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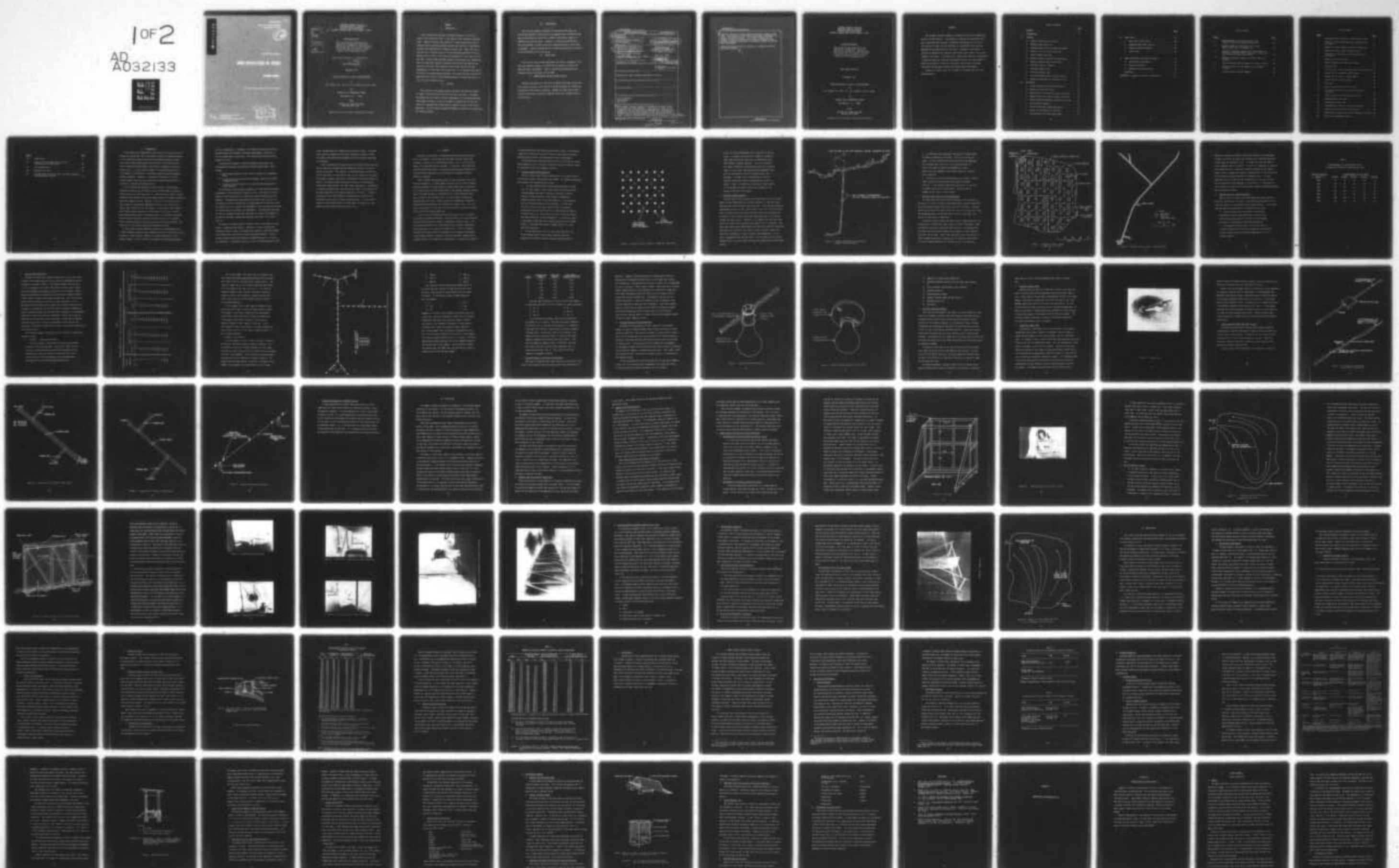

FINAL REPORT 44U-862-2

MINE UTILIZATION IN CRISES

PLANNING MANUAL

Approved for Public Release; Distribution Unlimited

RESEARCH TRIANGLE INSTITUTE
OPERATIONS ANALYSIS DIVISION
APPLIED ECOLOGY DEPARTMENT
RESEARCH TRIANGLE PARK, NORTH CAROLINA 27709

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DETACHABLE SUMMARY

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FINAL REPORT 44U-982-2

September 1976

Mine Utilization in Crises - Planning Manual

by

M.D. Wright, S.B. York, III, D.R. Johnston, and M.N. Laney

for

DEFENSE CIVIL PREPAREDNESS AGENCY

Washington, D. C. 20301

under

Contract No. DCPA01-74-C-0266
DCPA Work Unit 1217E

SUMMARY

I. INTRODUCTION

One of the options available to defense planners in the area of nuclear civil protection (NCP) is the idea of crisis relocation planning (CRP). Under this option, the residents of likely target areas are relocated to more sparsely populated areas during a period of international tensions with implications of leading to nuclear war. Under such plans, the provision of fallout shelters for the relocated population in the reception areas is vital if the life saving potential of such plans is to be realized. Previous DCPA-sponsored research has indicated that underground mines not only offer superior protection from fallout radiation but are also one of the most cost-effective of the shelter options available. Consequently, in areas where such mines exist, it is important that they be utilized to the maximum extent possible. This manual provides guidance for developing plans for utilizing underground mines as fallout shelters as a part of crisis relocation plans.

II. LIGHTING

This section of the guidance manual identifies the preferred layout of lights in both room and pillar and drift and stope mines. Procedures for determining the material and tool requirements and the engine-generator requirements are given, as well as guidance in selecting sites for positioning the equipment and connecting the lighting circuits to the engine-generators. Also included are suggested methods of installing and operating the lighting systems.

III. VENTILATION

This section presents a procedure for determining the amount of ventilation required in mine shelters and suggests means of obtaining the required ventilation by installing a complete ventilation system or by augmenting an existing system. Guidance in selecting and positioning fans and generators is given along with suggested sources of these items of equipment. Several alternatives for achieving the required distribution of the ventilating air are also given.

IV. WATER SUPPLY

This section gives minimum requirements for water in emergency situations and presents guidance in identifying the necessary resources for obtaining these requirements. Means of achieving and maintaining the necessary purity of the water are outlined.

V. HUMAN EXCRETA AND SOLID WASTE DISPOSAL

Minimum requirements for facilities to handle both human excreta and solid waste are given in this section along with guidance for identifying and obtaining the necessary resources. Methods for achieving and maintaining the necessary sanitation standards during the in-shelter period are also given.

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This document provides guidance to planners on the use of underground mines as fallout shelters. The guidance is based on the assumptions that only locally available materials, equipment and manpower will be available and that 72 hours will be available for accomplishing the required upgrading of the habitability of the mines. Guidance is provided for installing or upgrading the NEXT Page

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lighting, ventilation, water supply, and sanitary systems in the mines. The guidance for lighting and ventilation improvements is based on previously conducted experimental studies, and the guidance in water and sanitation is based on information from existing literature concerning such emergency systems and minimum human requirements.

