channel open at all times, from any phone underground, to some central communications center above ground. It is not necessary that this line be connected to the commercial phone system. Since the mine management are the first to be notified in the case of an emergency, they in turn can call whatever is needed. In a mine this size the time saved by placing the call from underground to the commercial system for assistance, then notifying management, would be of little help.

Any type of system must be rugged enough to withstand the mine environment and still meet the requirements set up by law. Instruments placed on machines and track vehicle will be subjected to large amounts of vibration and should be designed as such. Movable parts, such as buttons and switches, should be sealed from dust. Due to the large amount of moisture and dust present, devices should be completely sealed. The phone should be capable of being mounted by existing materials (nails, bolts, etc) on existing materials (blocks, timbers, etc) and moved with little effort. Weight and size are important when considering hand-carried units. The unit should be battery powered with as long a lifetime as possible.

3.4.5.1 Communications Requirements - Based on Survey Analysis

Keystone No. 1 has some communication problems that are related only to the extreme age of the equipment used. Yet, problems due to the large size of the mine may be typical to other large mines.

Signal noise ratio causes problems when talking great distances (5 to 10 miles). A new system must start by improving SNR on long distance conversations, which may be typical of many large mines.

An analysis on the telephone traffic density was provided earlier. From this study an increase of three more channels (total six channels) would make the system comparable to an estimated mine standard of one in a hundred chances of getting a busy signal.

A dial system or an FDM system would be highly acceptable here. This would help to lessen the load of the dispatcher. There is often a need for conference calls, in which case these systems provide this capability. These systems also provide the channel privacy requested by mine management.

For safety reasons, the trolley phone system should remain one channel.

An improved 2-way, wireless radio for the track vehicles is needed also.

Using the above analysis and the suggestions of mine management, the following list of improvements was derived:

a. Reliable 2-way vehicle system
b. At least a total of six channels to meet minimum standards
c. There should be at least one secure channel
d. Portable 2-way wireless communications for certain key personnel
e. Battery operated communications equipment that will work during an emergency
f. A communications center located at dispatcher
g. The equipment must be capable of withstanding the mine environment

3.5 HARRIS MINE NO. 1, ON-SITE SURVEY OF JULY 18 AND 19, 1973

3.5.1 Mine Contacted

The Harris No. 1 mine of Eastern Associated Coal Corporation, Bald Knob, West Virginia.

3.5.2 Initial Mine Contact

T.A. Salvat - Division Manager
J.J. Higgins - Vice President--Production

3.5.3 Personnel Interviewed

T. E. Francis	-	General Mine Foreman
William R. Cook	-	Chief Electrician
Willis Boshell	-	Mine Foreman
Bob Rinehart	-	Comm. Installation and Maintenance
Herbert J. Elkins	-	Dispatcher, first shift
A. Patrinicola	-	Chief Engineer

3.5.4 General Mine Information

3.5.4.1 Mine Description

The Harris No. 1 mine has a drift entry in the 5.5-foot, soft coal Eagle seam. The working sections are presently 3.5 miles in from the entrance, with the expectation of eventually working at twice this distance. Mining at the present rate gives the mine a life of from 30 to 40 years.

The two operating longwalls are about 500 feet wide and will travel a range of 3,500 feet.

A glance at the mine map, figure 3-48, will show that 5 longwalls will have been completed west of the north-south mains (the upper portion of the map). The area south of the mains is not presently being worked. New to mining in this area is the "stall machine" used at the tail end of the plow longwall to give better roof control. The "stall machine" is a limited travel shear that leaves a cleaner end on the longwall than the plow. About one third of the mining

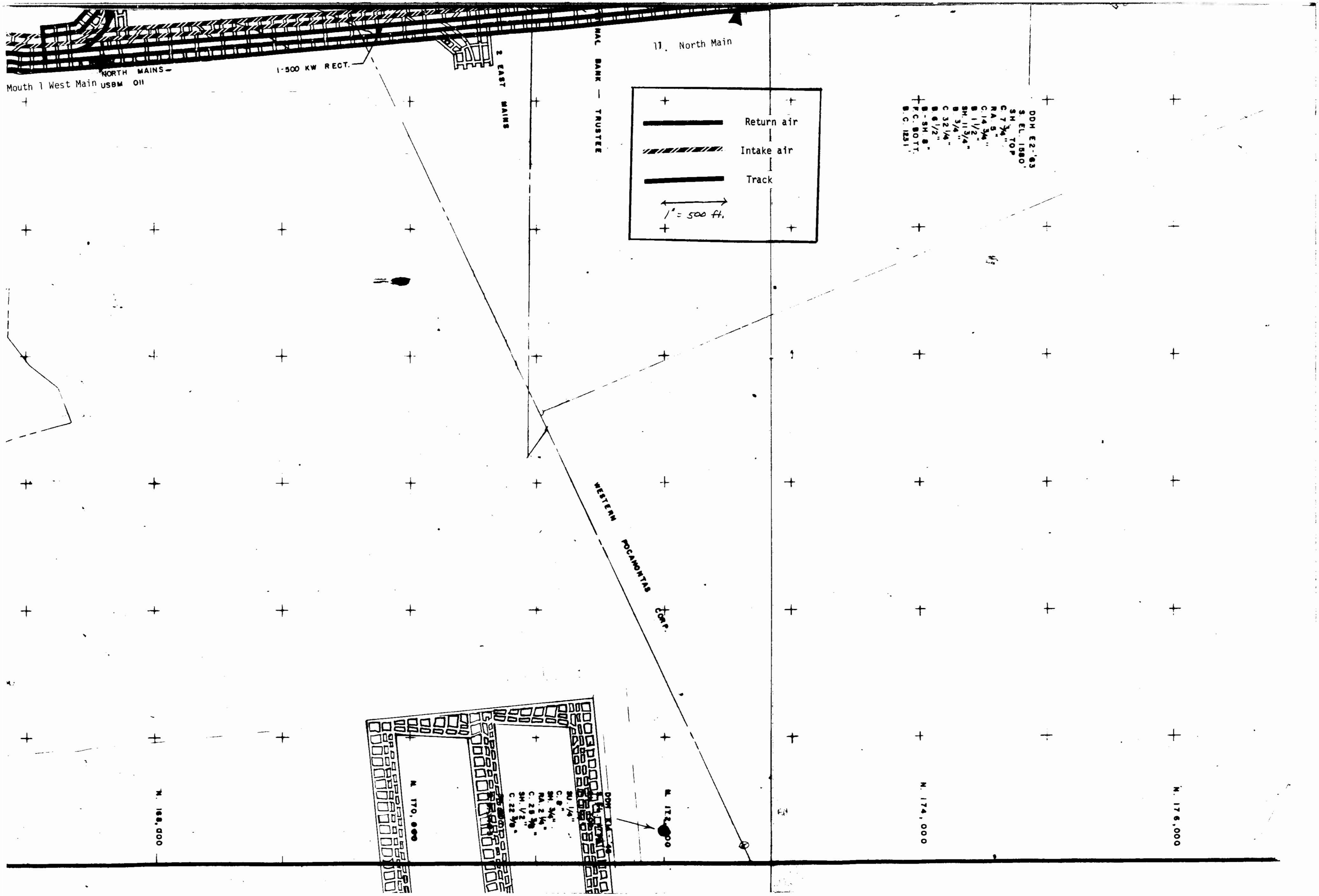
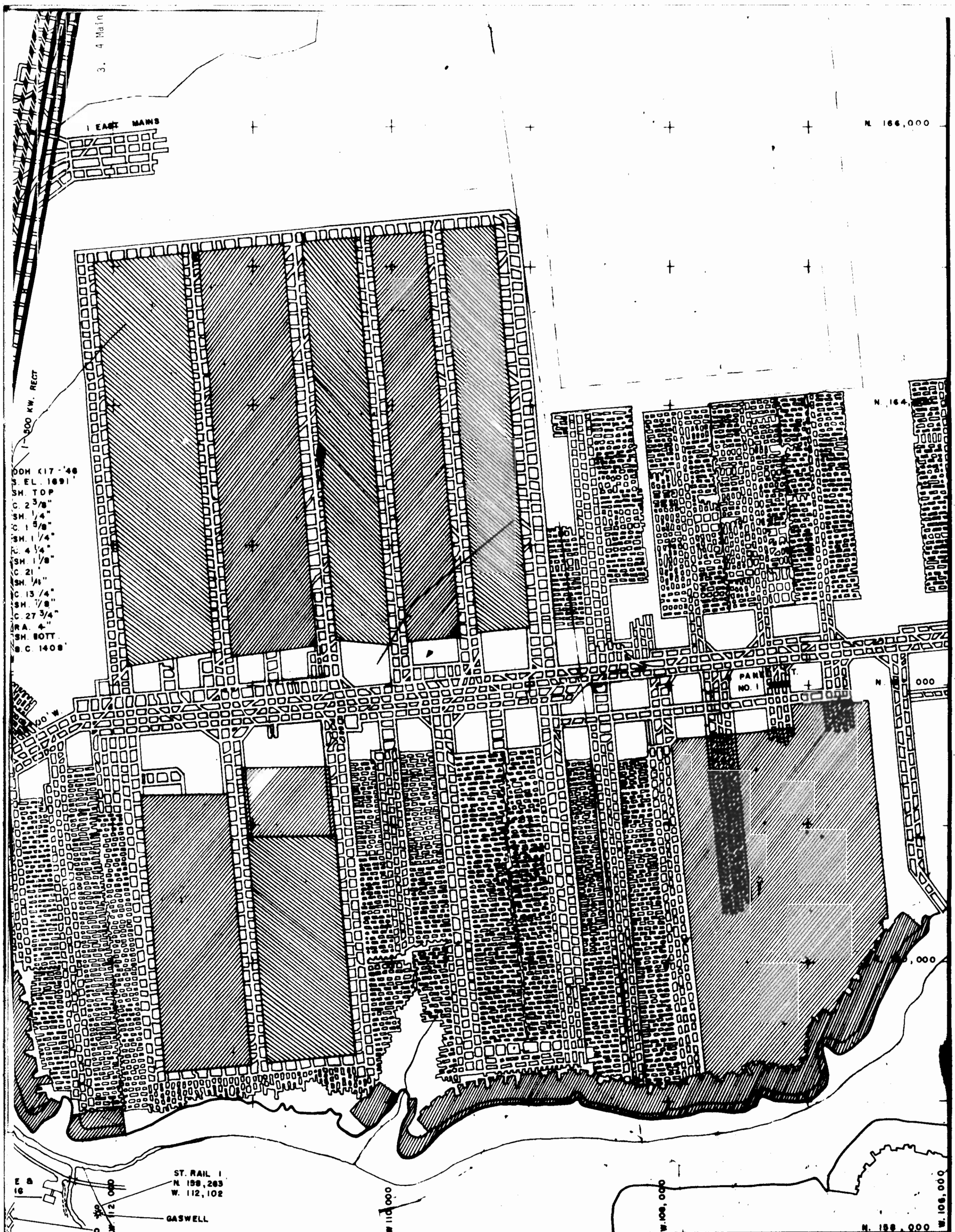
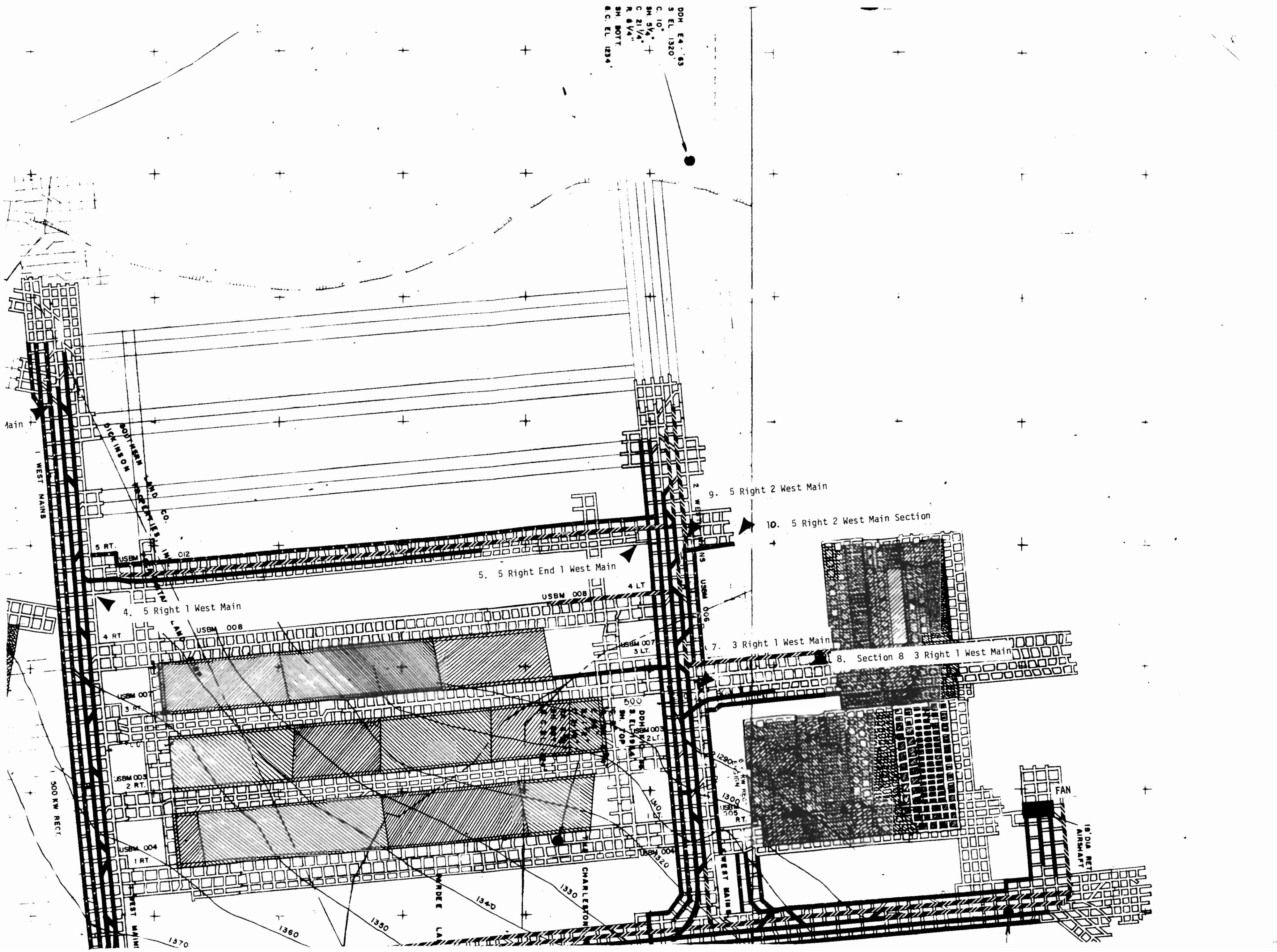


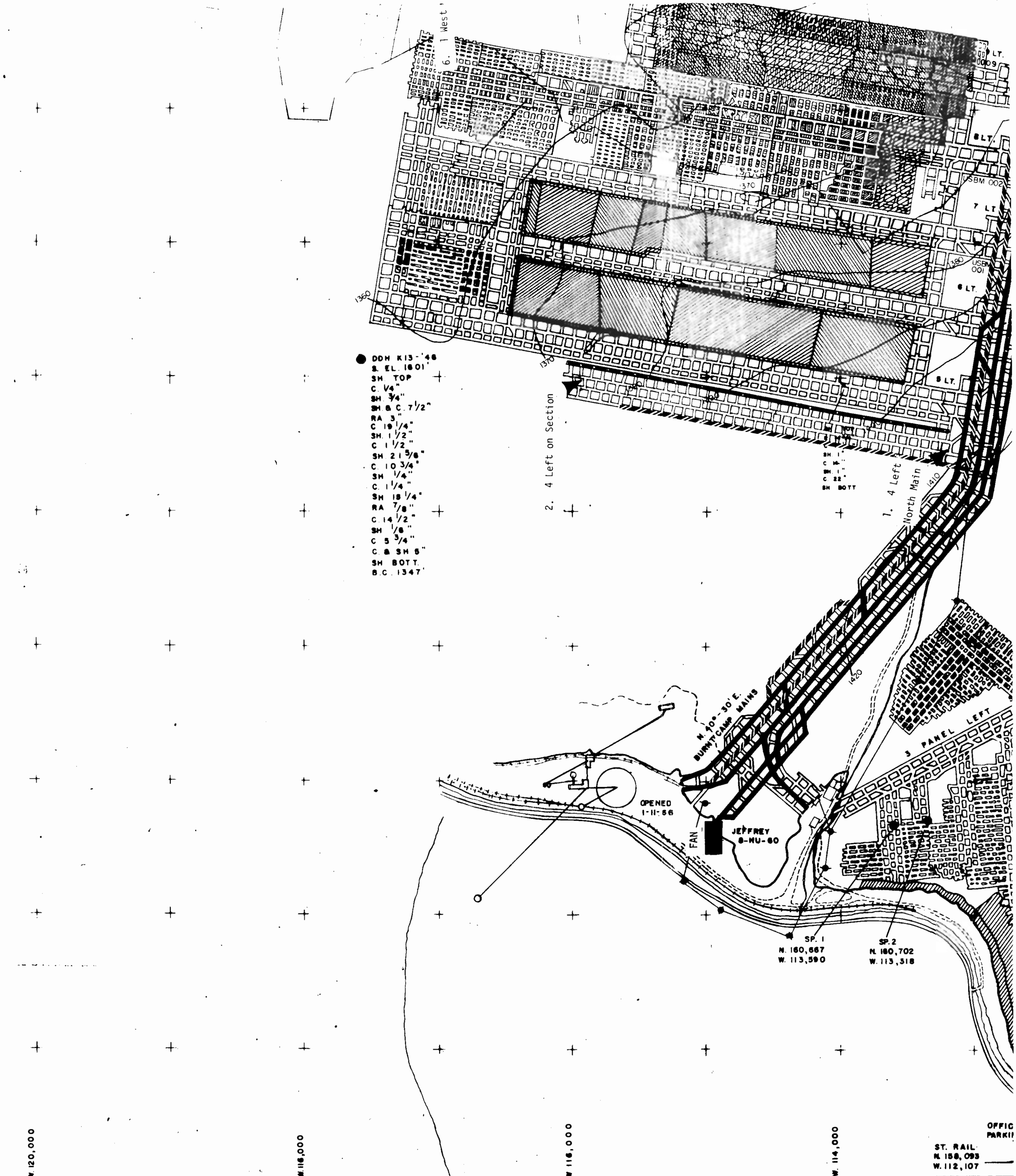
Figure 3-48. Harris Mine No. 1.



NAME	DATE		HARRIS MINE 1	SCALE 1" = 500'	B. M. NO.
E. B.	2-18-66	EASTERN ASSOCIATED COAL CORP. PITTSBURGH, PA.	PROJECTION IN EAGLE SEAM	L-6-122 SHEET 1 OF 2	



DDH E4-'63
S. EL. 1320'
C. 10"
SH. 5 1/4"
C. 21 1/4"
R. 6 1/4"
SH. BOTT.
B.C. EL. 1234'
9. 5 Right 2 West Main
10. 5 Right 2 West Main Section
5. 5 Right End 1 West Main
4. 5 Right 1 West Main
7. 3 Right 1 West Main
8. Section 8 3 Right 1 West Main
2 WEST MAINS
USBM 006
USBM 008
USBM 007
USBM 012
USBM 003
USBM 004
USBM 005
4 LT
3 LT.
2 LT.
5 RT.
4 RT
3 RT.
2 RT.
1 RT
SOUTHERN LAND CO.
DICKINSON PROPERTIES, INC.
1 WEST MAINS
WEST MAINS
500 KW RECT.
CHARLESTON
PARDEE LA
1290
1300
1320
1330
1340
1350
1360
1370
FAN
18' DIA. RET. AIRSHAFT



POSTED TO 7-1-73

500' 1000' 1500' 2000' 2500'

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at Harris is by longwall, with about the same proportion for conventional mining, and the last third by continuous mining. The number of working sections for each type of mining is as follows:

	SHIFT	
	1st	2nd
Conventional	2	2
Continuous	2	2
Longwall	1	1

Only a small amount of mining is done during the maintenance or third shift so it was not listed in the table.

The Harris mine has no problem with water, and they have only a trace of methane present. Methane monitors used at the mine are made by MSA and Bacharach. The Bacharach units on machines have no backup battery power so they become inoperative with loss of electrical power.