Example utilization plans are included to illustrate the use of the guidance manual.

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ABSTRACT

This document provides guidance to planners on the use of underground mines as fallout shelters. The guidance is based on the assumptions that only locally available materials, equipment and manpower will be available and that 72 hours will be available for accomplishing the required upgrading of the habitability of the mines. Guidance is provided for installing or upgrading the lighting, ventilation, water supply, and sanitary systems in the mines. The guidance for lighting and ventilation improvements is based on previously conducted experimental studies, and the guidance in water and sanitation is based on information from existing literature concerning such emergency systems and minimum human requirements.

Example utilization plans are included to illustrate the use of the guidance manual.

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I. INTRODUCTION

In the event of an international crisis, which has the possibility of ending in a nuclear war, one of the options available to defense planners is the relocation of people from large concentrated population centers. This option protects those people from the high risk of receiving the direct effects of nuclear weapons which might be targeted on our metropolitan areas. In such an event, however, the dispersed population is still subject to the effects of the fallout radiation which accompanies nuclear explosions. Therefore, if population relocation is to be an effective means of saving lives, plans must be made to provide fallout protection in the host or reception areas.

A recent study by the Research Triangle Institute indicated that underground mines are one of the most cost-effective means of providing fallout shelters in such areas (Ref. 1). Mines offer very nearly complete protection from radiation and have the added advantage of offering protection from direct weapons effects. However, if mines are to be used to house large numbers of people under emergency conditions, it is necessary to improve their habitability to some extent. In most cases, these improvements should include providing a minimal degree of lighting to prevent people from becoming lost or frightened, providing sufficient ventilation to maintain the oxygen and carbon dioxide concentrations at acceptable levels, providing potable water for consumption and personal hygiene, and providing for the sanitary handling and disposal of wastes.

In view of the excellent sheltering capability of underground mines, it seems reasonable that mine space should be utilized to the maximum extent possible in a CRP situation. Because of current limitations in civil defense funding, it is not feasible to upgrade existing mines beforehand, for use in emergencies. Therefore, it is important that plans outlining expedient means of providing the necessary improvements in mines on a crisis oriented basis be available. This manual was prepared with this objective in mind.

In developing the manual, certain assumptions pertaining to the implementation time and to the period of occupation were made. These include:

1) Mine occupancy within 72 hours of the initiation of contingency plans,

2) The use of only locally-available equipment, materials and labor in upgrading mines,

3) A maximum in-shelter period of 2 weeks after the detonation of nuclear weapons.

The following sections describe procedures for providing the necessary improvements in mine habitability during a crisis. The manual is not intended to be all-inclusive but is meant to be used for guidance by local planners. The methods described may not be the best ones to use in all circumstances, and the availability of various materials at the local level may prohibit the use of some of the improvements or may be cause for choosing alternative means of providing the improvements. The procedures described are felt to be workable under most conditions and some of the methods described for providing lighting and ventilation have been field tested (Ref. 2).

The manual is divided into four sections; each section deals with one aspect of upgrading mine shelters. Section II is concerned with mine lighting; Section III deals with ventilation; Section IV describes methods of providing water, and Section V deals with waste disposal. In each section, planning tasks which need to be accomplished prior to a crisis are identified. In addition, Sections II and III provide guidance for the actual implementation of lighting and ventilation systems. The manual also contains an appendix which gives illustrative examples of mine utilization plans which were developed using the guidelines presented in the manual.

Prior to preparing utilization plans for a specific mine, the local planner should be provided with the sheltering capacity (in terms of people) of the mine. This capacity is determined either by the floor area of the mine or in shaft entry mines, by the capacity of the hoists (the number of people that could be transported into the mine within 72 hours). This capacity should be used as the basis for determining ventilation, waste disposal and water supply requirements. Calculations of sheltering capacity by floor area may vary from 10 to 30 square feet per space depending on the general conditions in the mine. In mines having clean level floors which are completely dry, people may be sheltered at the rate of 10 square feet per person. In mines having uneven or rock-littered floors or having damp or wet areas, up to 30 square feet should be allowed per shelter space.

II. LIGHTING

Generally, the interiors of underground mines are completely dark. This is an unnatural and frightening environment for most people and, therefore, if mines are to be habitable during a crisis, at least some degree of illumination must be provided. If possible, lights should be installed before the shelter is occupied and should take precedence over the ventilation system which can be installed or upgraded after the shelter is occupied.

From a lighting system design point of view, underground mines fall into two categories: (1) mines where room and pillar or similar methods have been employed to extract the ore, leaving large rooms suitable for use as shelter and, (2) mines where other mining methods (stoping, caving, etc.) have been utilized, in which most or all of the habitable floor area is found in the haulage drifts. In the following procedure for designing and installing a lighting system, the fundamental differences between these two categories are reflected in Steps B and C. Part 1 of each step pertains to a room and pillar mine and Part 2 pertains to mines where other mining methods were used.

If mines are to be effectively utilized during a crisis situation, plans must be prepared beforehand. Steps A through H below are concerned entirely with the planning stages of providing a lighting system. The remaining steps describe the installation of the lighting system which would take place in the event of an actual crisis. The only planning associated with these steps is the estimation of resource requirements and the identification of sources of tools and materials (hammer drills, expansion bolts, etc.) required for installation. An electrical engineer or experienced electrician would be particularly useful in the planning stages and, if possible, to help in laying out the lighting circuits, preparing specifications, and estimating resource requirements.

In developing the lighting system for a mine, a mine map (or sketch drawn roughly to scale if no map is available) should be used as a means of identifying circuit and equipment locations.

A. Identify Light Fixture Locations

The first step in the lighting system design is the identification of locations at which light fixtures are needed. The following paragraphs offer guidance for accomplishing this step.

1. In mines characterized by large rooms separated by pillars left for roof support, light fixture locations should be identified throughout the areas of the mine to be used as shelter. Generally, these should be in the centers of quadrangles defined by sets of four pillars and should be spaced at approximately 100-foot intervals in each direction. In most mines, this will result in the lights being located in alternate quadrangles, but the location will be a function of the spacing of the pillars (e.g., in a mine with pillars on 100-foot centers, the lights should be in every quadrangle). If the pillar layout is not known, a spacing 50 to 60 feet on centers may be assumed. Figure 1 illustrates the spacing of light fixtures in a room and pillar type mine.