The two return airshafts--that also serve as escapeways--are located at opposite ends of the mine, the far left and far right on the mine map. The two fans at these shafts exhaust air at the rate of 375,000 cu ft per minute. The fan shaft at James Creek is 300 feet deep.

The Harris mine is small enough that there is no underground maintenance shop. Hence, repairs that cannot be made at the site of the failure must be made outside.

Coal is moved from the face by shuttlecar except on the longwalls where it goes directly to belt. Local belt haulage is used between the shuttlecars and tracked cars on the main line. The longest belt run is 4,500 ft.

Harris No. 1 does not have a rescue team. Should one be needed it would be furnished by one of the nearby mines.

3.5.4.2 Crew Composition

The conventional mining crew consists of the following personnel:

Cutter operator (1)
Roof bolters (pin men) (2)
Shuttlecar operators (2)
Shot fireman (1)
Loader operator (1)
Belt operator (boom man) (1)
General--curtain man, clean-up man, rock dust man (1)
Foreman (1)
Mechanic (1)

Total 11

The continuous mining crew consists of the following personnel:

Roof bolters (2)
Shuttlecar operators (2)
Timbermen (2)

Miner operator (1)
Miner operator helpers (2)
Belt operator (1)
Foreman (1)
Mechanic (1)

Total 12

The longwall mining crew consists of the following personnel:

Boom man (1)
Belt operator (1)
Head operator (1)
Tail operator (1)
Jack setters (5)
Stall operators (2)
Foremen (2)
Mechanic (1)

Total 14

During the first shift there are no idle sections so there is no need for maintenance crews when each section crew has its own mechanic. But during this shift there are extra mechanics who work along the main line, and help section mechanics when needed.

During the third shift, when few sections are working, there are three maintenance crews whose specific job is to work on equipment at the idle sections.

3.5.4.3 Mine Equipment and Power

Power is fed to the mainline trolley wire at 250 volts dc by four rectifiers. There are "dead-blocks" between the four sections of trolley wire so that each rectifier supplies power to only one short length of wire. All face mining equipment is ac operated so there is no need to have nip points from the trolley line.

Rather than utilizing power bore-holes, 7200-volt ac power is brought in along the mainline, up to transformers at the working sections. There the voltage is stepped down to 440 volts. Thus as the sections advance, the transformers must be moved to follow.

Their only power outages have been due to storms or hunters shooting transformers on the power company's outside distribution system. Outside there are two high-lines feeding the mine's single substation.

Should there be a power interruption within the mine, the substation attendant will check by telephone with the sections before reenergizing the distribution system.

3.5.5 Present Communications

3.5.5.1 Telephone System

FEMCO loudspeaker/telephones, AM2570B, are used in a network of 11 phones along the track throughout the mine, plus a phone in the dispatcher's outside office and one at the communication repair station in the shop. The underground phones are shown on the mine map, figure 3-48, numbered left to right, one through eleven.

The bar graph, figure 3-49, Telephone Call Categories, shows the number of times specified subjects were discussed during the first shift when recording was made of the pager-telephone system. During this 8-hour shift there were 160 discussions concerning the location and movement of empty and loaded coal cars. For the next most common topic, there were near 80 discussions concerned with the production of mined coal. Collectively the other subjects add up to about 80, so no one of them is a significant user of channel capacity.

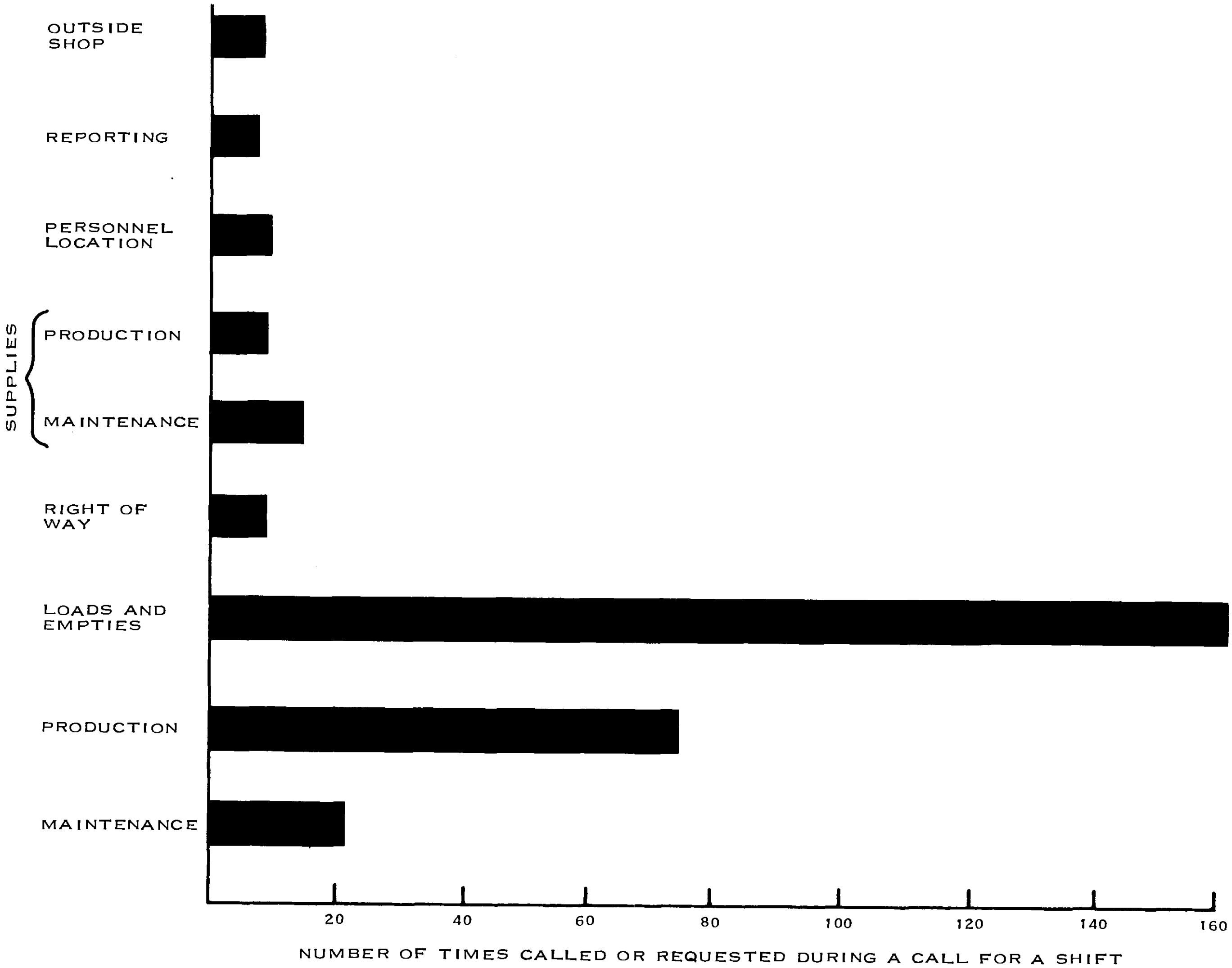


Figure 3-49. Telephone Call Categories.

The cumulative time the telephone system was used, during each shift hour, is shown by the graph, figure 3-50. The shape of the curve shows the system is used most near the beginning and during the last two hours of the first shift. Figure 3-51 presents the number of phone calls placed during each hour of the same shift. Note that the near congruency of the two curves suggests that all calls take about the same length of time. During the second hour of the shift this averages to about 20 seconds per call.

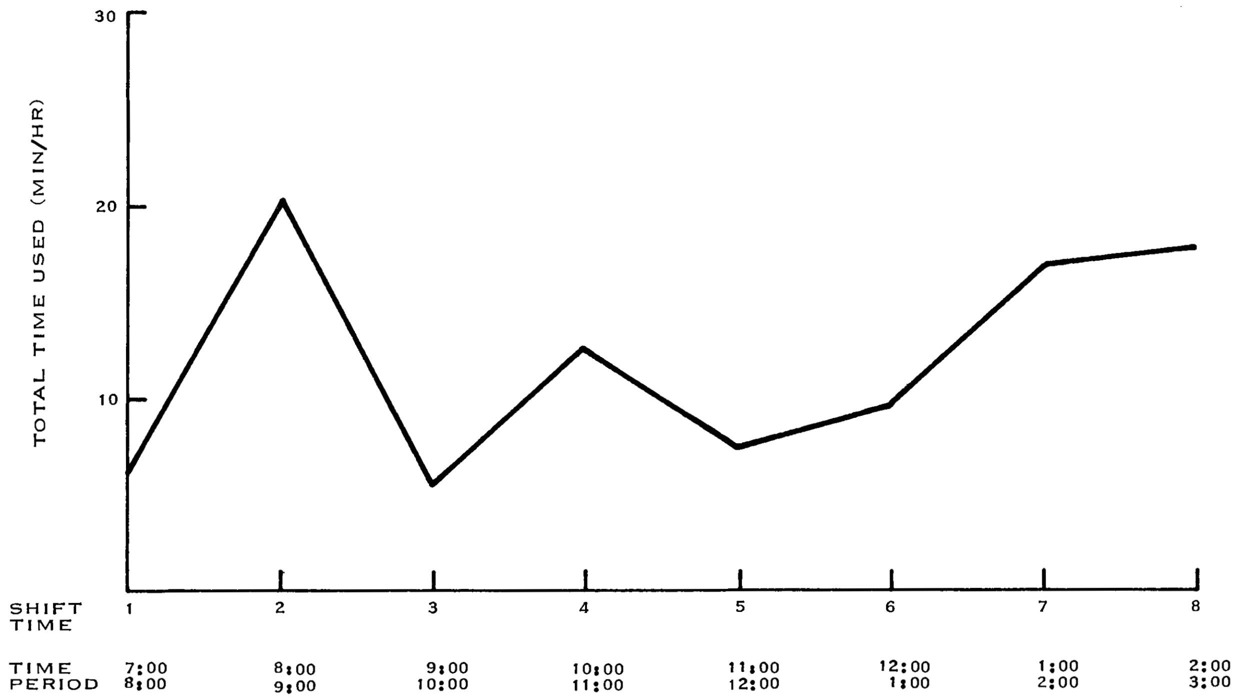


Figure 3-50. Total Time Phone Used.

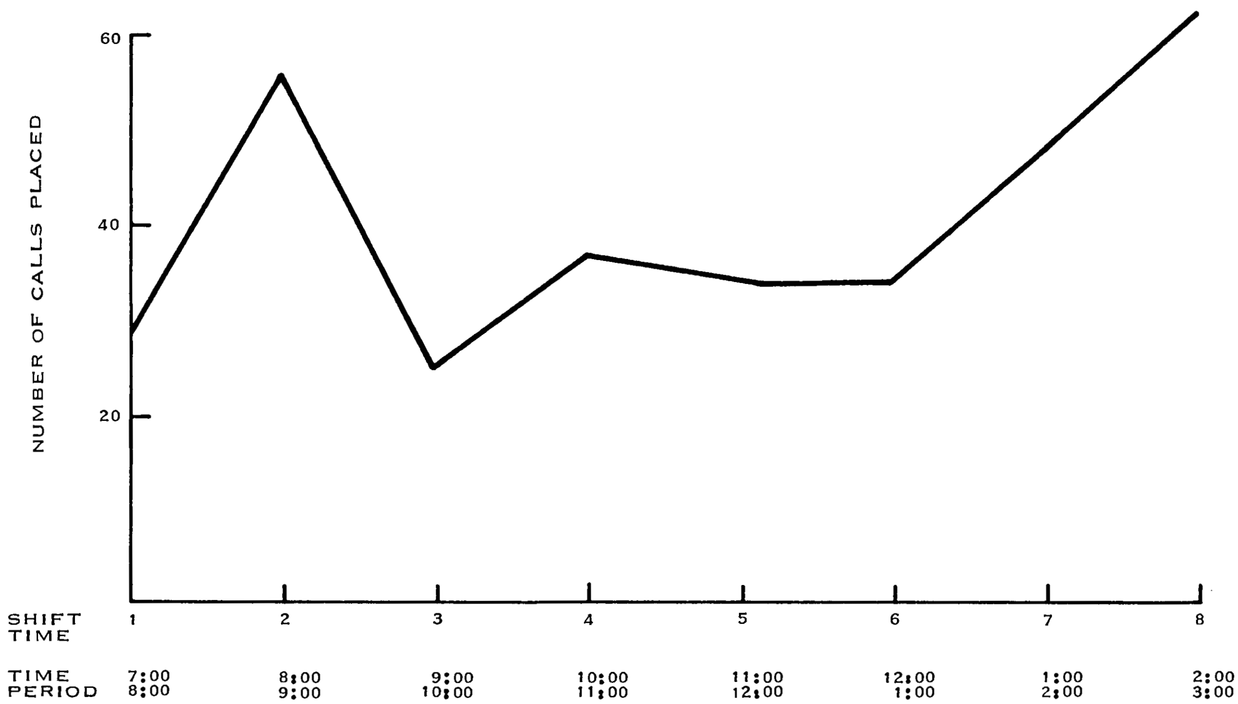


Figure 3-51. Number of Calls Placed.

Figure 3-52, the last graph for the telephone system shows the percentage of time the phones are used during each quarter hour and each hour of the first shift. Early into the shift, and just before the end, the phones are used as much as 50 percent of quarter-hour intervals.

The Harris mine, with its single channel telephone system, has a traffic density of 0.48 Erlang during the busiest hour of the first shift. This places the probability of a potential caller finding a busy line at one chance in three--again considerably higher than the one chance in a thousand the telephone industry defines as being the minimum acceptable.

The loudspeaker/telephones have an average age of about four years. Rock dust does seep in through their cases but the users and maintenance men report there are few failures and these fall in no consistent pattern. The people interviewed could give no suggestions on how the phone system--the one following the track--could be improved. There are several reasons that could be contributing to their satisfaction:

a. The phones are relatively new
b. The phone network is not large
c. The time and talent spent on maintaining the system is great
d. The fact FEMCO gave them much help in setting up their systems
e. The characteristics of the phone lines are good

The phone lines run parallel to the track, and are conventional number 14 wire, parallel pair cable such as used in house wiring. An upper and lower flange on the back of the telephone provides a means of nailing, bolting, or wiring the units to timber or other structures in the mine. The telephone case seems adequate and the lack of use of modular construction seems appropriate considering the simplicity of the unit.

Evidently the lack of interference rejecting and balance maintaining properties of twisted-pair wires are more than compensated for. The unusually large size wire, number 14; the thick weatherproof insulation; and five items listed above are probably also compensating factors. The fact that the phone lines are shared by the trolley carrier communications system does not seem to detract from the phone system performance as would be expected.

The telephone network is such that anyone on a working section is never more than 350 feet from a phone. They feel this is adequate and that having a phone any closer would not really be of more value. Other phone locations are the boom and tailpiece of every belt, plus four in the escapeway. No allowance has been made for emergency usage in the sense that, should a telephone line be broken, there is no loop-back to carry the signal.

Maintenance of all communications systems is performed by one man on the day shift and a second man on the third shift. These two men have other lesser duties but seem to devote sufficient time to the communications systems.

3.5.5.2 Trolley Phone System

The trolley-phone is a 72-kilohertz carrier system that uses the trolley power line as the main signal path. Even though this is a fairly small mine, they did experience dead zones of unacceptably low signal strength when the trolley line was used as their only signal path. The problem was solved by coupling the 72-kilohertz signal back and forth between the trolley line and the phone lines which run parallel to the track system. This is accomplished with five or six coupling boxes distributed throughout the mine, between the parallel running trolley lines and phones lines.

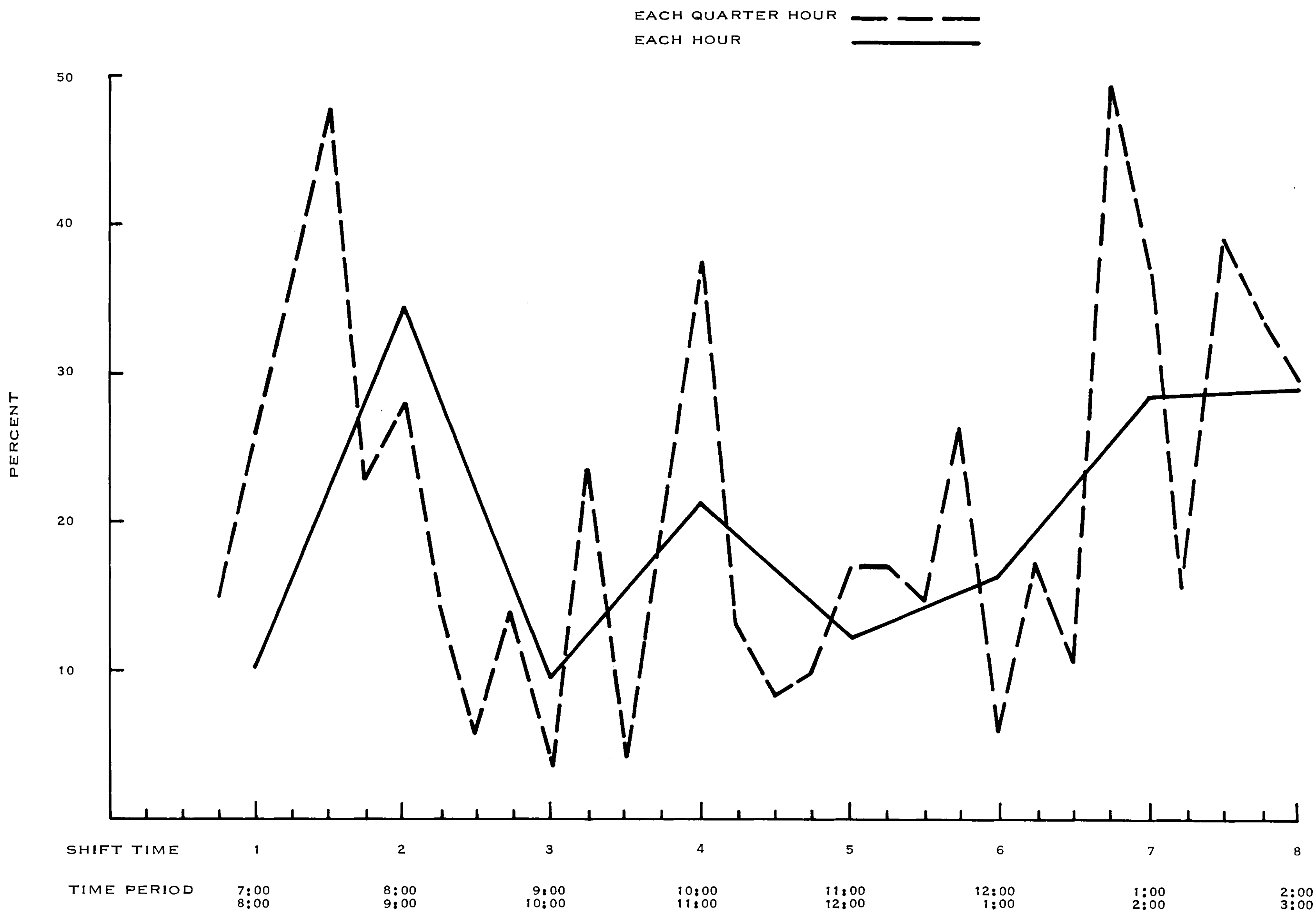


Figure 3-52. Percent of Time Phone Used.

The trolley phone system is used for communications between track vehicles and between track vehicles and the dispatcher. The dispatcher has an outside dial phone as well as a speaker phone so he serves as a message relay center and an information center, as well as a dispatcher. The communications maintenance area of the shop also has a trolley phone to aid the maintenance people in servicing the trolley phone system. The trolley phones do not have storage battery backup. If there is a failure of trolley power, trolley phone communications is lost.

The dispatcher in this mine, like those in most of the mines we visited that had dispatchers, is nonunion and has a foreman's position. The union title of "dispatcher" describes the job of dispatching only and does not allow for the dispatcher performing the other duties mine operators have found necessary. Perhaps it would be better if the position were called the "communications center operator."

Harris has had a dispatcher for only the last two years. Before that, motor operators controlled the track for themselves. At that time Harris tried tying the telephone system in with the trolley phone system, but found it only added confusion to have those not near the main line hear all the discussions of the motormen.