2. In mines where most or all of the usable floor area lies in the haulage drifts, light fixture locations should be identified at 100-foot intervals along the habitable drifts,

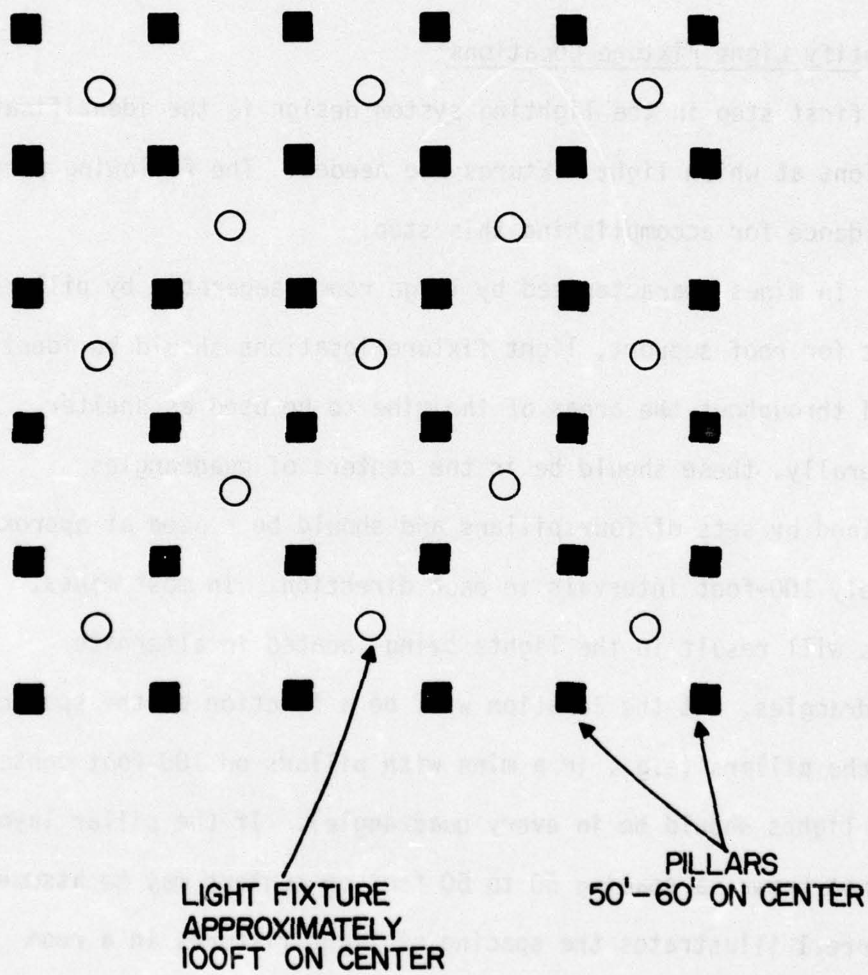


Figure 1. Spacing of Light Fixtures in a Room and Pillar Mine.

as well as along uninhabitable drifts that must be used as access. If stopes are found to be suitable for occupancy, light fixture locations should also be identified within these stopes at regular intervals. The ceiling height of the stopes is often too high to permit access for attaching lights, in which case, the fixtures may be attached to the walls at approximately 100-foot intervals around the perimeter. If lights can be installed in the ceiling, locations should be identified approximately 100 feet on center. Figure 2 illustrates the spacing of light fixtures in a mine where the usable floor area is located in the haulage drifts and in one stope.

B. Identify Lighting Circuits

Once the light fixture locations have been identified and the total number has been determined, the fixtures should be divided into groups with each group constituting a separate circuit. This grouping should be accomplished so that the total load on each circuit will be sufficiently small to permit the use of readily available wire sizes as feeders and to permit the use of readily available engine-generators as the source of power for each circuit. Generally, this requires that the total load current for each circuit be kept in the range of 10 to 15 amperes. This means that groups having approximately 36 lights each should be identified. Each group will constitute one circuit, having a separate feeder line which may be powered by a single, portable engine-generator. If the mine is composed or more than one level, circuits should not be divided between levels, since this would unnecessarily complicate the installation process.

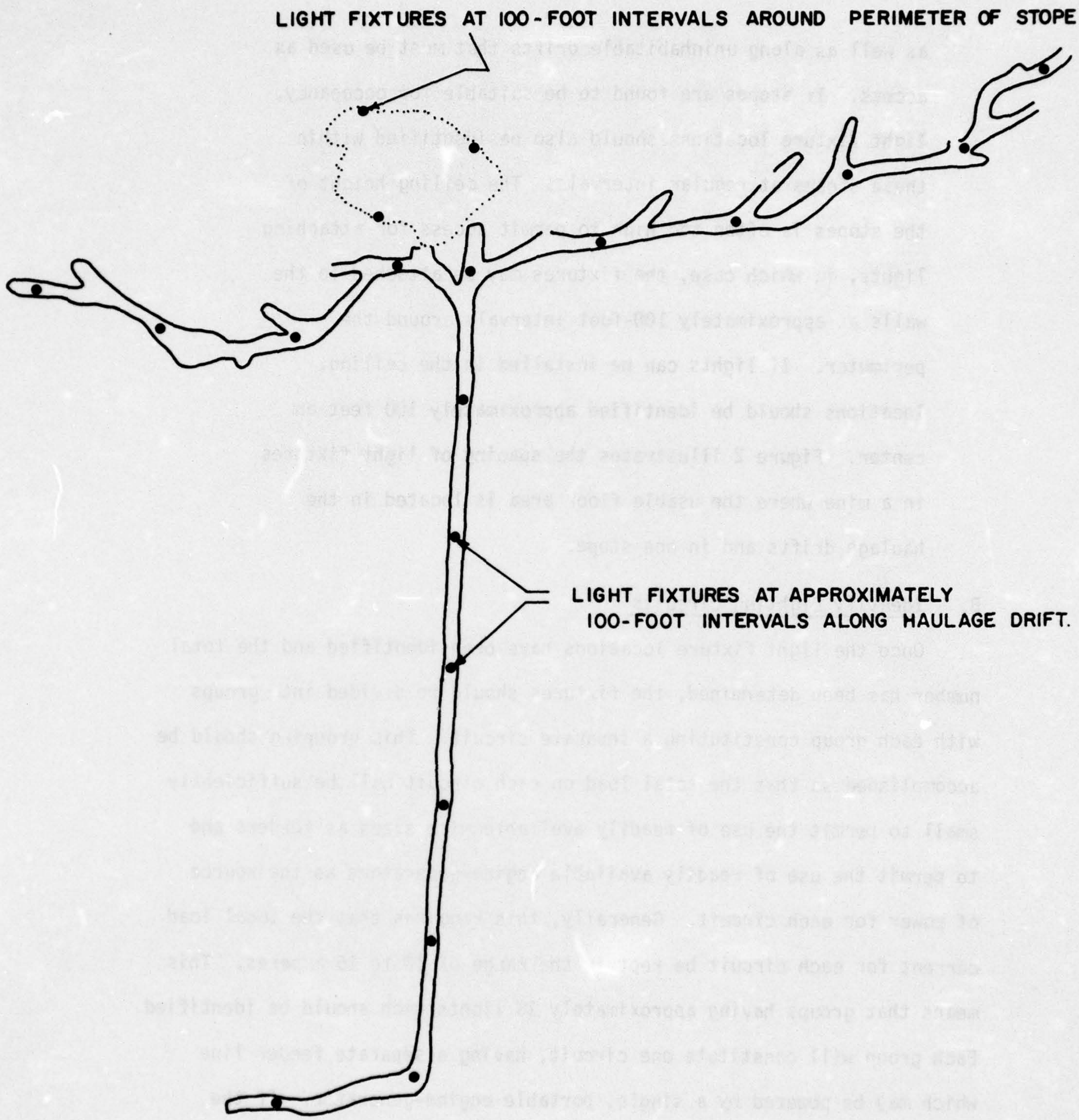


Figure 2. Example of Light Fixture Spacing in Haulage Drifts and Stopes

1. In room and pillar type mines, the groups of lights should be chosen as compactly as possible. This will serve two purposes: (a) the installation of the circuits will be expedited, and (b) should one circuit fail, its associated area will receive low levels of light from neighboring circuits. Figure 3 gives an example of the circuit layout in a room and pillar type mine.

2. In mines in which the haulage drifts are utilized, alternate lights along the drifts should be connected to different circuits. In this manner, should one circuit fail, a low level of lighting would still be maintained. Figure 4 gives an example of this type of circuit layout.

C. Determine Availability of Engine-Generators

To insure that sufficient electrical energy will be available in the event of a crisis, sources of engine-generators should be identified and a determination made of the numbers and sizes available. Estimates should also be made of the quantity of fuel that will be required to keep the engine-generators running continuously for up to two weeks, and sources of fuel should be identified.

In general, the most widely available types of engine-generators are single-phase, 120-volt with a power output of 1500 to 5000 watts. Most construction contractors own one or more such units, and consequently, the number available around industrial and commercial areas should be sufficient for the need. Other larger generating units are available in smaller numbers from rental companies and civil defense supply depots. In matching engine-generators to lighting circuits, care should be

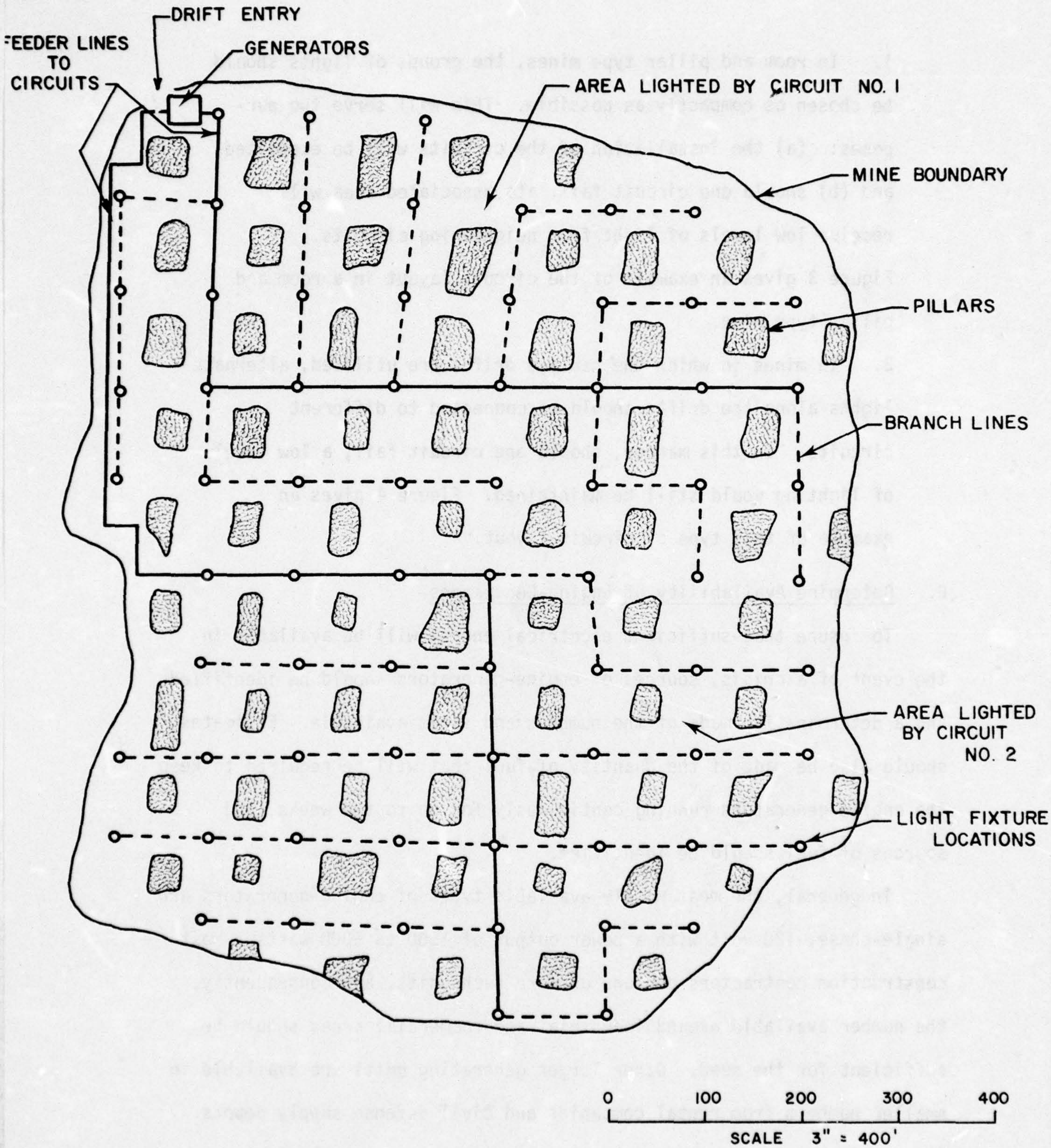


Figure 3. Example of Circuit Layout in Room and Pillar Mine.