Figure 3-53 presents the various topics and how many times they were discussed during an 8-hour first shift of the trolley phone system. Again, as in the case of the telephone system, the most often discussed topic had to do with the location and disposition of empty and loaded coal cars. And again this category was discussed twice as often (240) as the next most discussed category, "Right-of-Way" (100).

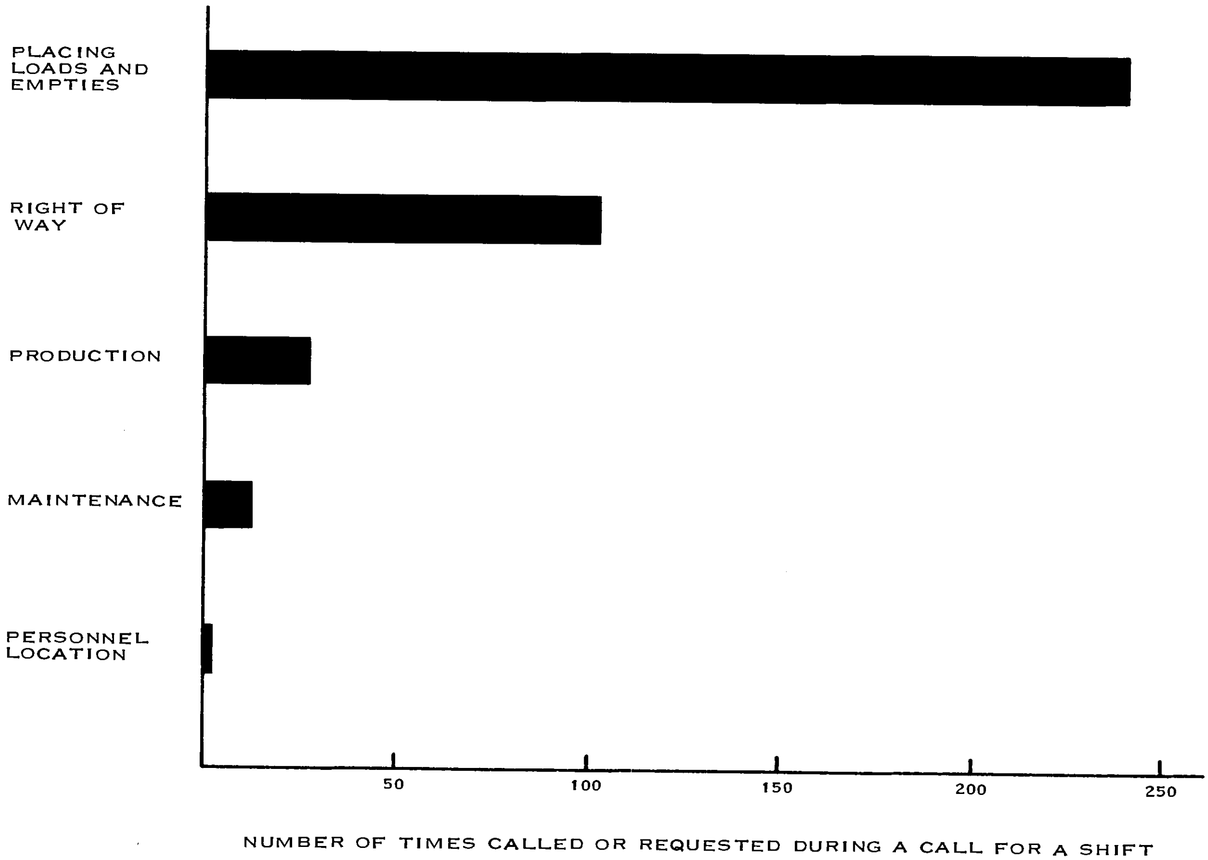


Figure 3-53. Trolley Phone Categories.

Figures 3-54 and 3-55 present the total time and number of calls placed during each of the hours of the first shift. Note that the same pattern exists as for the telephone system; with high usage during the second hour, low usage during the third, and a steady increase to the end of the shift. Note also that the average call is only about half as long as the average telephone call; 13 seconds compared to 20 seconds.

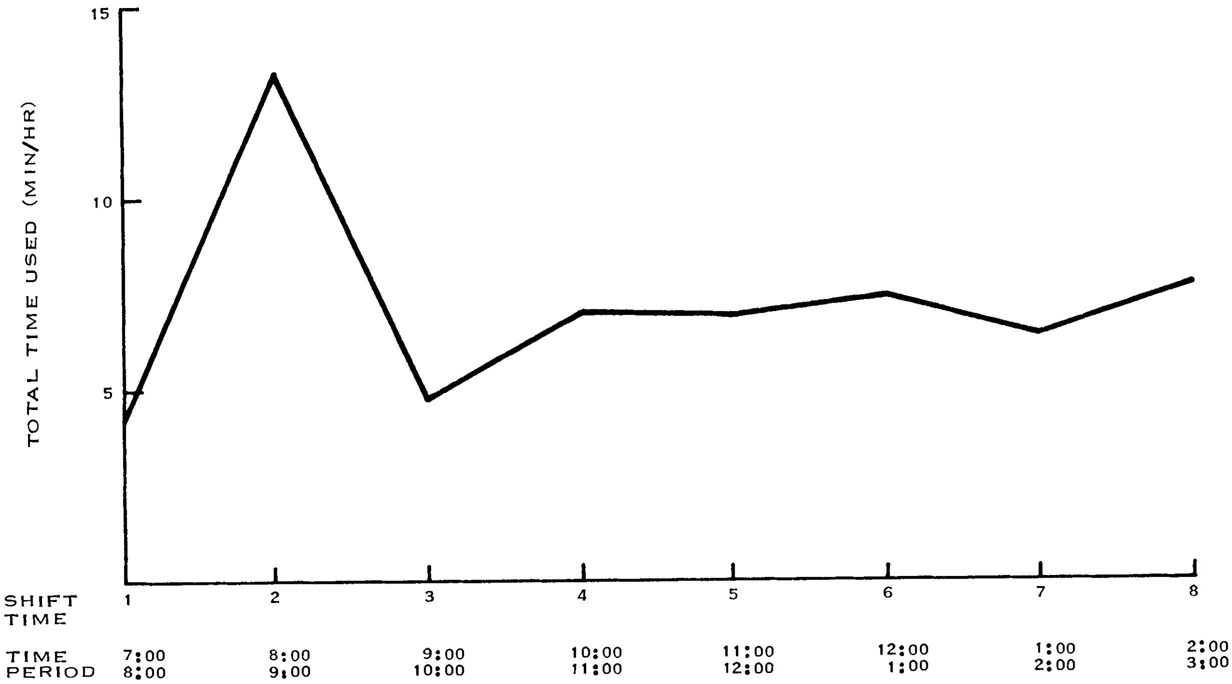


Figure 3-54. Total Time Trolley Phone Used.

The last figure for the trolley phone system is figure 3-56, showing the percentage of time the trolley phone is used during quarter hour and hour periods of the 8-hour shift. The trolley phone is used the most at the first half hour after the shift start when it is used 35 percent of the time.

Harris uses FEMCO 641904/603 72-kHz, 300-volt trolley phones. They have 16 trolley phones on vehicles and one spare in the shop.

The main path for trolley signal transmission is via the dc trolley wire. To get the signal around the dead-blocks, 2 microfarad capacitors are used. To keep rectifier "hash" out of the 72-kHz system, L-filters are used at each rectifier. The filter consists of a 50-microfarad capacitor across a rectifier's output, with a 10-turn, heavy cable coil, the coil having an approximate diameter of two feet. Their man from FEMCO tuned the filter to reject 72-kHz interference.

The couplers used to transfer 72-kHz trolley phone signal back and forth between the trolley wire and the adjacent telephone lines were made by FEMCO. The device is basically a 72-kHz tuned transformer having blocking capacitors to keep the trolley dc power out of the telephone system.

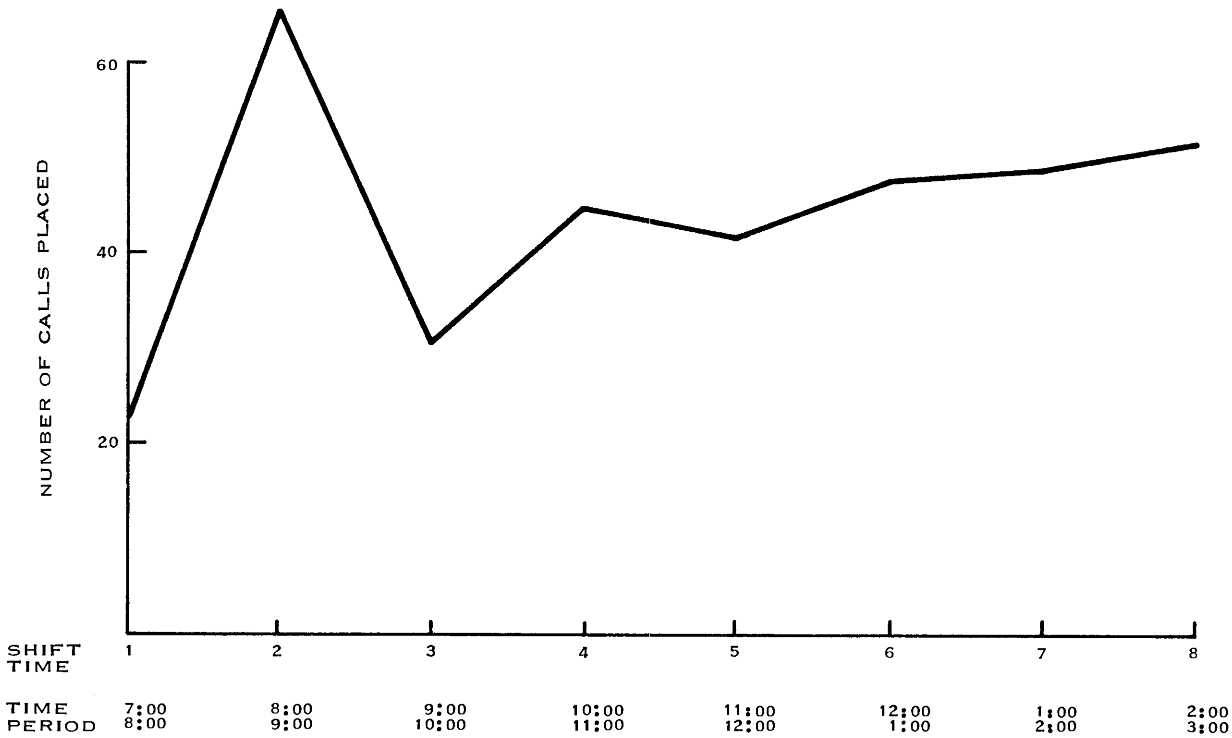


Figure 3-55. Number of Calls Placed on Trolley Phones.

The only trouble they have had with this coupling scheme was the one time rainwater dripped into one of the nonweatherproof couplers located close to the mine entrance. This not only disabled their trolley phone, but it also disabled their telephone system--a point to remember when tightly integrating previously independent communications system.

The only complaint the communications equipment maintenance man had concerning trolley phones was that the microphone cable broke often due to rough usage on vehicle units.

The maximum traffic density on the trolley-phone channel is about two-thirds that on the telephone system. This density of 0.38 Erlang gives a busy-signal probability of about one chance in four.

In these reports we are merely noting that busy-signal probability is much greater than the telephone industry finds acceptable. We are making no attempt to solve the obviously very complex problem of determining the degree to which this affects either productivity or safety.

3.5.5.3 Longwall Communications

The longwall miner has its own communications system consisting of seven loudspeaking telephones, one at each end, and the other five equally spaced along the 500-foot longwall. These loudspeaking telephones have no handset and thus operate in the pager mode only with the loudspeaker serving as a microphone on pressing the "push-to-talk" button. The telephone lines lay in the troughs that carry the hydraulic lines. At one time the wires were hung under the top-plate of the jacks, but slate falling between the jacks kept breaking the wires.

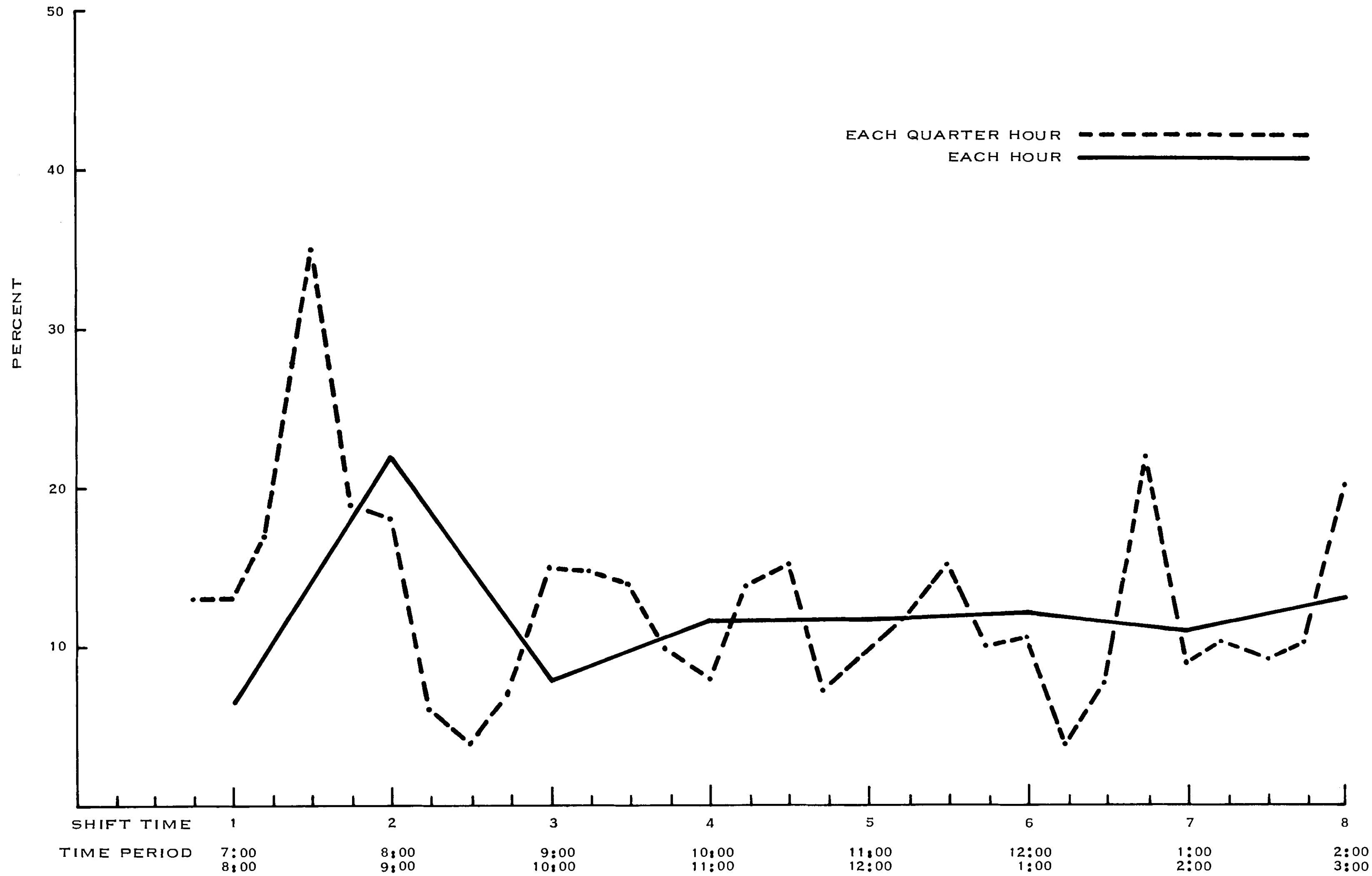


Figure 3-56. Percent of Time Trolley Phone Used.

There are also signal lights positioned along the longwall miner so the operators can coordinate their efforts if the phone system fails.

Each of the phones was operated on a trip through the jacks of an operating longwall miner. All phones worked, the quality of speech reproduction was good, and the loudspeaker volume was adequate in spite of the high ambient noise of the miner. A hand-carried tape recorder recorded the testing of the phones and the ambient noise.

The only complaint the personnel had was that the push-to-talk button failed often. This button is mounted on the recessed front face of the unit. The phones at the ends of the longwall are mounted horizontally so the recessed panel acts as a catch basin for the watered down coal dust. Evidently the directional properties of the speaker are such that this mounting is necessary.

During the trip both ways through the longwall, the miner was working well, with all personnel knowing their job perfectly, so there was no need to use the telephone system. Little can be learned from this except that the phone system is used mostly during abnormal situations. But the system is used often enough that several people complained about the high replacement rate for the push-to-talk switches.

The longwall phones are permissible units built by FEMCO, model number 691301/203, 204. The phones presently in service are less than a year old.

3.5.5.4 Emergency Communications

It was mentioned before that Harris did not have their own rescue team so nothing can be reported on this form of communications. The emergency use of signal lights on the longwall and telephones in the escapeway have also been previously described. The fan alarm and belt fire alarm systems could also be considered emergency communications.

At the time the mine was visited, the dispatcher had an alarm that would ring if the nearest fan stopped. The local phone company was in the process of running the five miles of wire needed to bring fan stoppage signal from the remotely located second fan shown on the right side of the mine map, figure 3-48.

At Harris there are attendants and phones at the tailpiece and boom of every belt so there is no need for automatic fire detectors at these points. Harris' longest belt run is 4,500 feet.

3.5.6 Communications Requirements--User's View

Except for correction of the minor problems already presented, the mine personnel had little to suggest about new communications systems that would make their work safer and more effective. This may be due to their present system being new and seemingly adequate for this size mine, or due to their not having tine to visualize how a higher capability system might profitably be utilized.

The one desire expressed at this mine was for a secure channel for seeking aid for an accident victum. As in other mines, when an accident is being reported, everyone that knows the phone is being used for this will listen in if he can. This lowers the productivity of the eavesdropper; takes his mind off his work, thus making him more accident prone; and worse, loads the telephone system so that the dispatcher can no longer clearly understand the report.

It probably is not essential that the conversation cannot be listened to, just that personnel not become aware that someone in a panic is calling the dispatcher. Personnel seldom listen in on the run of the mill conversations.

With respect to quickly contacting personnel on the move, they feel that doing it faster than presently would be of little value.

The people interviewed kept emphasizing that they would only accept personnel communications units for their foreman if the units were near zero in weight and bulk. With an anemometer, self-rescue, safety light, cap lamp, and roof probe, the foreman has all he can carry now.

The mine operators were specifically asked if they ever had a need to tie their independent communications systems together: longwall to telephone, telephone to outside, telephone to trolley phone, and so forth. Their comments on the last combination and their experience with it has been given previously. They felt no need for this type of system even if the interconnection was under switch control of the dispatcher.

3.5.7 Communications Requirements--Based on Survey Analysis

The exceptional high quality and the unusual amount of care given to the telephone and trolley phone systems leave little to suggest in way of improving these two communications means in mines similar to Harris. But if the role of the "dispatcher" is looked at carefully from a different point of view, some low cost, easily implemented requirement becomes obvious.

Like the Harris Mine equipment, the first shift dispatchers work was of unusual high quality. After two years as a dispatcher, and five as a motorman, he could perform his duties flawlessly. Clear voiced, courteous, considerate, and competent, his contribution to this mine's operation could only be limited by equipment and from carrying the title "dispatcher."

Referring to the two bar charts that depict his duties, figures 3-49 and 3-53, we see that dispatching trains is only one of the many duties performed by the operator of Harris's communication center. To visualize him as an Information Center operator might aid in finding ways that he could be even more effective in the mining operation.

By using the traffic density of 0.48 Erlang, seen in figure 3-52, and assuming a 50-percent increase in true traffic offered, the mine can expect 0.72 Erlang of traffic density at peak usage times. Therefore, a minimum of four channels will be required to handle the mine's underground communication.

In mines like Harris, where the communications system's performance is good, only lacking channel capacity, efforts should be made to make the new system compatible with the old. Thus, it would be desirable to use existing wiring and existing phones in the new system.

This mine, like some others visited, has a need for a secure channel as an aid in effectively handling injury problems, and it would be desirable to have a secure management channel.