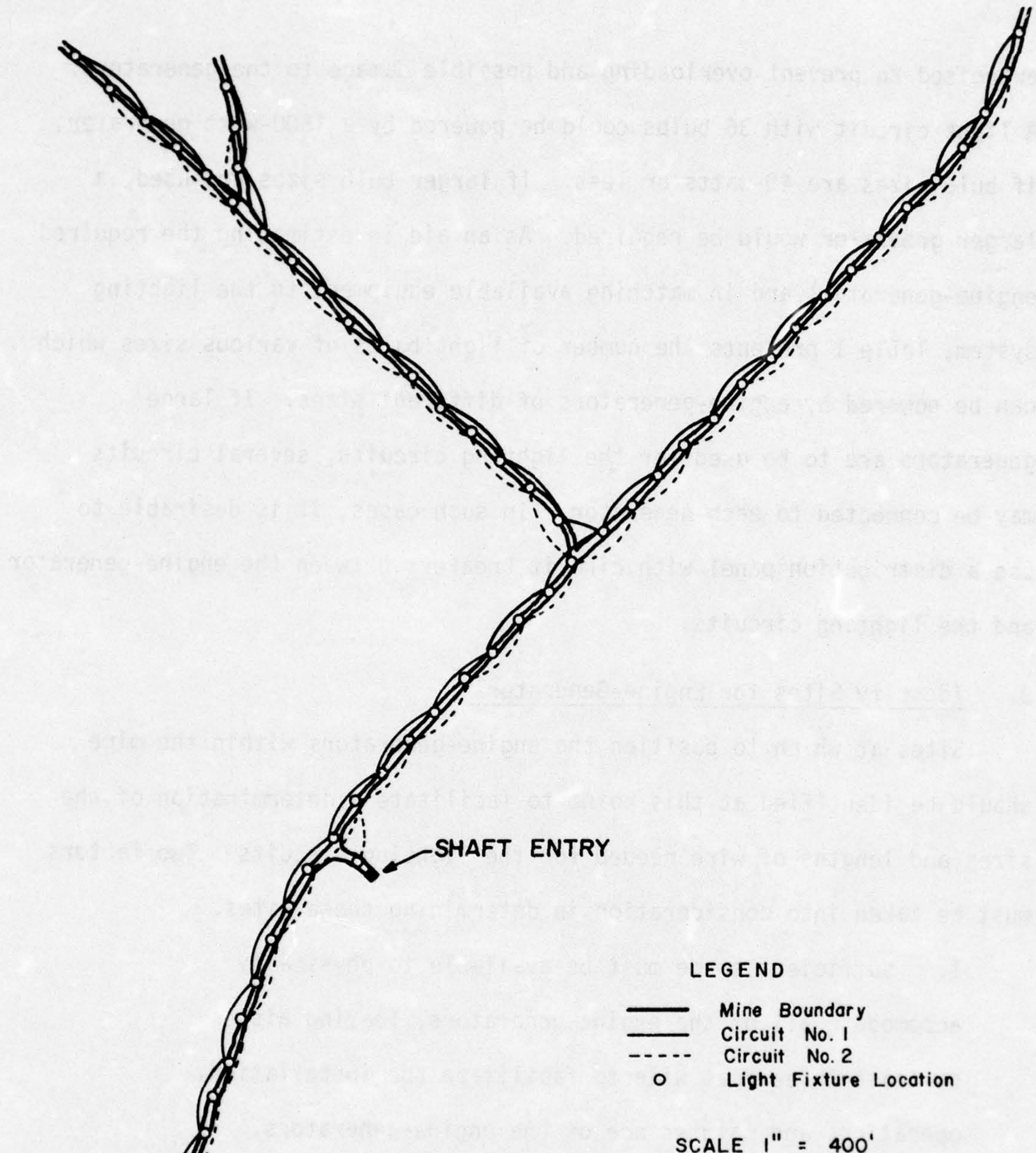


Figure 4. Example of Circuit Layout in Haulage Drifts.

exercised to prevent overloading and possible damage to the generators. A light circuit with 36 bulbs could be powered by a 1500-watt generator, if bulb sizes are 40-watts or less. If larger bulb sizes are used, a larger generator would be required. As an aid in estimating the required engine-generators and in matching available equipment to the lighting system, Table 1 presents the number of light bulbs of various sizes which can be powered by engine-generators of different sizes. If large generators are to be used for the lighting circuits, several circuits may be connected to each generator. In such cases, it is desirable to use a distribution panel with circuit breakers between the engine-generator and the lighting circuits.

D. Identify Sites for Engine-Generators

Sites at which to position the engine-generators within the mine should be identified at this point to facilitate a determination of the sizes and lengths of wire needed for the lighting circuits. Two factors must be taken into consideration in determining these sites.

1. Sufficient space must be available to physically accomodate all of the engine-generators, leaving aisles at least three feet wide to facilitate the installation, operation, and maintenance of the engine-generators.
2. The generator location must be in the proximity of an opening through which air will be exhausted from the mine so that exhaust gases from the engine-generators will be carried outside.

TABLE 1

Maximum Number of Light Bulbs Which Can
be Powered by Different Engine-Generator Sets

Generator Capacity (Watts)	Maximum Number of Light Bulbs				
	25 Watt	40 Watt	60 Watt	75 Watt	100 Watt
1000	40	25	16	13	10
1500	60	37	25	20	15
2000	80	50	33	26	20
2500	100	62	41	33	25
3000	120	75	50	40	30
4000	160	100	66	53	40
5000	200	125	83	66	50

E. Specify Feeder Wire Sizes

To permit calculations of required resources to be made, the sizes of feeder wires needed with each circuit should be determined using the information presented in Table 2. The required feeder wire size for a circuit is dependent on the total load current for that circuit and on the distance between the generator and the area to be lighted. Table 2 shows the minimum wire size which can be used with a 15-ampere load for a given length of feeder and allowable voltage drop. This table may be used to select the wire to be used in an actual situation. It is preferable that the feeder size be chosen for a maximum voltage drop of 5 percent. A voltage drop of 10 percent can be tolerated, although the overall system performance may be rather poor, resulting in a considerable reduction of light output from the lightbulbs. Table 2 can be used to determine the voltage drop if the load current is other than 15 amperes, since the voltage drop is directly proportional to the load current. Conversely, the length of feeder given in Table 2 is inversely proportional to the load current.

The following examples illustrate the use of Table 2 in determining feeder wire sizes.

1. Example 1: Room and Pillar Mine

For this example, a room and pillar mine has two lighting circuits of 36 light bulbs each. The group of lights for one circuit is located 700 feet from the engine-generator and has 40-watt bulbs, while the lights for the second circuit are located 1200 feet from the generator and use 60-watt bulbs. The feeder wire sizes may be determined as follows.

TABLE 2

Maximum Length Of Triplex Cable For A Single Phase, 240/120 Volt, 15 Ampere Load

AWG size of conductors	Maximum voltate drop					
	Copper conductors			Aluminum conductors		
	2.5%	5%	10%	2.5%	5%	10%
No. 14	78 ft	156 ft	311 ft	47 ft	95 ft	190 ft
12	123	247	494	75	150	300
10	196	393	786	120	240	479
8	312	625	1250	190	381	762
6	488	976	1950	297	593	1190
4	772	1540	3090	472	943	1890
3	976	1950	3900	595	1190	2380
2	1240	2470	4940	752	1500	3010
1	1550	3100	6200	948	1900	3790
0	1960	3920	7840	1190	2380	4760
00	2470	4930	9860	1500	3010	6020
000	3120	6230	12,500	1900	3810	7620
0000	3930	7860	15,700	2390	4780	9570

For Circuit Number 1 the total load is 12 amperes since each 40-watt bulb draws approximately one-third of an ampere. This load is 12/15 of the load used to produce Table 2. The length of feeder to use in sizing the conductors may, therefore, be reduced by the ratio of 12 to 15. This gives an effective length of 700 × (12/15) = 560 feet. Using this length in Table 2, and allowing a 5 percent voltage drop, gives a wire size of No. 8 for copper conductors and No. 6 for aluminum conductors.

Circuit Number 2 has a total load of 18 amperes since each 60-watt bulb draws a current of approximately one-half of an ampere. This load is larger than the load used to create Table 2 which means that the length of feeder must be increased by the ratio of 18 to 15. This gives an effective length of 1200 × (18/15) = 1440 feet. Using this length in Table 2 and allowing a 5 percent voltage drop gives a wire size of No. 4 for copper conductors and No. 2 for aluminum conductors.

2. Example 2: Drift Mine

In this example, a circuit is laid out along a series of drifts with light bulbs spaced at 200-foot intervals. The calculation of wire size is quite different for this situation than for the room and pillar mine where lights are grouped relatively close together. For illustrative purposes, assume that the drifts to be lighted are as shown in Figure 5. By assuming that the bulb spacing is 200 feet, the length of wire needed in each segment can be determined to be as follows:

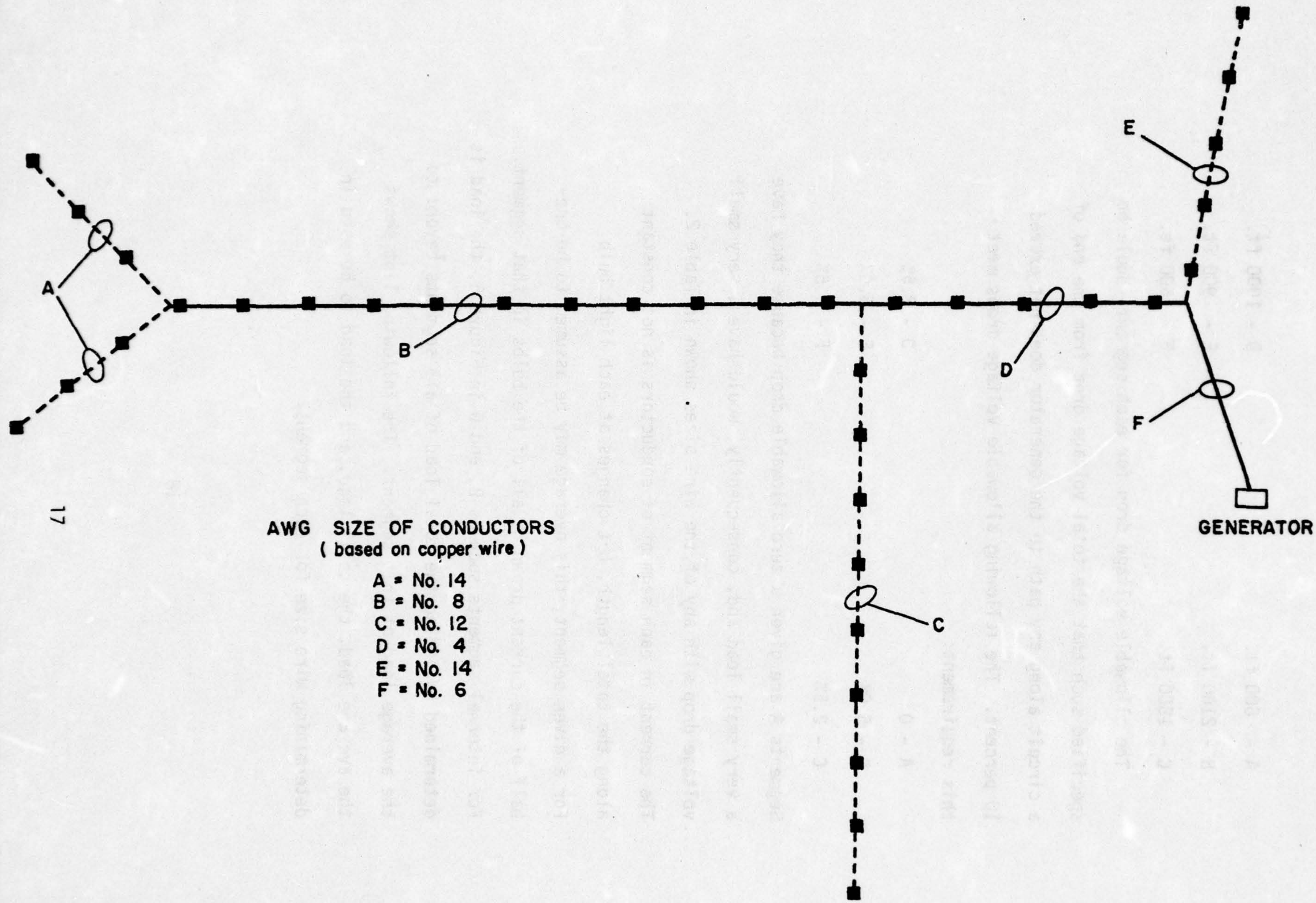


Figure 5. Illustration of lighting circuit layout in drift-type mines.

A - 600 ft. | D - 1000 ft.
B - 2100 ft. | E - 900 ft.
C - 1800 ft. | F - 600 ft.

The allowable voltage drop for each segment should be specified such that the total voltage drop from the end of a circuit along any path to the generator does not exceed 10 percent. The following allowable voltage drops meet this requirement:

A - 0 | D - 2.5%
B - 5.0% | E - 5.0%
C - 2.5% | F - 2.5%

Segments A are given a zero allowable drop because they have a very small load and, consequently, would have a very small voltage drop with any of the wire sizes shown in Table 2. The current in each segment of conductors is not constant along the total length, but changes at each light bulb. For a given segment, this average may be assumed to be one-half of the current drawn by all of the bulbs in that segment. For internal segments such as B, and D in Figure 5, the load is determined by adding the total load of all segments beyond to the average load of that segment. The following list shows the average load, the total load, and the load to be used in determining wire size for each segment.

Segment	Average Load (Amps)	Total Load (Amps)	Load Used to Determine Wire Size
A	0.50	1.00	0.50
B	1.83	3.67	3.83
C	1.50	3.00	1.50
D	.83	1.67	7.33
E	.83	1.67	.83
F	12.00	12.00	12.00

From the above information, the wire size for each segment is determined from Table 2 to be as follows for copper conductors:

A - No. 14	D - No. 4
B - No. 8	E - No. 14
C - No. 12	F - No. 6

To illustrate the procedure, the wire size calculation for Segment B is as follows. The load to be used in determining the wire size is the sum of the average load in Segment B (1.83 amps) plus the total load in each of the two A segments (1.00 amp each). This gives a total of 3.83 amperes. The length of wire to be used in Table 2 is equal to the actual length of Segment B multiplied by the ratio 3.83/15. This gives an effective length of [2100 × (3.83/15)] = 436 feet. From Table 2 the wire size for copper conductors and a 5 percent voltage drop is No. 8. Wire sizes for the other segments are computed similarly.