In addition to utilizing present speaker-phone systems, the requirements for the new telephone are as follows:

a. The design shall be such that under mine environment condition, and with the rough handling and abuse normally given equipment, the mean-time-to-failure shall be at least two years.
b. Power shall be from internal batteries that are trickle charged from the phone lines.

c. If possible, the new telephone system shall be compatible with the existing speaker-phone network. It would be desirable, through multiplexing, to use existing single phone lines for the four channels.
d. There shall be a separate, well-marked, emergency switch that operates to cut out all other phones except for the Communication Center operator's, and shall operate a special signal to alert the Communication Center operator that an emergency call is being placed.
e. For exclusive management use, these shall be a key-operated (optional) switch that allows use of a secure channel and signals the Communication Center operator that a management call is being placed.
f. Remote loop-back shall be provided between each network and the Communication Center.
g. Only a single pair of telephone lines or coax (plus loop-back) shall be required.
h. Provision shall be made for adding an environment sensor/data transmitter package to the telephone. The unit that could be added would use one of the voice channels when the channel is not used by the phones.
i. The telephone unit shall be modular so that by changing internal plug-in modules the phone's capability can be varied between four and ten channels.

Another area where better communications capability would increase productivity, is in longwall mining. Of the mines visited to this point that had longwall miners (three), only Harris had theirs working on the days of our visits. Tours down nonworking and working longwall miners revealed that fast effective hands-free communication is needed by operating personnel both during operation and repair of the miner. Because of its high production rate--and thus the high cost of downtime--and because of the almost impossible working conditions, it seems essential that all longwall workers have their own wireless communications net with each having small, lightweight equipment, including speakers and bone conducting microphones mounted in helmets. The Communication Center operator should also be able to monitor this net.

The problems this mine has had with electric cables and switches suggest that special attention in design must be given to equipment components such as handsets, speakers, connectors, and cords. Making cases easy to mount by a variety of means will reduce the abuse given equipment during installation.

Loudspeakers for any high ambient noise environment should have adjustable degree of directivity, should be on gimbals so that they can be aimed in each specific application, and should have audio characteristics compatible with the high noise level environment.

3.6 BALDWIN UNDERGROUND NO. 1 MINE, ON-SITE SURVEY OF NOVEMBER 14, 1973

3.6.1 Mine Contacted

Peabody Coal Co. Baldwin No. 1
P. O. Box 67
Marissa, Illinois 62557

3.6.2 Initial Mine Contact

Bill Will - Evansville Office.
C. W. Schulties - VP Underground Operations

3.6.3 Personnel Interviewed

D. L. Gilmartin	-	Superintendent
J. R. Goaring	-	Chief Electrician
Garry Craig	-	Chief Clerk

3.6.4 General Mine Information

3.6.4.1 Mine Description

Peabody's Baldwin Mine has a slope entry to the Illinois Number 6 soft coal seam. Although the mine is only a year old, it covers an area about five miles square, employs 236 union and 50 supervisory personnel, and is producing 7.7 kilotons per day of clean coal. At this location the Illinois No. 6 seam has an average thickness of 6.5 feet with an overburden of 100 feet. Coal is removed by belt to storage silos and the Randolph preparation plant, some 7,200 feet from the mine entrance. Men, material, and supplies are moved by the 5-mile trolley system utilizing 60-pound track.

Continuous mining, by room and pillar, is the only method used here by the five mining sections during each of three shifts. In addition to section crews, there is a 6-man track-laying crew during one shift only, two men devote full time to dust control, and there is a mine safety manager. There are two maintenance foremen for each shift.

Probably because of the newness and the size of the mine, the operators feel that their 60 pager-telephones provide adequate communications with sufficient channel capacity. Having belt haulage, the trolley traffic was light enough that they felt no need for a trolley carrier phone system.

In contrast with previous reports, this one will emphasize the usage of communications as a tool for coal production rather than communications usage independent -- to some extent -- of coal production. The size and newness of the mine suggested this as a worthy change in survey objectives.

The management of the Peabody Coal Company and the Baldwin Underground No. 1 mine are listed here by position and name:

Company President:	E. L. Phelps
Senior VP, Operations:	D. C. Hall, Jr.
VP Underground Operations:	C. W. Shulties
Director, Underground Operations:	S. R. Barrett
General Superintendent, Central Illinois:	R. Gothard
Baldwin Superintendent:	D. L. Gilmartin
Shift Mine Managers:	(3)
Maintenance Foremen:	(2 per shift)

3.6.4.2 Crew Composition

Each of the five mining section's crew of 10 men consists of the following:

Foreman (1)
Continuous miner operator (1)
Miner operator's helper (1)
Shuttlecar operators (2)
Roof bolters (2)

Mechanic (1)
General inside laborer (1)
Scoop operator (1)

3.6.4.3 Mine Equipment and Power

The following is a list of equipment, manufacturers, and type numbers used directly in the production and in-mine transporting of coal.

Miner:	Joy 12CM
Shuttlecar:	Joy 10CM
Roof bolter:	Lee Norris
Scoop:	S and S

Man trips are provided by four portabuses: two Goodman and two Joy (Hart).

The remaining piece of equipment used in the mining operation is the belts that receive coal from shuttlecars and move it to the outside cleaning plant. Section or panel belts feed submain or main line belts. The main line belt feeds the slope belt leading to the outside storage silo. From there the coal is moved by belt to the cleaning plant some 7,200 feet away. Baldwin has what they call a "belt cleanup man" who continuously patrols the belt lines. The interlocks on the belt lines are so arranged that the stoppage of a submain, the main, or the slope belts will automatically shut down all belt lines, but the stoppage of a feeder belt will not. Presently the belt system has fire suppressors, with the parts for the newly required detection system on order.

Electric power at 12.5-kVac is brought into the mine at one point through two power bore holes. The two miles of 300-Vdc trolley wire are fed from solid-state rectifiers, one for each 4000-foot section of trolley wire. "Deadblocks" isolate the sections of trolley wire from each other. Ac power is brought to each section; some being transformed to 480 Vac for utilization by ac equipment, and the rest being rectified to dc to power the shuttlecars. Because each section has its own ac to dc conversion there is no need to draw dc power from the trolley wire by nip points.

3.6.4.4 Health and Safety

Ventilation fans exhaust air from the mine at a rate of 380,000 CFM at a water gauge pressure of 1.9 inches. The fan operation is monitored at the hoist house which is manned 24 hours a day. The law requires 9,000 CFM at each working face. Air at each section is checked by the section foreman, the shift mine manager, and daily readings for each shift are made by an examiner for the State of Illinois.

The "general inside laborer" is curtain man for his crew, and the shift mine manager directs a ventilation man as well as a crew of masons who build cement block walls and overcasts for directing air. The mine has two men assigned specifically to a dust control program under the direction of the Mine Safety Manager. There is little methane in the mine so ventilation is used mostly as a means of dust control.

Underground escapeways are maintained as required by law and there is an emergency hoist at the intake air shaft. There is a telephone at the top and bottom of this automatic hoist. These phones are simply tied into the mines overall phone circuit so that a short on the line, somewhere near the escapeway's underground phone, could limit communications to the topside escapeway phone.

As at all mines visited, should the ventilation fans be off for 15 minutes, all personnel would leave the mine. All new underground employees are given a tour of the mine and are shown escapeways and emergency exits.

3.6.4.5 Industrial Engineering Analysis

The visiting team on this mine survey included an industrial engineer as well as communications equipment engineers. Although insufficient effort was expended to yield a thorough industrial engineering analysis, it was felt that such an engineer would see significant factors that might be overlooked by communications systems design engineers. This industrial engineer assisting the project was from Collins Work Methods Department. The following paragraphs reflect his observations during our one-day visit to the Baldwin Mine.

The topics discussed in the following paragraphs include the following items:

a. Downtime
b. Travel time
c. Maintenance program
d. Mechanical delays
e. Mining output
f. Areas of investigation
g. Communication and productivity

Downtime or lost production averaged 37 to 43 percent of the available shift time of 8 hours. The reason for the downtime and percent of shift lost to downtime is listed in the following table. Each of these areas should be examined to find ways of reducing downtime and thereby increasing productivity. A brief comment on each of these areas follows the tabulation below.

MINING OPERATIONS,

AVERAGE DOWNTIME FOR EACH SHIFT

MINUTES	PERCENT	REASON
48	10	Routine maintenance
60	12 1/2	Travel time
72-96	15-20	Mechanical and other delays
180-204	37-43	Total

a. Travel Time for the Working Section

Travel time is now 60 minutes per shift, or 12.5 percent of the working time available per shift. In order to reduce this lost time, a study of the present and future mining areas should be made to determine the feasibility of opening a remote entrance for men and supplies. Some alternatives include longer working times, moving the mine office, and the use of a bus to transfer men to a remote shaft and returning them to the present mine office for showers, etc.

b. Present Maintenance Program

The present maintenance program is centered around a scheduling of the continuous mining equipment for downtime in two out of seven mining shifts. This is accomplished by having five working sections and seven continuous miners. As the number of mining sections increases, this method of scheduling maintenance may have to be changed since no idle equipment is available. Possibilities include maintenance on weekends and extended maintenance shifts. It should be possible to schedule maintenance during the crew travel time and lunch break.

c. Mechanical Delays and Other Delays

Mechanical delays and other delays amounted to 15 to 20 percent of the total shift time. The types of delay this includes are conveyor belt downtime, cable problems, water problems, wait time for roof bolter, "top" problems, power outages, fan down, etc. The average downtime in the coal industry is from 8 to 15 percent for mechanical delays. Since this mine is above this figure, a study of the maintenance system should be made to determine possible changes in the system or equipment that could improve productivity. In addition, a possible problem of work imbalance is noted in that it was necessary to wait for the roof bolter at times during the day.

d. Mining Output

The average output per mining section per shift was 750 tons of raw coal. This raw coal was transferred to the cleaning plant by conveyor belt. At the cleaning plant 32 percent of the raw coal was lost as waste (fire clay, shale, etc) or screenings. It is possible that this 32 percent waste represents both waste and an error in calculating daily output. Possible changes in the cleaning plant procedures could be made to reduce lost coal.

Areas for Industrial Engineering investigation that could result in increased productivity are as follows:

1. The method of calculating and reporting output should be examined to determine sections with low output and to examine sections with high output for superior methods, etc.
2. The frequency of conveyor belt moves and location of belts should be examined to determine the optimum belt moves and locations.
3. The present equipment utilization should be examined to determine excesses or needs for additional equipment.
4. The working section should be examined to determine workloads and achieve work balancing.

e. Communication and Productivity

Baldwin Underground Mine No. 1 uses a communication system consisting of an MSA Pager-II system having one channel and approximately 600 feet between phones. The steps necessary to use the present system in the mine are as follows:

1. Walk to nearest phone
2. Wait until the phone is not in use
3. Page the party desired on the phone
4. *Wait for the party paged to walk to the nearest phone and answer
5. Complete the communication
6. Return to the work station

During the interview, three observations concerning the communication system were made which indicated that potential productivity increases could be made by better communication systems.

1. Wait time to get on the phone system was observed. This mine has only one channel for five working sections and more channels of communication could reduce or eliminate this problem.
2. Maintenance time to service the phone system's batteries was a complaint. Battery replacement was made on a monthly basis and was thought to be excessive by both the Mine Superintendent and the Chief Electrician and Maintenance Foremen.
3. Wait time and repeated paging were necessary to contact certain individuals on the phone system. This probably was due to the distance between phones in the mine and walk time necessary to get to a phone if and when a paging call was heard. Repeated paging of one individual seems to indicate problems in the mine in hearing page calls from distant phones.

The ideal phone system should eliminate the walk and wait times noticed in the present system and should have a minimum of maintenance for batteries, etc.

3.6.5 Current Mine Communications

This mine has three independent communications systems:

a. 60 pager phones on the in-mine system
b. 2 pager phones on the single office to cleaning plant line
c. 2 trolley phones on the slope-car to hoist-circuit

*It is possible that no response to the page will be made and that the call will need to be placed again.

At the time of the visit the trolley phones were not being used so communications between the hoist operator and anyone wanting to use the slope-car, was by a standard bell system and code of the State of Illinois. The phones at the top and bottom of the emergency hoist share the phone line network with all underground phones so they cannot be considered an independent system.

The mine has 60 of MSA's Pager-II phones, with six additional spares. These phones were new when the mine was started in May of 1973.

Underground phones are located at each section, each power station, and at each belt drive. Phones are also spaced at 600-foot intervals along the main track. In this same network are the three above-ground phones; one each in the Superintendent's office, the supply room, and in the hoist house. Figure 3-57 shows the location of the more important phones, but not those positioned at 600-foot intervals along the track. (Scale of reduced map: 1 inch = 776 ft.)

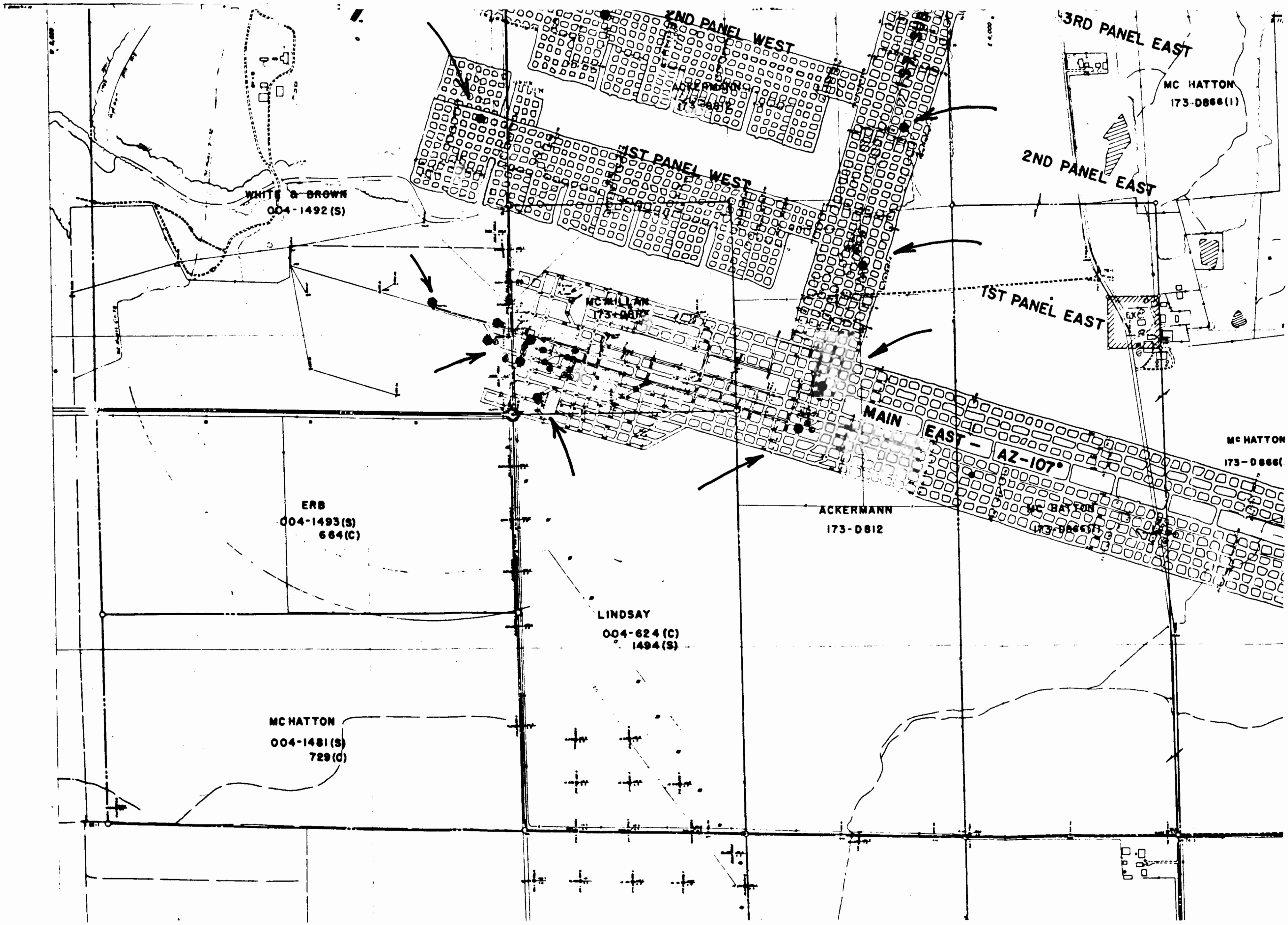
During normal working hours someone is always in the supply room so all phone pages are continuously monitored, and that person in effect is the communications operator; he takes and relays messages and helps locate personnel. During off-hours when someone may be in the mine, system paging is continuously monitored by the hoist operator.

The impression of the interviewees was that most phone calls are initiated by section foremen, who are calling underground maintenance personnel. They felt that the second most prevelent calls were those of the Shift Mine Manager calling outside for supplies. Their stating that the phone system gets very heavy usage when equipment breaks down implies that calls at this time are from section personnel to maintenance personnel. At the end of the shift, each section foreman calls in his "first report" of coal tonnage mined, and also calls maintenance and reports on the condition of the section's machinery. The phone system is used often to locate management personnel in the mine, and it evidently works well, with those hearing the page telling the paged person when he is within earshot.

Except for near the end of the shift -- when the scheduled phone reporting is done -- there appears to be little problem with the line being busy. (Perhaps optimum use is not being made of the phone system.) Near the end of the shift the congestion problem is serious enough that the mine is working on a scheme to get the shift mine manager and chief electrician together so that the phone system will not be needed for their long, drawn out coordination planning efforts. While conducting the interview it was noticed that George Parks, the shift mine manager, was paged regularly and much more often than anyone else. Only hearing the page, we must assume the pages were usually answered.

Other than having a phone at the top and bottom of the emergency hoist, there were no plans for how the existing phone system might be used in an emergency. No provision has been made for loop-back to provide a telephone path should the main line be broken. The mine does not have a rescue team so this need for communications cannot be covered.

Battery life was the only complaint the mine operators expressed about the Pager-II telephones. When the terminal voltage of the 12-volt batteries drops to 10, the phones will no longer operate. They feel that being able to operate with lower voltage would extend the battery's life significantly. Even after suggesting specific possible problem areas, they could find no fault with connectors, cords, switches, handsets, or with rock-dust penetrating the telephone's housing. They were satisfied with the way the phones could be mounted, and with the required mounting hardware. As mentioned in earlier reports, the need for modular construction means little for such a simple device as the Pager-II.


3RD PANEL EAST
MC HATTON
173-D866(1)
2ND PANEL EAST
1ST PANEL EAST
2ND PANEL WEST
1ST PANEL WEST
WHITE & BROWN
004-1492(S)
MAIN EAST - AZ-107°
Mc HATTON
173-D866(
ACKERMANN
173-D812
ERB
004-1493(S)
664(C)
LINDSAY
004-624(C)
1494(S)
MC HATTON
004-1481(S)
729(C)

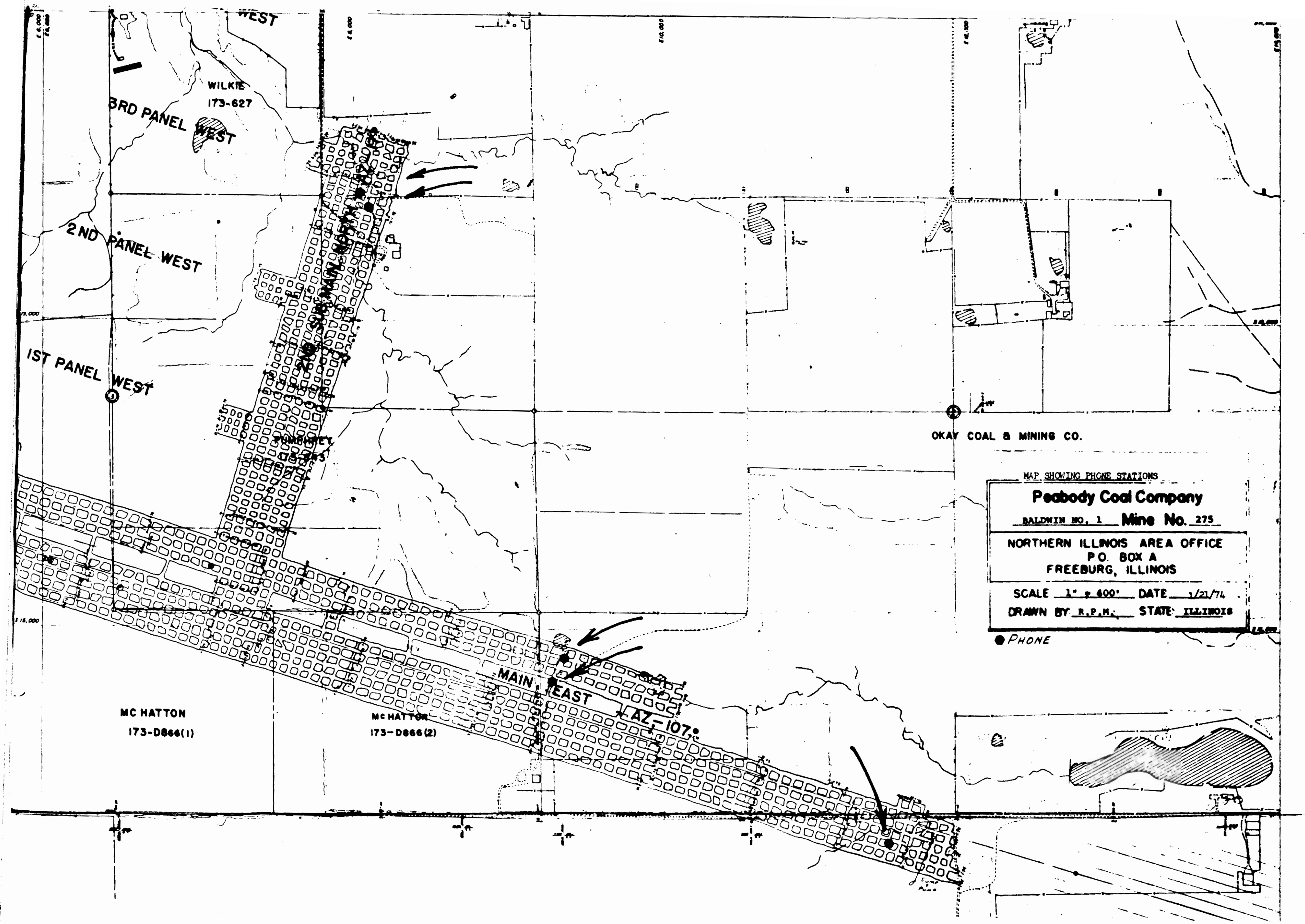
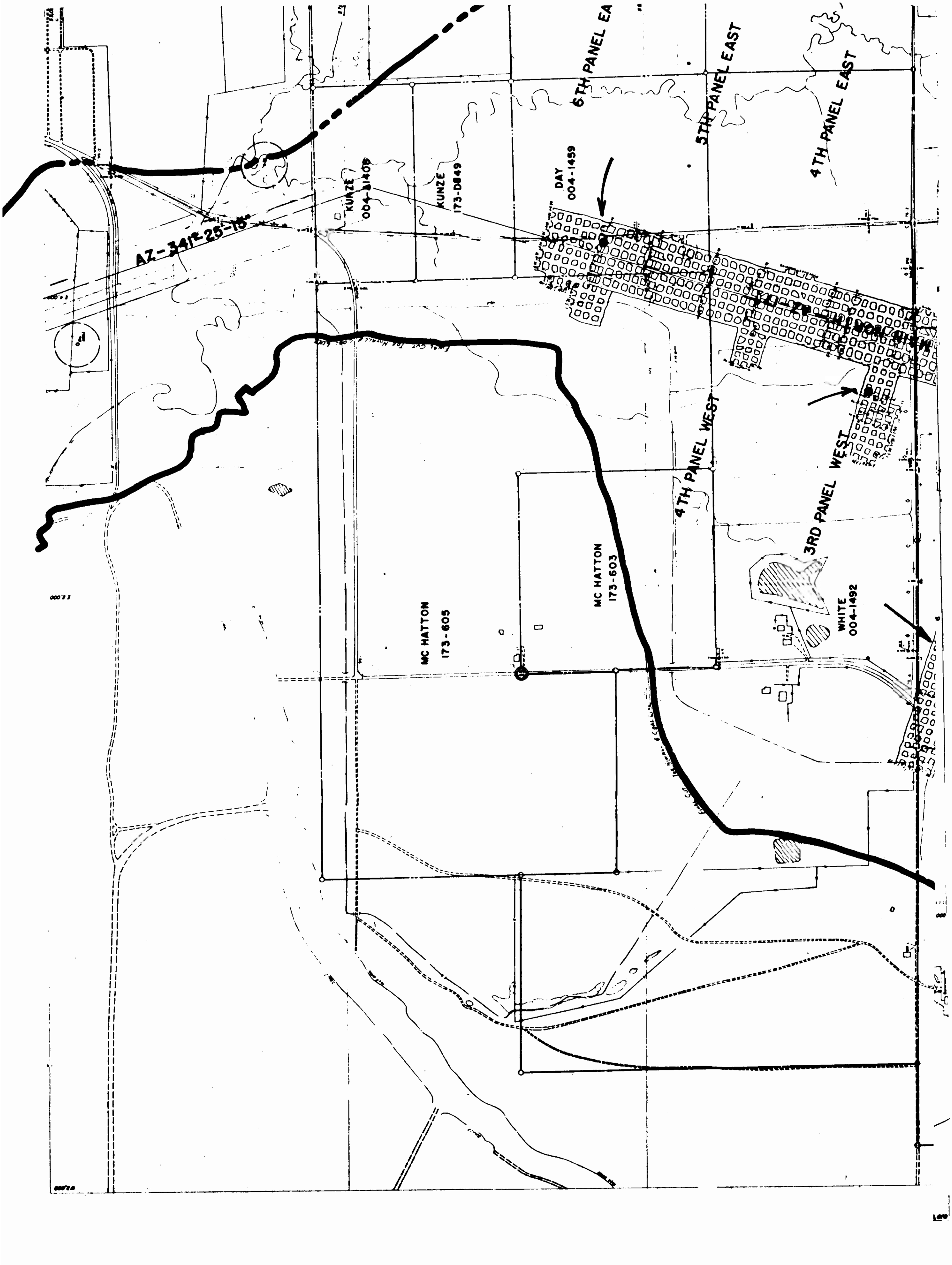


Figure 3-57. Peabody Mine Phone Stations.



6TH PANEL EA
5TH PANEL EAST
4TH PANEL EAST
DAY
004-1459
KUNZE
KUNZE
173-D849
AZ-341-25-15
4TH PANEL WEST
3RD PANEL WEST
MC HATTON
173-603
MC HATTON
173-605
WHITE
004-1492

The wire interconnecting the 60 phones is SO-TW neoprene covered cable having two number 14 wires. Their only complaint about this cable is that now and then a poor splice will cause degraded performance.

The mine was dry, there is little temperature variation, and the phones are relatively fixed mounted; therefore, there is little abuse from the environment or from workers. The mine operators had no complaints along these lines.

3.6.6 Communications Requirements -- User's Views

3.6.6.1 Present System

Because of the present age and size of the mine, and keeping with its present operating methods -- that is, not visualizing how a higher performance system might operate and how much it might cost -- this mine feels its present communication is generally adequate. They would like to see eliminated the nuisance of having to regularly change the batteries in each of their 60 telephones. And they would like to obtain use of a greater proportion of the battery's life.

Their greatest fear at this mine is that future, higher capability equipment will inevitably be more expensive, more prone to failure, more temperamental in operation and more difficult to repair.

3.6.6.2 Future Systems

This mine was the most receptive of any we've visited to the idea of personal portable paging or communications units for some management personnel; they didn't insist that such equipment be of zero bulk and weight. They thought the idea of having several channels was good -- if it didn't require hanging more wires. Highly thought of were selective independent channels for: maintenance, management, and emergency. They did not like the idea of a secure channel -- or any channel -- that required a key to operate. But when we toured the mine they didn't seem to note the inconvenience of finding the right key for the jeep. They also noted that higher capability communications -- which will create more traffic -- generates its own problems of mutual interference, and of isolated faults propagating throughout the entire integrated system. Throughout the entire interview the mine superintendent kept emphasizing, "We believe in good communications ... but we don't want to create more problems than we have now."

3.6.7 Communications Requirements -- Based on Analysis

3.6.7.1 Communication Functions Needed

In mines like Baldwin there is the additional need for several telephone channels for different functions as well as the one general channel they have at present. Because in this type of mine the supply clerk is the nearest one in the mine to an Information Center Operator, he should monitor and be able to operate in all channels. Because there was specific interest at this mine in an emergency channel and a secure channel, these should be a minimum requirement along with the present pager-phone single channel.

The important characteristic of the emergency channel would be that only the superintendent, the safety manager, and the supply clerk can hear pages and the identifying alarm on this channel.

Management's secure channel has the characteristic that only one phone at a time can be called and can take part in the conversation - except of course that the supply clerk monitors all channels including this one. Thus the person initiating the call is assured that only the station called can hear the conversation.

Again because personnel at this mine showed specific interest, small, lightweight personal portable communicators should be available so that roving miners can communicate with an Information Center (supply clerk for this mine) operator from any place in the mine. To keep the costs down on these units, which are likely to be more costly than present telephone units, their function should be as simple as will be acceptable, and only as many as is essential should be planned for each specific mine. The success of the few units will be the justification for investing in additional units. For instance for the Baldwin mine, the ability for the superintendent, the shift mine manager, and the chief electrician to have portable communications with the supply clerk may be all that is needed.

For new telephones, the physical requirements and how well they can tolerate the abuse from man and the environment, need only be as good as that for the present Pager-II units. Personal portable units need to be at least as rugged as cap lamps, batteries, methane monitors, and other items presently carried by personnel in the mine.

3.6.8 Communications Related Human Factors

In broadening our outlook from purely physical aspects of communications to Productivity and Industrial Engineering considerations, we become aware of communications related concepts that are at least worth mentioning in passing.

In visiting all the mines of this program, the universal high ambient audio noise levels were noted. We don't know if these noise levels have the same detrimental effect on productivity as in other industries but we suspect it has. Surely the high pay scale is one of the greater motivating factors mine workers have. If every section crew member had either bone-conducting or noise canceling microphones, and ear-plug earphones, increased productivity, improved communications, and reduced fatigue due to noise could result. In such a system all miners on a section would be in constant communication with one another.

A tremendous savings could be realized if use could be made of the presently wasted portal-to-portal travel time. One mine has used this time to offer safety programs over the trolley phone system. Poor trolley phone quality, high ambient audio noise, and amateur programming of the offering makes the value of this seem questionable, even though the mine was satisfied with the results. With humane audio characteristics, such an information system could be used to keep miners informed of their own and other sections productivity and of company's objectives and goals, to offer training programs, as well as to offer safety training. In mines without trolley phones or with poor audio quality trolley phones, tape players could be used.

The above two schemes might be considered too far out, but the possible yield from the small investment suggests that some thought along these lines might be profitable. As evidence of the value of considering psychological and social factors -- as well as the technical -- consider a case presented in the January 1974 issue of Industrial Engineering, "Work Structuring, Part I." The example is that where employee turnover dropped from 50 to 12 percent and absenteeism dropped from 25 to 17 percent at a Swedish auto plant when more than the technical factors were considered in Work Methods design.

3.7 LOVILIA NO. 4 COAL MINE, ON-SITE SURVEY OF DECEMBER 6, 1973

3.7.1 Mine Contacted

Lovilia Coal Co. Lovilia No. 4 Coal Mine
Melrose, Iowa 52569

3.7.2 Initial Mine Contact

Billie Williams - Superintendent
(515) 726-3211

3.7.3 Personnel Interviewed

Tom Wignall, Jr.	- Chief Engineer
Tom Wignall	- General Manager
Billie Williams	- Superintendent

3.7.4 General Mine Information

3.7.4.1 Mine Description

The Lovilia No. 4 coal mine is owned by the Lovilia Coal Co. and has been operational since 1963 with production originally estimated for 25 years. Coal is being mined from the Mammoth seam in the Cherokee group. Seam thickness is approximately 60 inches.

This mine was the only nonunion mine surveyed. As a result, some of the operations were notably different from those seen at all other mines examined.

The mine employs conventional mining techniques and employs tracked haulage to remove the coal. Personnel entry and coal removal are through a single shaft.

Coal production is approximately 250,000 tons per year. There is one mining section, operating one shift. Coal is mined via the room and pillar method with activity rotating through six active rooms.

The mine will ultimately be approximately 1-1/4 miles square. Mining activity is currently occurring about 3/4 mile east of the shaft.

The overburden at the shaft is 157 feet, increasing gradually to the working face. Tunnels are typically 12 feet wide and vary between 4 and 6 feet high. Four and 6-foot roof bolts are installed on 5-foot centers.

NOTE

> The Lovilia mine is now installing resin-anchored roof bolts. The use of this type of bolt must be considered as it affects a roof-bolt-antenna communications system.

There are no bore holes into the mine. The fresh air entrance serves as the emergency exit and is located about 500 feet from the main shaft. The main shaft serves as the air exhaust.

3.7.4.2 Mine Management

Since there is only one mining section, the mine operates with very few management personnel. These include the following:

Tom Wignall - General Manager
Tom Wignall, Jr. - Chief Engineer
Billie Williams - Superintendent
John Lee - Foreman

Management personnel do quite a bit of filling in as necessary; however, the chief engineer normally tends to topside operations while the superintendent stands by at the bottom of the shaft. The foreman remains at the face.

3.7.4.3 Mining Operations

There are five mining operations rotating continuously through the six active rooms at the face. A cycle starts with the cutter undercutting the coal face. This is followed by the coal driller drilling holes for the charges. After the driller moves on, the charges are set and fired by the shot firer. After a delay for the air to clear, the loader is moved in to begin loading shuttlecars, which transfer coal to the haulage cars. When a room has been cleaned of the loose coal, the roof bolters move in to extend the supported section of the roof.

Loaded haulage trains are pulled to the shaft where the cars are dumped into a skip, one car to a skipload. The skip is lifted up the shaft and dumped into the crusher. Crushed coal is conveyed into semitrailer trucks that are used exclusively to haul the mine's output.

The mine has 25 men underground during the shift. The crew composition is as follows:

Superintendent (normally underground) (1)
Foreman (1)
Cutter operators (2)
Coal driller (1)
Shot firer (1)
Loader operator (1)
Shuttlecar operators (3)
Bolter operator (2)
Timberman (also do concrete stopping) (2)
Track layers (2)
Bottom man (dumps cars into skip) (1)
Motorman (3)
Mechanic (1)
Electrician (1)
Helper (3)

Rock dusting is done as required. At a given time there may be from one man all the way to the entire crew working at rock dusting. If a crew member is absent, another crewman or the foreman fills his job for the shift. The helpers assist on any job in the section.

The working day runs from 6:45 am to 4:00 pm. Approximately 10 minutes of this period is spent in travel to and from the working face. An additional 15 minutes is taken out for lunch. Since operations rotate continuously through the rooms there is very little nonproductive time during a shift. If a crew member does have some slack time, there is always additional rock dusting, supplies moving, etc, to be done. Additional general purpose work is performed on Saturday, as necessary.

The maintenance philosophy of this mine results in a large amount of nonproductive machine time. There is a complete operating spare for each type of machine in the mine. As a result of this philosophy, however, there is virtually no downtime for equipment maintenance. A minor failure is repaired on the spot, and in case of a major failure the spare machine is placed in service while the broken one is fixed.

3.7.4.4 Support Operations

As mentioned above, maintenance is performed on the spot. The maintenance personnel travel with the mining crew, there is no fixed shop location. The presence of spare machinery permits repairs and maintenance to be performed thoroughly without slowing production.

Supplies are delivered via the haulage cars. Just before the end of each working day the foreman calls his list of supplies to the hoisting engineer. These are placed at the top of the shaft and delivered to the face either at the end of the day or the beginning of the next one. Repair parts are delivered during the day via a return trip of the haulage cars.

The mine has a single mantrip car. This is sufficient to carry the entire crew, so only one mantrip is made, morning and evening. Administration of the mine operation is quite informal. The general manager oversees all operations and assists the topside personnel as necessary. All management personnel assist when and where needed.

Ventilation is via a single fan, blowing into the escape shaft and exhausting through the main shaft. Within the mine, water sprays are used to keep dust down. There has never been any problem with excessive water, so the only water handling gear is that used to control dust. Three methane detection stations are located at the face. These are at the transformer station, on the cutter, and on the loader. The detectors are powered from the machine they are mounted on.

3.7.4.5 Coal Production

Annual production is approximately 250,000 tons. The daily production for the shift is about 900 tons. As there is but the one shift and crew, no relative production comparison can be made.

3.7.4.6 Equipment Description

The following pieces of mining equipment are in use at the Lovilia mine:

Shuttlecars, Joy 10SC (3)
Loader, Joy 14BU10 (1)
Cutter, Joy 10RU (1)
Roof bolter, Acme SPH RD-2 (1)
Coal drill, Long Airdox TDF-24 (1)
Locomotives, Goodman 8 ton (3)

In addition to the equipment in use, there is one operating spare of each type of machine. In case of major breakdown the spare is placed in operation while the broken unit is repaired.

3.7.4.7 Power System and Distribution

Primary power comes into the mine through the main shaft. A 2300-volt, 3-phase line is run to the two transformer-rectifier sets used. One transformer feeds the trolley for the haulage system, the other powers all machinery at the face. All machines in the mine run off 280 to 300 volts dc.

3.7.4.8 Emergency Procedures

The inlet air shaft, about 500 feet from the main shaft, serves as the emergency exit. The lift at the emergency shaft is powered by a gasoline engine, located at the top of the shaft. Operation of this engine is checked before the men go below each morning. If the emergency exit has to be used, the man at the bottom signals the hoisting engineer. A switch is used to light a bulb for this signal. Someone then comes to the emergency hoist, starts the engine, and lifts the man out. For emergency situations not involving the exit shaft, such as a personal injury accident, the paging telephone is used. An ambulance from the nearest town can be at the mine by the time an injured man has been carried to the top of the shaft.

3.7.4.9 Employee Job Satisfaction

The mine has not had a problem with absenteeism or with a large turnover. On the occasions when they have added employees they have had no trouble getting men. The prime reason appears to be their pay scale. The miners are paid a base rate for a 9-hour day, plus a production bonus for coal mined beyond 200 tons per day. As a result the 1972 pay for nonsupervisory personnel ranged between \$14,000 and \$20,000.

3.7.4.10 Foreman's Workload

In addition to supervising the crew, the foreman can and does fill in at any job at the face. Shortly before the end of the shift he calls an order for the following day's supplies over the pager phone. During the day he also calls for any repair parts that may be needed. At the end of the working day there are report forms to be filled out; however, these normally require only about 5 minutes to complete. The basic data for the forms is called up at the time the supplies list is phoned up.

3.7.5 Current Mine Communications

3.7.5.1 Descriptions

Lovilia No. 4 Mine currently has a combination of three independent voice communication systems. The loudspeaking phone system uses two of the four available units. An 8-year-old Femco MI2774 and three 3-year-old MSA pagers are available to this system. One of the active stations is located at the hoisting engineer's position, with the other at the working face. A 2-station Talk-A-Phone intercom connects the top and bottom of the shaft. Another Talk-A-Phone connects between the hoisting engineer and the mine office. The two spare loudspeaking pagers serve as backup and permit a third station to be patched in if work is being done a long way from the face.

The hoisting engineer serves as "communications central," tying the three systems together.

In addition to the internal communication systems, an extension of the outside telephone line is located at the chief engineer's desk.

3.7.5.2 Installation and Maintenance

The small size of this mine results in there being almost no installation operations. The pager at the face is kept mounted near the power sled, so the two are moved together. Nothing else is moved.

All equipment has been holding up well. Occasionally, on the order of twice a year, one of the pagers will quit operating. Whenever this happens, the bad unit is sent to a repair station in Marion, Illinois, to be fixed.

3.7.5.3 Normal and Emergency Use

In normal system use, all calls are made from a remote point to the hoisting engineer "comm central." As long as calls are being made in this manner, the system functions well. A possible exception might occur in an emergency situation at the face. The pager at this point is 50 to 100 feet from the nearest working room, and on the other side of air diverter flaps. It is conceivable that an accident could occur in which the phone would not be accessible. The other possibility involving an accident situation would involve the phone cable. There is a single run with no backup or loop-back path. This cable is, however, protected in being mounted on vertical timbers and is of armored construction.