F. Determine Branch Line Material Requirements

The types of conductors and light fixtures to be utilized in the branch lines should be specified based on the local availability of materials. Figure 6 illustrates the use of brewery cord, which is a twisted pair of stranded insulated wires, and pin-type light sockets. This combination is the easiest and quickest to install and is recommended for use if available. These sockets, however, require the use of stranded copper conductors which are not approved for installation in damp locations under the National Electrical Code, and do not comply with the Occupational Safety and Health Act. Consequently, they may not be generally available. Figure 7 illustrates the use of porcelain light fixtures which may be used with solid conductors. These take slightly longer to install but are generally more readily available and should be used when brewery cord and pin-type sockets are not available. Type UF cable, type USE cable, or conduit with type TW conductors should be used for these lighting circuits.

G. Estimate Required Tools and Materials

Estimates of the quantities of tools, materials, and manpower needed to install a lighting system should be made and sources of these resources identified. The choices of methods of installation in Steps J and K will be influenced by the local availability of certain materials; therefore, this step should be completed concurrently with the planning for Steps J and K. The quantities of tools needed will be dependent on the number of teams of electricians working, which can best be estimated by an electrical engineer or experienced electrician. This, again, points out the desirability of having such a person to assist in the design of the lighting system.

It may be assumed that sufficient quantities of hand tools (hammers, pliers, etc.) will be available; consequently, the survey for sources of tools and materials should concentrate on the following:

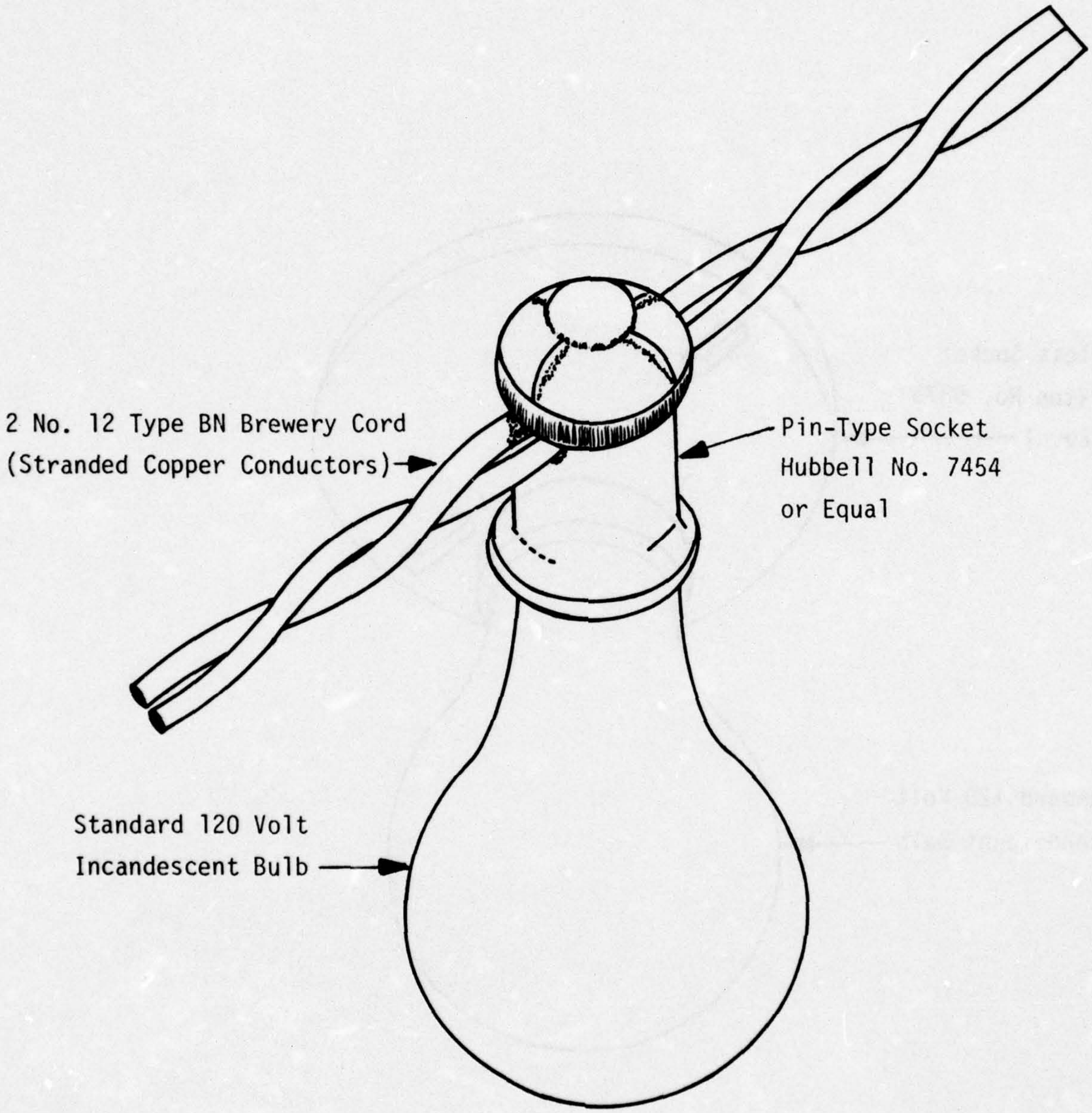


Figure 6. Brewery Cord and Pin Socket.