When calls are made from the "comm central" position to other parts of the mine the system would not appear to work so well. A complaint was made that if the superintendent leaves the bottom of the hoist it may take a half hour to get a message to him. It appears very unlikely that a call to the pager at the face would find anyone near enough to hear it. The fastest route to the face appears to involve relaying a message to a motorman at the hoist and having him deliver it to the face when he returns. This was not felt to be a bother as there was thought to be almost no reason to call the face.

3.7.5.4 System Use

One of the systems is in continuous use. The intercom between the top and bottom of the hoist is always used to monitor the activity at the bottom. The hoist operator uses this information to determine when to lift the skip. If a call is to be made to the bottom, it is initiated from the top. The loudspeaking pager is not used more than twice an hour. Calls are normally made from the face to the hoisting engineer.

During the day these calls are normally supplies/repair parts requests. Near the end of the shift the foreman calls with his daily report, including a list of the supplies needed for the following day's work.

The intercom between hoist and office is rarely used. In case of an incoming telephone call which cannot be handled at the office this intercom is used to call the necessary party and have him pick up the phone extension at the hoist. With the system configured as at present, there is no problem with contention for a channel. All workers have become accustomed to the capabilities and limitations. With one pager channel exclusively available for use by one work crew, a busy line can be considered a nonexistent condition. The minimal amount of communications between the hoist operating position and the face made it impossible to determine frequency of unanswered calls. Since a man is always in position at both the top and bottom of the hoist, there are no unanswered calls over this system. There are cases, however, where a given individual cannot be found. All management personnel have general assignments, keeping them in certain expected locations. If they leave these locations, they may be out of touch for an extended period. Even if an individual's approximate location is known, there is very little chance he can be called. The best that can be done is to leave messages so that a contact can be made at some time in the future.

3.7.5.5 Other Communications Uses

Under the present scheme there are, in effect, three private channels. No others are needed. At one time some additional pager stations were connected to the system to see if this would improve communications. These were removed because system usage went way up and there was channel contention. In addition, the management disliked the fact that others could listen in. Nothing was said about the length of time the added stations had been installed. It is possible that the added usage was a result of the novelty of being able to call additional places. If not, this shows that the present low usage is a result of getting used to the capabilities of a limited system. In effect, the mine now has a 3-channel system with no capability of interconnecting all locations. The hoisting engineer provides relay service. If this were a single system no more than three channels would be necessary, with one of these being a private channel. It would, however, appear desirable for there to be more station locations along the main tunnels for safety purposes.

The chief engineer complained that whenever the superintendent leaves his normal post at the bottom of the hoist he is out of contact. If he is needed, messages must be left so he may be told to call into "comm central" by the next person who sees him. This may take a half hour. Some form of portable comm gear would be desirable. The chief engineer felt that 2-way equipment would be preferred to paging gear. The primary drawback to a pager is the need to find a station from which to call. In this mine those stations are nearly nonexistent. Probably most or all the management people should have some form of portable comm, especially since there is no fixed office where they may be found.

A mine this small has very few items that might be monitored as additional communications functions. The air supply monitor is an air vane that feeds an indicator by the hoisting engineer. Another indicator tells him if someone needs to have the emergency hoist placed in operation. No readouts are provided on the methane monitors; however, we were told there has never been any methane in Iowa so there was thought to be very little need for anything beyond the normal monitor operation.

In this mine there appears to be no production or safety advantage in having a direct interconnection between the mine and public telephone systems. In case of accident the hoisting engineer must be notified that an injured man is being brought out. By the time the man has been brought to the top, an ambulance can have been called and be ready and waiting. No time can be saved by calling directly from the face.

3.7.5.6 Equipment Physical Requirements

There is little need for moisture and vibration resistance in the communication equipment as presently used in this mine. Dust resistance is, however, important, and any equipment sealed to the necessary degree would be both dust and moisture proof. Rather than considering vibration resistance, a fairly high degree of shock resistance is necessary simply to withstand normal handling.

Modular construction is a desirable feature on any new equipment. This can permit on-site repairability and reduce spares stocking requirements. The exception to this comment would concern gear in which an entire unit is built to be a nonrepairable, throwaway device.

Case and component durability are important considerations in the design of any equipment for use in a mining environment. Aside from the one pager at the face, the equipment in this mine probably is treated as gently as possible. This still means that cases should be made of metal, preferably low corrosion alloys, or plastic. The plastic used might be either ABS or polycarbonate resin. Handsets, cords, and loudspeakers must be ruggedized. This includes both impact resistance and dust sealing.

Within the mine equipment, mounting ease must be considered. Since the telephone sets are moved regularly, if they are hard to mount it is likely they will be left lying on the ground.

In a system as used in the Lovilia mine, replaceable batteries perform well. The task of transferring rechargeable batteries to and from the phone stations is greater than that of the infrequent replacement of dry batteries. As an alternative to battery transport, a tap would have to be made to the trolley system for a battery charger.

3.7.5.7 Recommendations

In the Lovilia No. 4 mine, communications efficiency would be improved by replacing the three independent 2-station phone systems with a single multistation, multichannel system. The system should have a minimum of seven stations. Their locations would be as follows:

Mine office
Hoisting engineer's position
Shaft bottom
Working face
Bottom of emergency shaft
Midway between bottom and face along inbound haulageway
Midway between bottom and face along outbound haulageway

Other stations which might be considered include the following:

Topside storage/shop area
Chief engineer's desk
Crusher
Each of the haulage motors

A station on a haulage motor would couple into the trolley line, with a coupler used to connect the trolley into the phone system.

Most of the added stations would be concerned more with safety than with production. As things stand, it is possible to be blocked from a phone station or to be a long walk from one. In addition to the fixed stations, the management personnel should have radio communicators. This would eliminate the existing situation in which a critical man can be out of touch when others need a decision or information.

An expanded system needs no more than two general channels plus a private channel. Radio communicators would operate best if they can access all three channels, but could operate with access only to one of the general channels.

The cable into the mine should be a continuous loop of armored wire for maximum reliability and protection. By using a multiplex system, all channels plus monitors could be included on a single cable.

Any other expanded communications requirements are dependent upon decisions to change parts of the mining procedure. Methods can be seen to keep equipment in more constant use. If such changes are made, communications requirements also change. Assuming unchanged mining procedures, this mine is coping quite well under the limitations of the existing three private channels.

3.8 ORIENT NO. 3 COAL MINE, ON-SITE SURVEY OF JANUARY 10, 1974

3.8.1 Mine Contacted

Freeman Coal Mining Company, Orient No. 3 Coal Mine
Waltonville, Illinois 62894

3.8.2 Initial Mine Contact

Virgil Robinson, Superintendent
(618) 229-4911

3.8.3 Personnel Interviewed

Paul Budzak	-	Safety Director
Curt Mundell	-	Safety Inspector
Harvey Wallace	-	Chief Electrician

3.8.4 General Mine Information

3.8.4.1 Mine Description

The Orient No. 3 coal mine is owned by the Freeman Coal Mining Co, and has been operational since 1951. Bituminous coal is being mined from the Illinois No. 6 seam. In this region the seam thickness exceeds seven feet.

Continuous miners are in use at all working faces with belt haulage used for coal removal. Battery-powered man-trip cars travel over the trackage paralleling the belt and remain with the working sections throughout the shift. Man-entry and exit is via two entry shafts. Materials are hauled through a drift entry paralleling the belt by means of battery-powered locomotives.

Coal production is approximately two million tons per year. The two mining shifts operate 13 active sections. Three additional sections are on standby, while the third shift is used entirely for maintenance.

Entries have currently been driven to cover most of the 4- by 5-mile area of the mine property. Working sections are mining coal at faces scattered about the extreme limits of this property. Bore holes are located on 4,600- to 5,000-foot centers throughout the mine. The overall mine configuration is shown in figure 3-58.

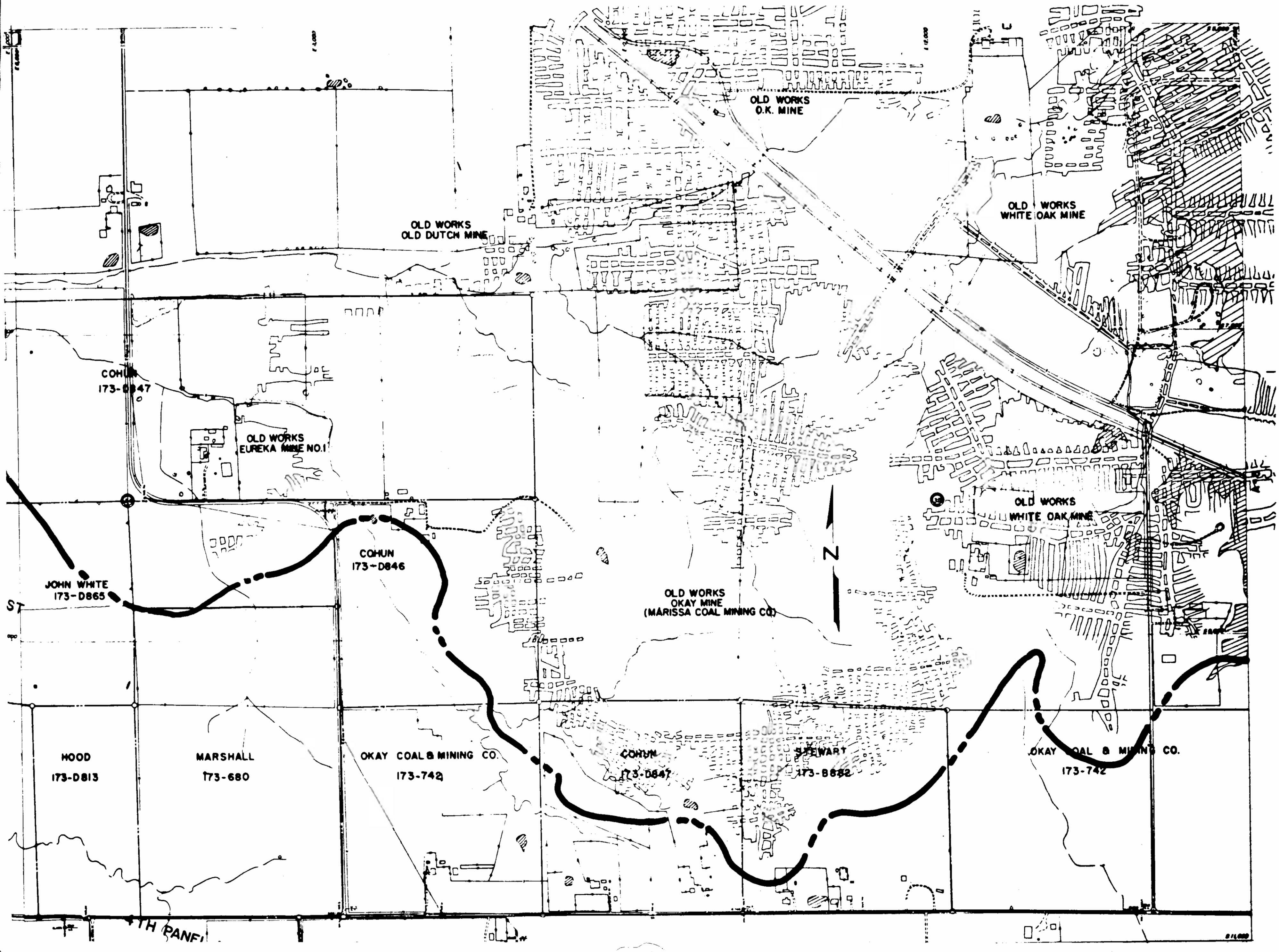
3.8.4.2 Mine Management

The management of the Orient No. 3 mine is organized around the Superintendent, Virgil Robinson, and his Mine Manager, Pete Helmer. The mine manager has two assistants. Total supervisory personnel number in the low 50's, providing supervision for the 26 mining sections, maintenance needs during the mining shifts, and the maintenance shift.

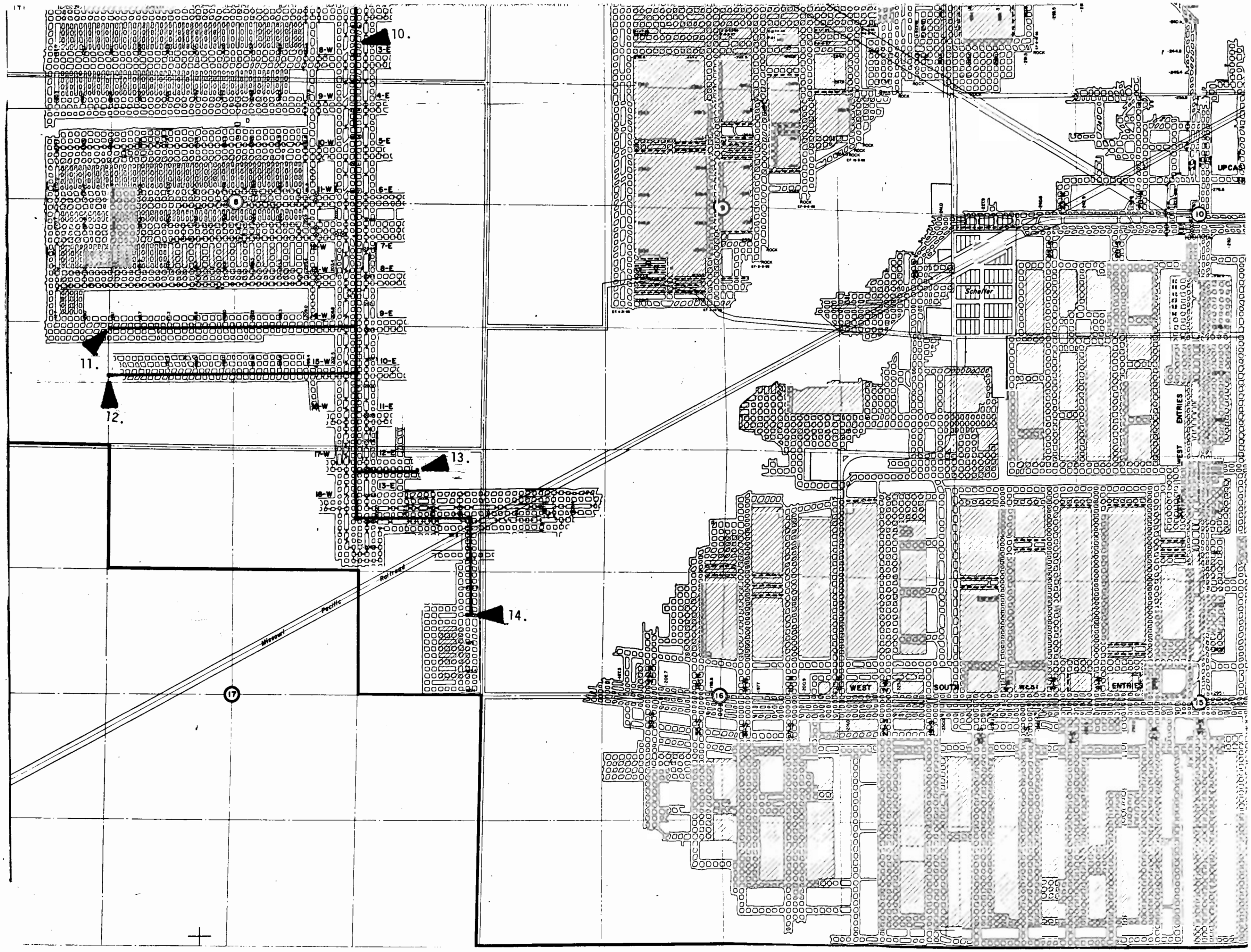
3.8.4.3 Mining Operations

Continuous mining is used throughout the Orient No. 3 mine. There is sufficient equipment in the mine to operate 16 sections; however only 13 of these are active on any one shift. The equipment is in use for two shifts daily. Each section uses one miner, two shuttlecars, a roof bolter, and a power center. To operate the equipment, a crew consists of a foreman, a miner operator and his assistant, two shuttlecar operators, two roof bolters, and a section mechanic.

About 65 percent of a shift is actually spent mining coal. The balance of the shift is spent in travel between the top and the face, eating lunch, and in machine downtime. In addition, continuous mining, by its very nature and in spite of the name, is an intermittent process. Mining can only take place until the storage bin is filled unless a shuttlecar is waiting to be loaded. As mining advances the distance to the belt feeder varies, as does the waiting time for either the miner or the cars.



OLD WORKS
O.K. MINE
OLD WORKS
WHITE OAK MINE
OLD WORKS
OLD DUTCH MINE
COHUN
173-D847
OLD WORKS
EUREKA MINE NO.1
OLD WORKS
WHITE OAK MINE
N
COHUN
173-D846
JOHN WHITE
173-D865
OLD WORKS
OKAY MINE
(MARISSA COAL MINING CO)
HOOD
173-D813
MARSHALL
173-680
OKAY COAL & MINING CO.
173-742
COHUN
173-D847
STEWART
173-B882
OKAY COAL & MINING CO.
173-742


10.
11.
12.
13.
14.
Missouri Pacific Railroad
Schafer
SOUTH WEST ENTRIES
WEST ENTRIES

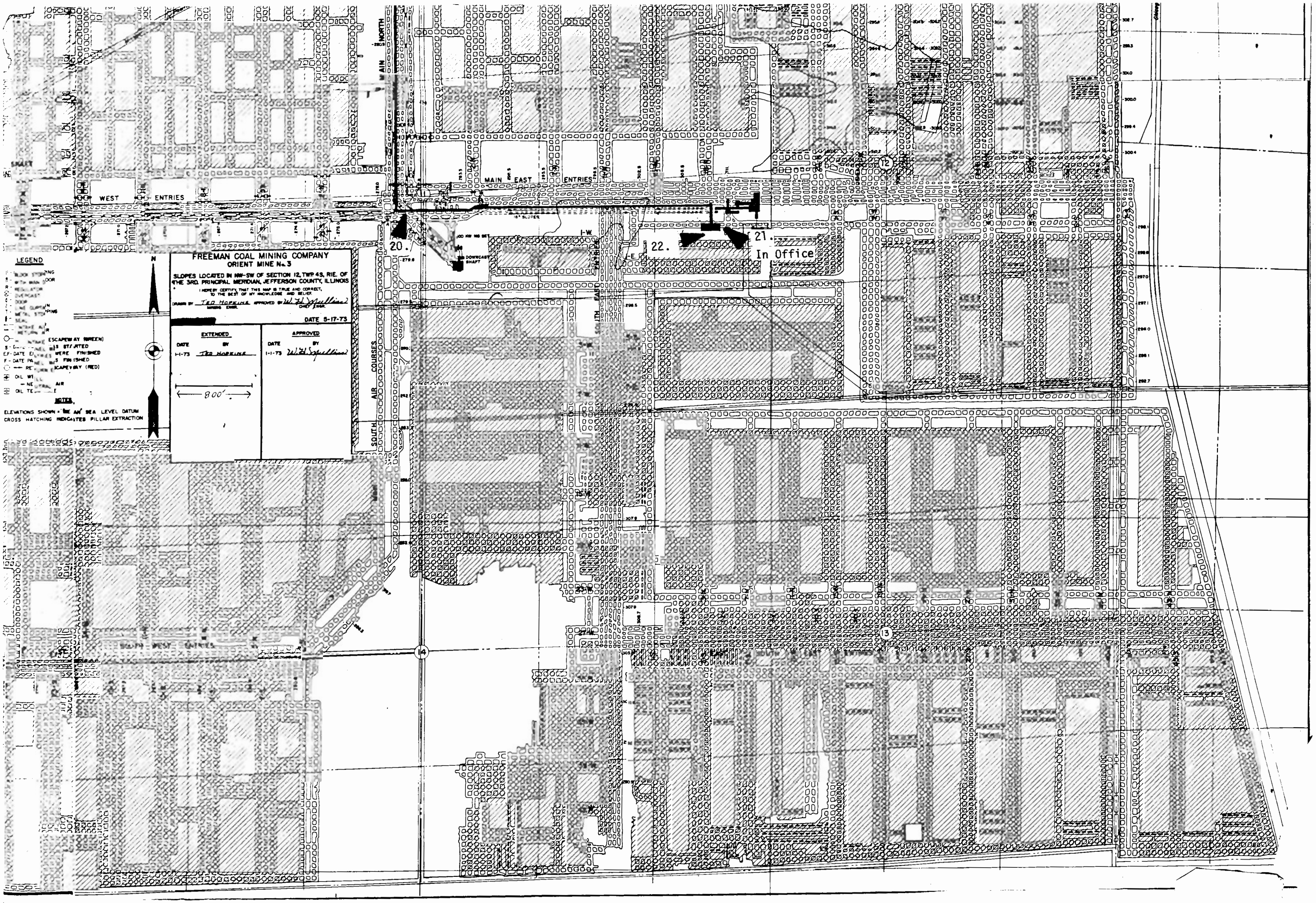
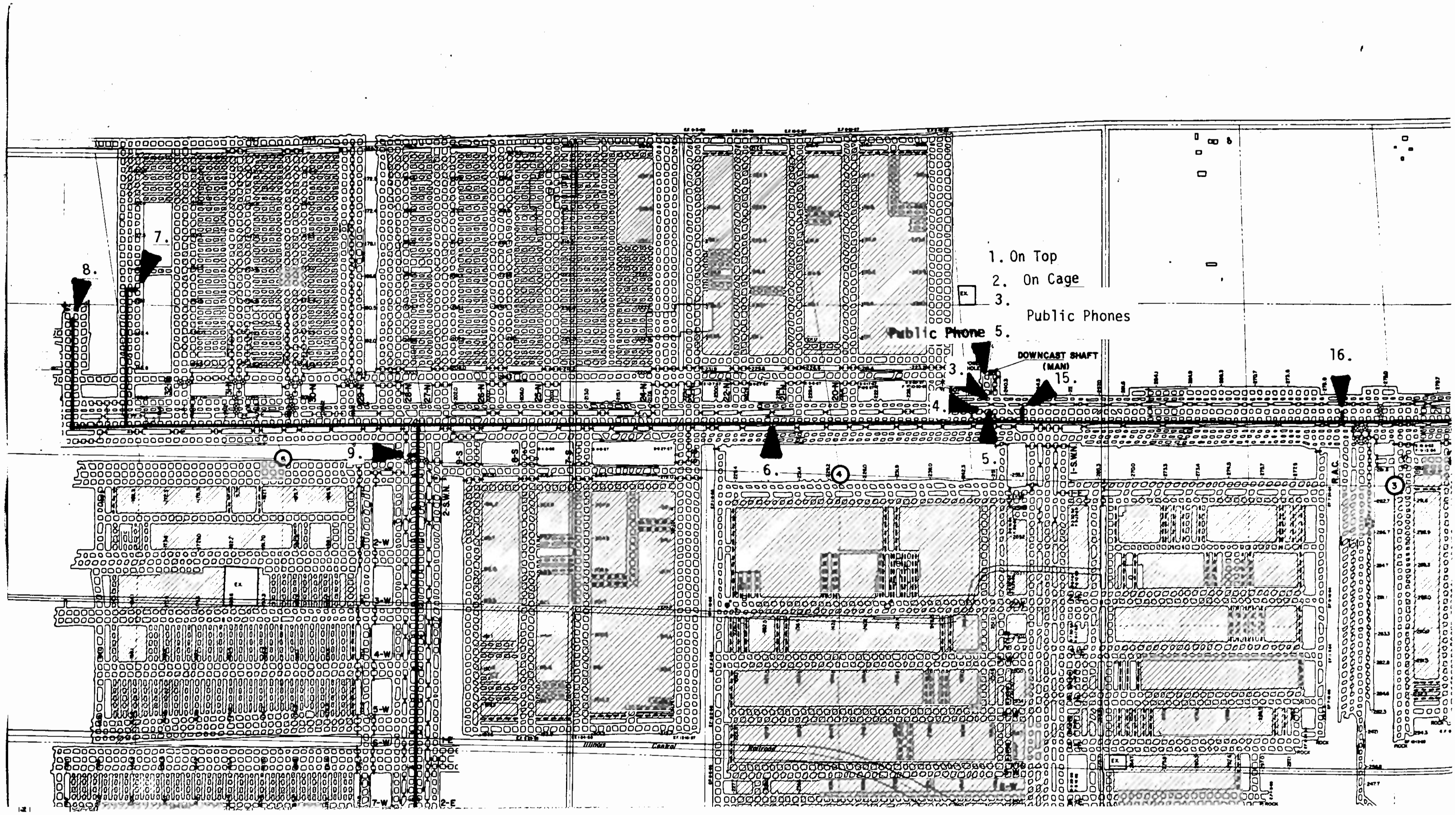


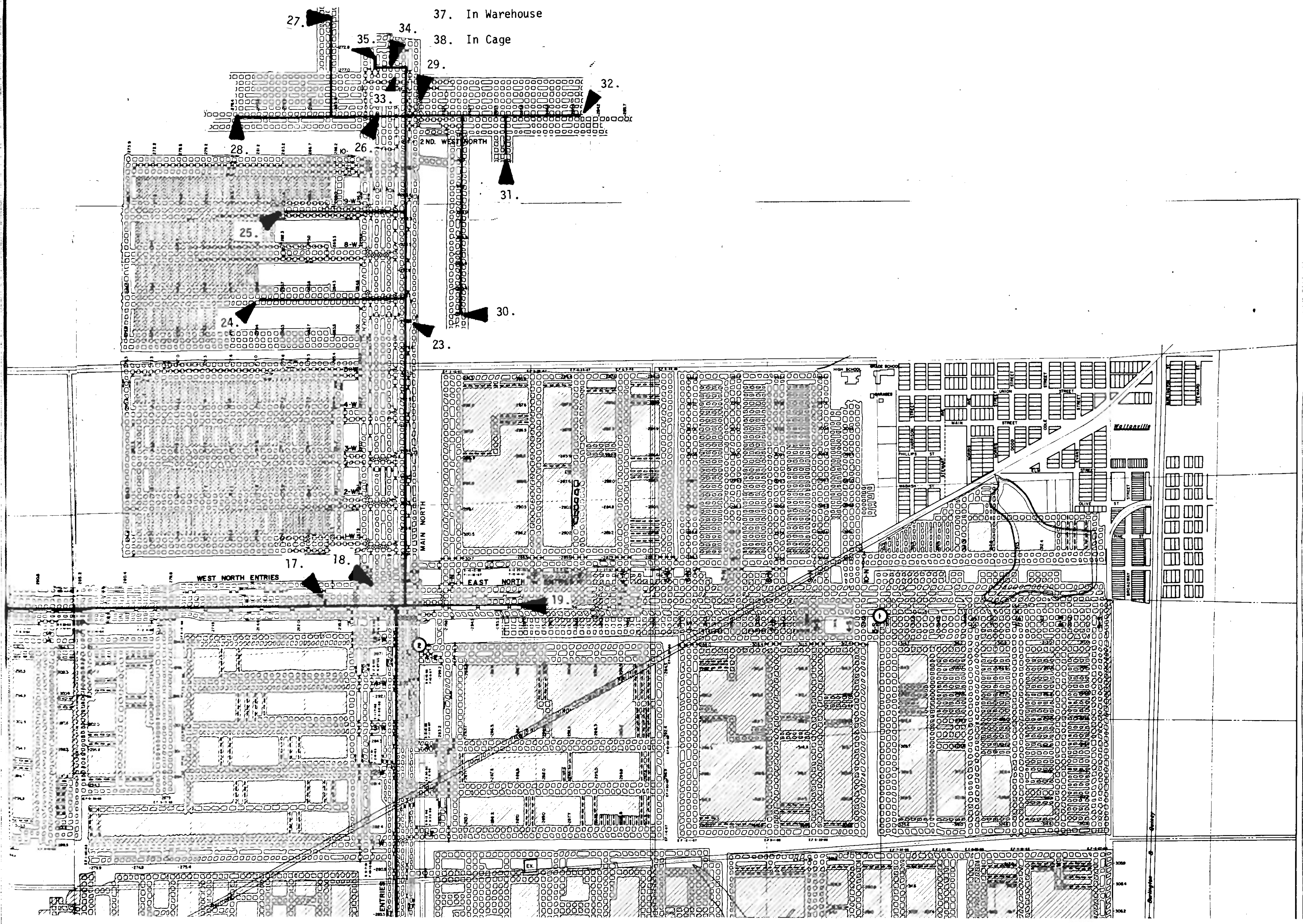
Figure 3-58. Orient No. 3 Mine-Map.


1. On Top
2. On Cage
3. Public Phones
Public Phone 5.
DOWNCAST SHAFT (MAN)
3.
4.
5.
6.
7.
8.
9.
15.
16.
R.A.C.
1-S.W.N.
2-S.W.N.
2-W
3-W
4-W
5-W
6-W
7-W
2-E
Illinois Central Railroad

36. At Top

37. In Warehouse

38. In Cage



3.8.4.4 Support Operations

Support machinery includes the scoops used in cleaning entryways and the ratio feeders required in loading shuttlecars onto the belt. Additional support is provided by the rock dusting machinery. A total of nine scoops roam the mine, removing debris and maintaining the necessary degree of cleanliness. Four ratio feeders are located at major transfer points for loading coal onto the belt.

Support personnel include the scoop and duster operators, plus track layers and maintenance personnel. There is one operator per scoop and per duster, plus 15 maintenance men assigned as necessary for maintenance operations during each shift. An additional 40 maintenance men are assigned to the third shift, during which only maintenance operations are performed. Six to eight men are assigned track laying duties during each mining shift.

For travel to and from the face, there is one mantrip car per working section. One car carries one section crew, and the car remains by the face during the shift.

The section foremen order all supplies for their sections; however, a given foreman orders all supplies of a given type for the following day rather than ordering all supplies for the following shift. Supplies are carried in to the sections by the motorman. Other than supplies ordering, all of the foreman's reports are filled out on top, after the shift ends.

3.8.4.5 Coal Production

The annual production of clean coal for the Orient No. 3 mine is approximately two million tons. Each shift averages 550 tons of coal produced, resulting in a production of approximately 450 tons of clean coal. No figures were available to compare production differences between working sections.

3.8.4.6 Equipment Description

Equipment in use at the Orient No. 3 mine includes the following items:

Lee-Norse miners
Jeffrey miners
Joy shuttlecars
Manson roof bolters
Long-Airdox roof bolters
S & S scoops
Clark scoops
5-ton locomotives

3.8.4.7 Power System and Distribution

Both ac and dc equipments are in use in the Orient No. 3 mine. The basic ac power into the mine is brought in as 4160 V, 3 phase. This is converted at the power centers to both 480 ac and 300 dc. In addition to the power centers at each of the working sections, there is a general center for the mine. This center supplies a 300-volt line, which is run throughout the mine alongside the 4160-volt ac line. Two uses are made of this 300-volt power. Throughout the main haulageways, the mine is lighted. Additionally, whenever a power center is to be moved, it is shut down and the auxiliary 300-volt line serves to power the traction motor used to drag the center forward.

3.8.4.8 Emergency Procedures

There are a total of three entryways into the mine. Two of these are the normal man-entry shafts, the other is the slope entry used for material haulage. In case of an emergency involving one of these entries, the others serve as reserve points.

The safety director commented that one pressing need in case of an emergency situation was a small, lightweight source of oxygen. He commented that there was a Chemox system developed by the Navy during the first world war, which he felt would be highly usable in the event of a mine emergency. He felt that if this were packaged into a 1-hour supply, it would provide for almost any emergency need, allowing a miner to get past a danger point and into fresh air.

3.8.4.9 Foreman's Workload

The foreman must fill out his daily reports after returning to the top; however, this required only a few minutes. A problem exists in calling the foreman when he is needed. Even though the pager phone is located no more than 600 feet from the face, the noise levels are so high that the foreman can rarely hear a page. As a result, it often takes an excessive amount of time to contact him when he is needed. There is also contention for the phone when reports are being made. Several minutes must be spent waiting for the line to clear.

3.8.5 Communications System Analysis

3.8.5.1 Existing Systems

There is a single common or "party line" pager phone system installed, with stations located throughout the mine. The MSA pager permissible self-contained telephone and loudspeaker is used at all stations. These station locations are shown on the mine map included within this report. As shown on the map, there are also a limited number of public telephone extensions located underground. These are all located near one of the shaft bottoms.

The pager phone system includes 38 phone units located in the mine, in the man hoists, and at selected locations on top. These phones have been in use for six to seven years. The system wiring consists of a cable containing two twisted, shielded pairs of no. 22 wires. Each twisted pair is connected in parallel, forming a single shielded wire. The shields are grounded. This cable runs alongside the belt throughout the mine. The route carries it along all main entrys, out the submains, and then to the working sections.

In the time in which the pager system has been in use, it has proven quite reliable. Routine maintenance includes replacing all batteries every six months. Each phone contains two 12-volt batteries. The 38 phones average no more than two to three trouble reports per week. Two technicians are available to perform phone maintenance; however, only a small part of their work involves the phone system. The phones have proven to be very easy to repair. When there is a problem it has normally proven to be either a sticking relay in the pager circuit or a bad amplifier transistor.

The phones themselves have held up well in the mine environment through the years they have been in service. When damage does occur, the most common breakage involves the handset.

In normal mine operation, the phone system is felt to be adequate, excepting the difficulty in calling a foreman at the face. In case of an emergency, however, those persons interviewed felt that a wireless mode would be very desirable.

System communications quality is considered adequate most of the time. The mine covers a fairly large area, however, and when the phones in use are widely separated the signal level gets rather weak. Conversations are still normally satisfactory, even under weak signal conditions, as the line noise is quite low. The only real difficulty that occurs results from a shorted line or a stuck pager relay.

3.8.5.2 System Usage

Throughout most of a given shift the system is in use, with a calling frequency of three to five calls per hour. Most of these calls involve maintenance, with most of them consisting of a foreman placing a call to the maintenance shop. In addition to this steady usage, there are three times during a shift when the usage rises drastically. At the beginning of each shift each foreman calls in to report when his section begins mining coal. During the lunch period the foreman reports the amount of coal mined to that point, and at the end of the shift they call in to order supplies. The report on total coal mined for the day is filled in by hand at the top, so the phone system is not used for this. During these busy periods there is considerable amount of contention for the single available line. The safety director feels that at least three to five phone channels would be desirable to expedite handling of these peak loads.

In addition to the above, the system is used for miscellaneous calls relating to mine operations. The mine manager must stay in touch as continuously as possible. There is a need for him to have some form of a wireless pager, but lacking this he calls to report in every time he passes a phone if he is away from his station. Any stoppage of the belt will generate a call from nearly every section to inquire as to the problem. Most calls of any type do not last more than 15 to 20 seconds.

Nearly all of the calls made originate with the section foreman. Since the foreman rarely hears a call directed to him, the mine management is likely to wait for the end of a shift or a midshift call in to contact a given section. If there is a real need to contact foremen rapidly, the fastest method at the present time is to shut off the belt and wait for calls.

3.8.5.3 Additional Uses

A private channel was considered to be highly desirable. In any multichannel system, the availability of a channel that could be used for management discussions with no possibility of a "party line" being set up with many listening in was favored. To compliment this it was considered desirable that selective calling be included, eliminating the problem wherein it is nearly impossible to contact a foreman at the face. SELCAL would also permit the mine manager to be called while in transit.

Personnel at this mine considered a wireless communication system to be a highly desirable item. Further discussion on the topic disclosed that by "wireless communication" they envisioned a system consisting of a single base station at the bottom, with the ability to contact any supervisor located anywhere throughout the mine. When it was pointed out that the wireless, which was envisioned, would probably have multiple base stations, probably located in the same spots as the present phone stations, some of the enthusiasm disappeared. They still thought, however, that any system that enabled a foreman to be contacted would be a good one.

If a wireless system were available, there would be a definite priority list of those parties who need 2-way communication. At the top of the list are the maintenance foreman, the belt maintenance personnel, the mine manager, and the assistant mine manager. The communicators for these people could probably be mounted on vehicles, thereby permitting greater power and a better antenna system than could be used with a personal portable unit. Two-way communication with the section foreman would be "nice," but it was thought that the only real need was for a paging receiver which would direct the foreman to the nearest phone. The third category who would need at least a pager includes the company safety inspector and his staff plus the union mine examiners. It should be noted that all vehicles in this mine are battery-powered, so there is no trolley phone. As a result, anyone moving throughout the mine is totally out of communication except when he happens to pass a phone and calls in.

Assuming the existence of a wireless system, one channel would be insufficient. A common channel is needed for traffic control on the haulageways. Two to five additional wired channels are needed to handle normal business generated at the working sections. One of these, as a minimum, needs to be a private or "management" line. There also needs to be one or more channels available for paging, plus at least one 2-way private line.

Within this mine there are a number of ways in which the phone system could be used as the heart of a comprehensive mine monitoring system. There are a number of belt controls located throughout the mine that could be monitored and/or controlled from a central location. There are presently many fire monitoring points along the belt. The condition of these could be displayed at a central point instead of relying on regular personnel passage by the point monitored to keep track of conditions. The safety director feels that a more reliable methane monitor is needed, with conditions displayed at one location.

A combination of better communications and monitoring could be used to reduce lost time within the mine. The present method of checking and repairing a belt problem involves several steps. First, a search must be instituted to determine the precise nature and location of the problem. Then this information must be relayed to the supplies depot and the materials dispatched to effect the repair. Effective monitoring would reduce the time required to pinpoint the trouble location, and portable communication would save up to 15 minutes of time required to walk back to a phone and order repair parts. In addition, any questions concerning the problem could be answered on the spot.

While a connection to the public phone system might be considered a nicety, it falls very low on the list of priorities in adding communications capability in this mine. There is no desire to allow outside calls to be made directly to the face, and likewise no desire to permit miners to be made directly to the face, and likewise no desire to permit miners to call out from the section. It was felt that the mine manager can either get a call relayed or wait until he returns to the bottom or top.

3.8.5.4 Equipment Specification Items

The present phone system is of very rugged external construction. The construction is rugged enough, as there has been no breakage of the case or internal components. Since only the one type of phone is used in this mine, no specific comments can be made as to whether a lighter duty phone would be acceptable.

In considering requirements for future phone system designs, the following environmental conditions must be included. The ambient air is moist near the working sections at all times, with a fairly constant temperature of 65 °F. At the shaft top and bottom the ambient temperature and humidity match that of the outside air. These conditions affect the present pagers in the form of some corrosion of the cast aluminum cases. With the use of tracked travelways throughout the mine, there is severe shock and vibration present whenever a vehicle is in motion. Any vehicular-mounted phone unit would have to be either shockmounted or be designed to operate in this environment without degradation.

Both the environmental conditions and maintenance requirements must be considered in designing any future equipment. The internal construction should be modular, with special provision made so a serviceman can locate and replace a faulty module rapidly. The case and internal components must withstand all environmental conditions. External components such as handsets, loudspeakers, controls and indicators must withstand not only the passive environmental conditions but also the use and abuse by the system operators. In the system as presently installed, handsets, cords, and loudspeakers must be replaced at a rate of three to four per year.

While meeting all the above requirements, the units in a system must be capable of being mounted in any of the ways typically used in a mine. These include being attached to vertical timbers, being hung from overhead, and being attached to the sides of rooms and vehicles. A separate category of phone unit is needed which is suitable for placement on the top of a desk.

If the phone units are battery powered, either primary or secondary cells may be used. The comment that was made during the interview was that the rechargeable type would be good, if they worked. In this case the requirement was that they be continuously on charge, not simply rotated continuously back to a charging station. The opinion was, that if the need to make the every six months replacement service could be eliminated, the rechargeable batteries could be as much as 10 times as expensive as the replaceable ones.

In discussing any other new items that would be desirable, the safety director stated that he needs and wants a wireless system. He made it clear, though, that this system would have to consist of a single (perhaps two) base stations communicating with the entire mine. He considers this to be the ideal that he is waiting for.

3.8.5.5 Recommendations

The primary recommendation in this mine involves the addition of communication to the various vehicles moving throughout the mine. Anytime one of the mine supervisors or an examiner leaves his "base" station he is out of communication. There is no communication between vehicles in motion, leading to inefficiencies in traffic control. This lack of communications forces vehicles to travel through the mine with no central dispatcher in control and no way for one driver to tell others where he is and what he is going to do. Since the vehicles are battery-powered there is no trolley line to be used in providing this communication channel. Of the alternative techniques, either a radiating cable laid along the haulageways or wireless transmitter-receivers spaced periodically might be used in providing communications.

The mine examiners and the manager periodically go to locations in which they are totally out of touch. A personal portable wireless unit is needed which will, as a minimum, allow these people to be paged. Far more desirable, especially in the case of the manager, is the ability to carry on 2-way conversations when away from a base unit.

No matter which form of wireless is used, the wired telephone system needs additional channel capacity. This would permit data reporting to take place without the time spent presently by the various foremen, each waiting his turn for the line. If each of the phone stations were individually addressable, there would be no need to page the entire mine in order to locate one man if he were at his normal station. If he were away from his station, some form of wired or wireless "total mine" calling system would be desirable that could be used after he had been called in the normal manner. If there is no system installed in which the vehicles are in constant communication, there should be a number of additional pager phones installed along the trackway. In this manner it would be far easier for key personnel to check in and to be paged when they were on the move.

RELATED CHARACTERISTICS OF MINES AND COMMUNICATIONS NEEDS AND REQUIREMENTS

The following section is the result of taking a look at the collective data and analyses presented in the individual reports. It will be seen that the closely similar requirements and needs of the individual mines can be met by communications systems that are flexible and that interface with the future through allowance for growth, modification, and expansion.

4.1 COMMUNICATIONS QUALITY OF EXISTING TELEPHONE SYSTEMS

4.1.1 Telephone Systems

In comparing the performance quality of the telephone systems in the eight mines, it becomes apparent that those mines having poorer performance are usually the larger, older mines.

This poorer performance appears to be a result of the larger mines generally having older equipment and lines, many more miles of line in the telephone network, and many telephone units on each circuit.

In table 4-1 is listed the eight mines, in order of decreasing communications quality. Rating factors include signal strength, noise, and distortion levels.

Table 4-1. Mine Communications Quality.

MINE	MINE SIZE, OUTLINE AREA IN SQUARE MI	BASIC NO. OF PHONES	RELATIVE AGE OF SYSTEM
Harris	5.0	20	Very new
Lovilia	0.2	4	New
Baldwin	2.2	15	Very new
Somerset	5.5	7	Medium
Orient	20.0	38	Medium
Greenwich	7.3	43	Medium
Robena	9.5	41	Old
Keystone	35.0	77	Ancient

Note that with the exception of Harris and Orient the ranking of decreasing quality agrees with the order of increasing mine size in terms of rectangular outline square miles. And again, with the exception of Harris, the greater the number of telephones, the poorer the performance quality. Table 4-1 also shows that the age of equipment -- including the telephone line distribution networks -- correlates well with the size and age of the mines.

4.1.2 Harris Differences

Of the eight mines, Harris in the only one that has all new equipment and lines. The mine management brought in communications specialists to integrate the telephone units and the telephone distribution network with the mine and its other systems. This points out the value of providing the industry with systems integration effort as well as with new communication equipment design.

4.2 REQUIREMENTS TO MEET PRESENT AND FUTURE TELEPHONE COMMUNICATIONS NEEDS

The mines surveyed represent a good cross section of the industry in terms of size, age, mining methods, and haulage means. A phone system meeting the needs of these eight would, therefore, be a candidate worthy of consideration for the industry as a whole.

For those few mines whose present communications are not obsolete, a cost savings can be realized while providing them with the new, higher capability equipment. The new equipment can be compatible with the best of presently installed systems so that the two can operate together until the older equipment reaches the end of its economic life. The cost savings will result from a sharing of the older but adequate telephone lines by both the old and new equipment.

A second concept is that the system capabilities should be expandable. Thus, present unsophisticated needs can be met without paying the price of higher-than-needed performance, and the simple system can be expanded, rather than requiring replacement, as future higher performances become necessary. With these two basic concepts as a guide, and with the survey results, we now face the problem of defining a communications system that will satisfy the specific needs of the eight mines, at a reasonably cost-effective price.

4.2.1 Channel Capacity Requirements

Just as the need for an expressway is never appreciated until after the always surprising traffic count is made, so too the operators at these eight mines do not think they have a need for additional channel capacity. Yet the statistical analysis of the phone systems tape recordings, and a knowledge of the significance of channel capacity in the telephone industry, lead to the conclusion that at each of these eight mines efficiency, effectiveness, and safety would be improved if there were greater channel capacity. The following list identifies the channel requirements for each of the eight mines surveyed:

MINE	CHANNELS NEEDED
Lovilia	3
Orient	5
Baldwin	4
Harris	4
Somerset	4
Robena	5
Greenwich	5
Keystone	6

It should be noted that these requirements are only for underground communication traffic and do not include the additional channels required for monitoring or surface communication. Depending upon the scheme used, a phone system that includes surface and monitoring traffic would require many more channels.

A cost effective requirement that would meet the needs of these mines would be for a basic 6-channel phone system, that could easily be expanded to eight and 12 channels for larger mines, and for the future needs of the present smaller mines. Phone systems up to eight channels should be compatible with the better of the present telephone line distribution system at least, and at best, also compatible with newer pager-phone telephone units.

4.2.2 Secure Accident-Reporting Channel

There is a unanimous opinion -- both among mine operators and the engineers on this project -- that a secure channel is needed for seeking aid for an accident victim in the fastest and surest way possible, which will not broadcast the news to every man in the mine.

Thus a telephone system requirement is that the user of any telephone shall have the option of selecting a channel that allows only communications between himself and a continuously manned station, such as the Communications Center operator, the supply room, or a hoist operator's station. Of course this central station must have access to a public phone. In lieu of this, the in-mine phone user shall have the option of direct accessing, over a public phone system, a doctor, hospital, or ambulance service.

4.2.3 No Battery Replacement Requirement

Rechargeable batteries should be used to power the telephone system and these should be trickle charged from power on the telephone lines. This is necessary in order to meet the requirement that a telephone unit shall have a minimum mean-time-between-servicing of one year.

4.2.4 The Basic Telephone Unit

The above constitute the requirements for the basic telephone unit, to which add-ons can be attached to extend the phone system's capability. Thus the small mine, requiring only limited capability, will need to pay for only what it needs.

In summary, the basic telephone unit will satisfy the above requirements by having the following characteristics:

a. Six channels with expansion capabilities to 12.
b. A secure emergency channel where the conversation can only be heard at the one in-mine station placing the call or at the center being called.
c. If no center exists, using the emergency channel will automatically cause a tie-in with the public phone system and dial an emergency number.
d. The mean time between servicing shall be at least a year, including any attention for telephone unit batteries.
e. The new phones must be compatible with reasonable quality present phone systems, and must be able to share the existing distribution network.

4.2.5 Add-On Features Requirements

As stated before, the basic phone unit should accept add-on modules to expand its channel capacity from 6 to 12. Besides the conventional voice telephone channel, modules shall be available for the following additional communications uses:

a. Sensor Data Transmission

   Environment, safety, or production monitoring data supplied to this unit would be transferred to a communications center for processing over an added telephone channel.

b. Remote Control

   A telephone system module should be available to allow remote control functions over an independent channel between any two telephones in the system.

c. Personal Portable Extension

This module would allow wireless 1-way paging or 2-way voice communications within reasonable distance from the fixed phone having the module and any other phone in the system.

d. Mobile Relay Station Module

This add-on channel provides a means of relaying signals between wireless transmit/ receive stations located near telephone units and wired thereto.

4.3 A COMPOSITE OF EXISTING TROLLEY SYSTEMS

Of the five mines having track haulage, four had trolley communications systems -- little Lovilia, with its single loop of track, had no need. Of the three belt haulage mines, only Greenwich had a trolley-phone system. A composite trolley-phone system can be conceived from the characteristics of the systems in these five mines.

A general look at trolley phone systems shows that they work very well indeed--considering the physical, electronic, and acoustic abuse under which they must exist.

Rugged as the vehicular equipment is, it is barely physically adequate. Mike cord breakage and switch failures are the main problems, with physical abuse from miners following. The fact that the highly directional speakers are often not aimed at the vehicle driver might also be called a physical problem.

The main electronic problem is that trolley phones must operate with a transmission system whose carrier frequency characteristics are completely undefined and vary widely from mine to mine. For instance, the 88-kHz back impedance of the dc trolley supply rectifiers and the dc vehicle and nip point loads are unknown and uncontrolled, and the propagation of rectifier generated electric interference, throughout both the ac and dc power systems, is uncontrolled. Having an uncontrolled and poorly matched transmission system results in high distortion, low signal strength, and in general a barely adequate system. The existing situation is only saved by using high power transmitters, and receivers having wide dynamic ranges.

Most of the time ambient acoustic noise levels are so high that loudspeaker gain controls must be run wide open, resulting in distortion in the amplifier, the speaker, and probably even in the human ear. Whether or not equipment was designed for the level and characteristics of acoustic noise can be questioned.

In spite of these drawbacks, miners have adapted to the situation and utilize the trolley phone systems very well. During all of our visits to mines it was rare that a repeat was ever asked for on the trolley phone systems. It should be kept in mind, when implementing any new, higher capability system, that the users will be habit-bound to their old operating procedures, and that the new system's full value won't be realized until new, more efficient procedures evolve.

4.3.1 Present Values of Trolley Phone Systems

Without a detailed industrial engineering study, it is impossible to say the exact extent to which the use of trolley-phones contributes to a mine's productivity and safety. But some insight can be gained from seeing the present level of usage the industry has found necessary -- recalling that mines have had years to optimize their operations, by trial and error, in a highly competitive industry.

One would suspect that the degree of trolley-phone usage would relate directly to track haulage rate in tons of coal per shift. Total mine output in tons per year would not be the best measure of trolley phone need because the mines visited had different shifts per workday and work days per week; yet yearly output is an easily obtained statistic so we shall see of what use it might be.

Figure 4-1 is a scatter diagram having coordinates of yearly tonnage and peak percentage of time trolley phones were used. The plotted points are those for the five track haulage mines we visited. Note that trolley-phone usage correlates very closely with yearly output for all mines except Robena. The fact that all trolley-phone messages at Robena must be repeated would account for some of its relatively higher usage. It would be a worthy challenge to determine the degree to which extensive trolley-phone usage contributes to US Steel's outstanding safety record at Robena.

It would seem reasonable that trolley-phone usage would be related to the number of phones in service at each mine. Figure 4-2 presents the relationships and shows that such a trend exists, but it can hardly be called a close relationship.

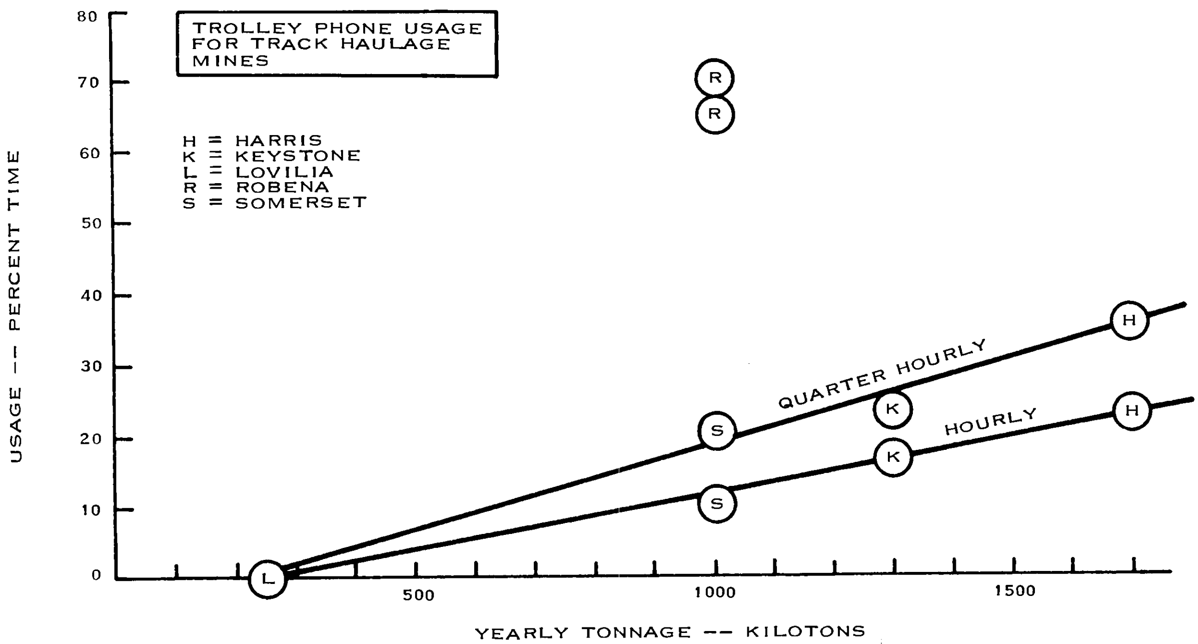


Figure 4-1. Trolley Phone Usage for Track Haulage Mines - Yearly Tonnage.

In both figures the Keystone data has been adjusted to reflect that the Keystone trolley consists of two sections in series, a 250-volt system and a 550-volt system. Each section has its own independent trolley phone frequency, and the peak percentage usage used on the scatter diagrams is the sum of that for each independent system.

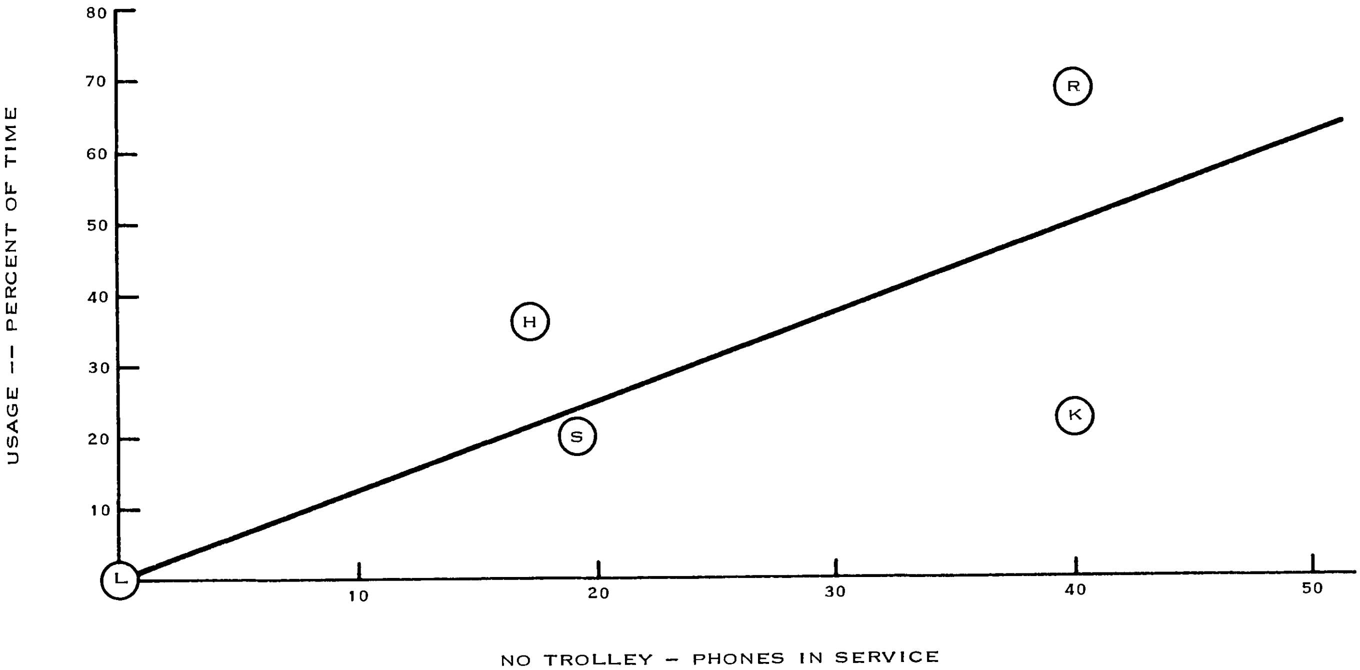


Figure 4-2. Trolley Phone Usage for Track Haulage Mines - No Trolley Phones in Service.

Note that although Harris had by far the cleanest trolley-phone system, the improved performance does not show up as exceptionally low duty cycle or usage per ton of coal mined.

4.3.2 Trolley-Phone Requirements

The physical ruggedness requirements for vehicular-mounted trolley phones must at least equal that of the more rugged present designs. In addition, abuse and harsh environment dictate that electric cords and all switches be required to meet higher standards than can any present equipment. Loudspeakers must be separable from trolley phone units and swivel mounted, such that the loudspeaker may be easily mounted and directed independently of the trolley phone mounting location and position.

Audio frequency amplifiers must have sufficient gain and frequency preemphasis to optimally overcome high ambient acoustic noise levels and frequency characteristics. Amplifiers must provide such output without distorting the signal, and the system gain and signal-to-noise characteristics should be such that the transmitter operator has no tendency to overdrive the system in attempting to compensate for deficiencies.

The use of frequency diversity should be used as a means of overcoming two uncontrolled variables that normally degrade the performance of trolley phone systems. Voltage and current standing waves will exist on the trolley line if its length is a significant part of a wave length at the phone operating frequency. By judiciously choosing the two diversity frequencies, it will be unlikely that at any point in the mine a null will exist at both frequencies. With diversity operation, the dc sources and loads of the trolley system will not load the trolley-phone system at both frequencies. This results since the impedances of the carrier frequencies will differ; thus the loading effect of each dc device will be less at one of the two frequencies.

System components are required to ensure effective use of the trolley power distribution system for communications use. This includes filters to keep rectifier hash from the trolley line, filters to prevent power-equipment-generated interference from being returned to the trolley line, bandpass filters to carry only the communications signal across dead-blocks, and blocking networks to prevent power-utilizing equipment from loading the trolley lines at communications frequencies.

Completing the requirements for trolley phone systems is test equipment for installing and maintaining the system. This equipment is needed to ensure the compatibility between the trolley-power and trolley-phone systems both for initial installation and for the continuing extension of the trolley system. The same test equipment will be needed for troubleshooting and maintenance, to maintain a minimum grade of system performance.

4.4 LONGWALL COMMUNICATIONS

Of the eight mines visited three were doing longwall mining. Of the three longwall miners, two were down for unscheduled maintenance. Interviews with mine personnel suggest that this is not an unusually great downtime. Thus, a requirement for longwall communications is that it must aid in reducing maintenance downtime as well as aid in increasing productivity. To be of acceptable value, hands-free operation must be possible between all maintenance and all operating personnel on the longwall. And with time being of the essence, longwall maintenance personnel must have convenient, instant communications with the communications center operator, and maintenance and supply shops as well.

One trip crawling through an operating longwall system in low coal is sufficient to verify the need for small, lightweight wireless personal portable units.

Realization of the cost of lost production from such a high capability machine being down justifies a requirement for an extraordinary mean-time-to-failure for communications equipment. Considering the large investment in and the high production volume capability of longwall mining equipment, failure of supporting communications gear is almost unacceptable. This high reliability must be maintained though the personal portable units are subjected to the water and dust environment, and to the mechanical abuse from men who have more important things to do than baby their communications equipment.

4.5 COMMUNICATIONS CENTER REQUIREMENTS

There are two fundamental requirements for the communications center. First the center must be expandable and flexible, so that its capability can grow with the mine, and so that more effective operating procedures can develop as more efficient uses of communications are found.

The second fundamental requirement is that, whenever the option presents itself, the communications center be located outside with multiple signal paths to the inside. An outside location will provide an environment more conducive to greater output from both the center and its operator. Good communication paths and multiple communications paths discount two of the three arguments for putting the center underground. The third argument, cost, will more than be offset by increased motivation of the operator, a better environment for equipment and other human factors.

The requirements for growth must be such that the communications center can most economically be expanded from a simple monitoring operation by a clerk or hoist operator, to a complex data center having a full-time operator, as the small mine is expanded.

Besides serving as an information center, the communication center must conveniently and efficiently interconnect the various networks, and also serve as a broadcast center for full-coverage announcements to all mine personnel. On request, any station, such as a trolley-phone station, must be able to be patched to any telephone station, longwall personnel, or the outside public phone system. For safety reasons the communications systems operator must be able to make announcements to everyone in the mine, with the assurance that he will be heard by all underground personnel.

4.6 ALARM SYSTEMS

Automatic alarm systems at the mines visited were all for fan stoppage warning, except for Greenwich where belt fire detectors will put tape recorders "on-line," broadcasting the problem location over the speaker phone system. Some mines were nearing completion of the beltline fire detector systems now required by law, and all belt haulage mines had done at least the initial work in obtaining such systems.

Interface requirements for alarm and monitor systems are simply that they be compatible with voice-grade communication distribution systems. Economics dictates that alarm and monitor sensors utilize communications networks for the transfer of data to the communications and monitoring centers.