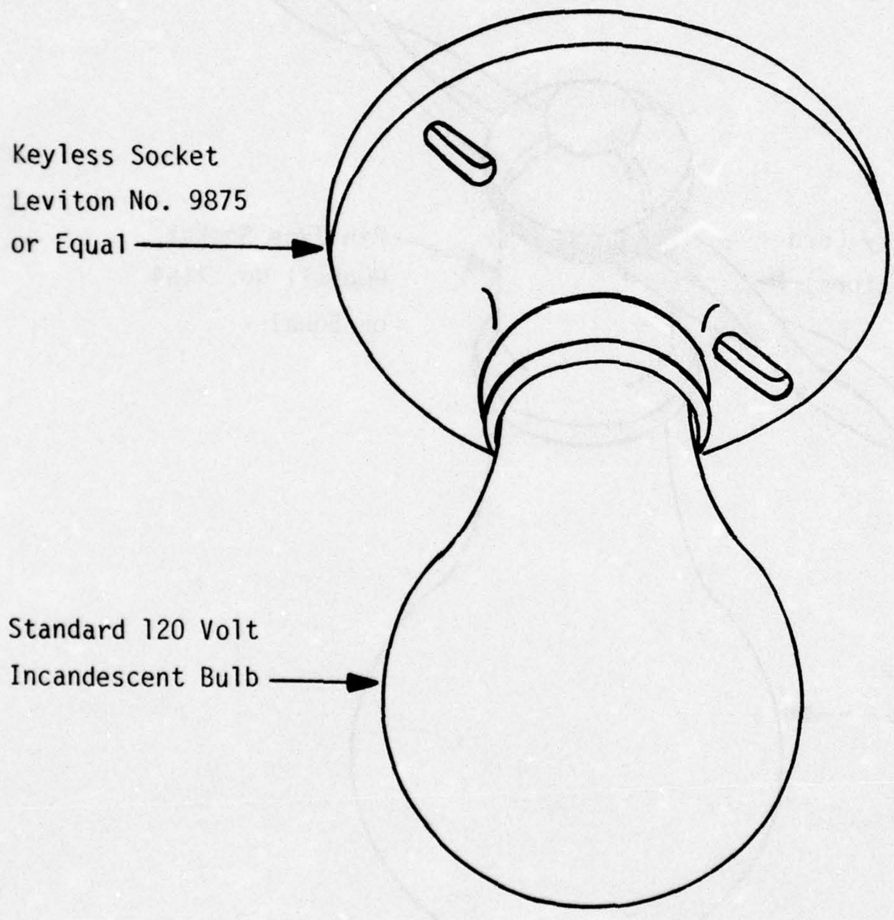


Figure 7. Porcelain Socket used with Type UF Cable.

1) Hammer drills and carbide-tipped bits;

2) Stranded insulated conductors and pin-type light sockets; or

3) Solid conductors and porcelain light fixtures;

4) Expansion bolts; or

5) Lead expansion shields;

6) Conduit, junction boxes and pull boxes; or

7) Messenger cable; and

8) Insulators.

H. Plan for a Working Platform

Due to the ceiling height in most mines, a working platform of some type will be needed to install wiring and fixtures on the mine ceiling. A covered truck or panel truck provides the most convenient type of platform for this purpose; however, in the absence of these, a wooden scaffold may be constructed on the back of any available truck or even on top of a car, using readily available materials. Trucks are the preferred vehicle because they can carry supplies as well as the working platform. One platform will be needed for each two-man team of electricians to enable one electrician to work from the platform while the other passes up supplies as needed.

A platform of this type can be used in mines with ceiling heights up to about 20 feet by using a step-ladder on the platform. In mines having ceilings higher than this, the lights should be installed along the walls of the drifts or on the sides of pillars at a height of about 12 feet above the floor.

For planning purposes, sources of panel trucks or covered trucks should be identified or sources of materials to construct a scaffold on other types of trucks should be determined and noted in the mine plan.

I. Fastening Items to Rock

Expansion bolts of the type illustrated in Figure 8 and which are usually available are the most convenient means of fastening items to rock. Should they not be available, lead expansion shields can be used; however, they require a great deal more effort and time to use. Both methods require that holes be drilled in the rock surface. All such drilling should be done using hammer drills and carbide-tipped bits, if these are available. Powder-actuated stud fasteners will not work well in most mines because of the uneven nature of the rock surfaces. The principal method of fastening, as well as an alternate, should be verified by preliminary tests if possible.

J. Installing Feeder Lines

Installation of the feeder lines to the lighting circuits may be accomplished using either conduit or a messenger cable as a means of supporting the conductors, which may be either a cable or individual wires. If conduit is used, it may be installed using expansion bolts with clamps on the end for holding the conduit. One such fastener per 10-foot section of conduit is sufficient for support. Junction or pull boxes should be installed in the conduit at each point where a branch line is to be attached and at approximately 100-foot intervals in long runs for use in pulling the conductors through the conduit. If a messenger cable is used, the cable should be attached to the ceiling of the mine at approximately 10-foot intervals using the same technique as used for the conduit. The feeder wire should then be tied to the cable at

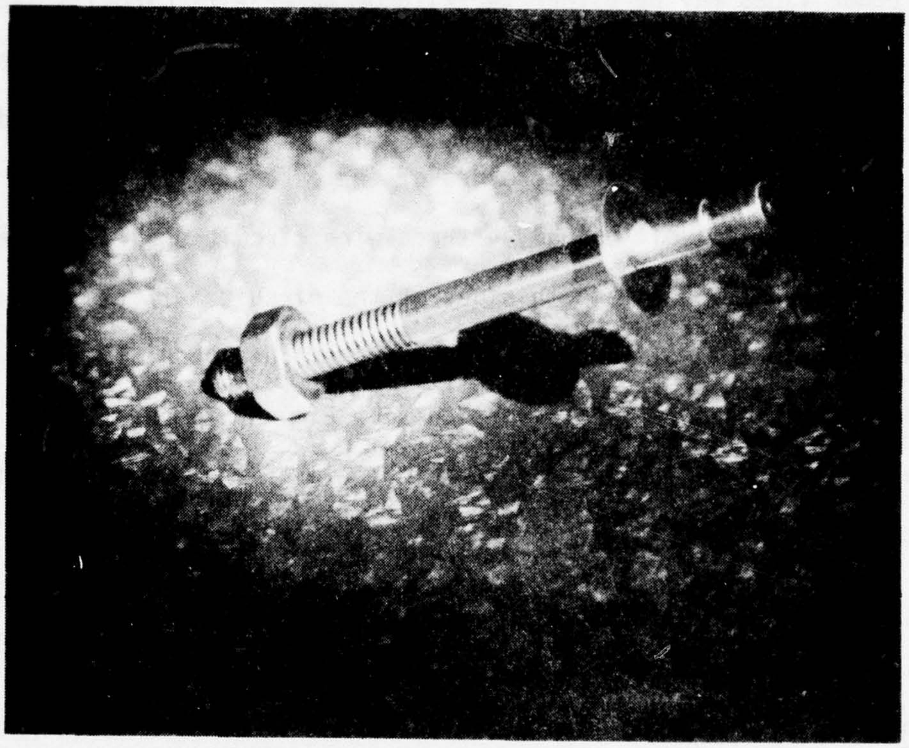


Figure 8. Expansion Bolt.

intervals spaced to prevent excessive sagging. Typical installations of conduit and messenger cable are illustrated in Figure 9.

Feeder lines may be either two-wire or three-wire circuits depending on the engine-generator used to supply power. If the generator has a 240/120 or 208/120-volt output, a three-wire circuit should be used and light fixtures attached to both sides of the circuit. If the engine-generator has a 120-volt output, a three-wire circuit should be used and light fixtures attached to both sides of the circuit. If the engine-generator has a 120-volt output, a two-wire circuit should be used and all light fixtures connected across these. Figures 10 and 11 show typical connections of branch lines to three-wire and two-wire feeders, respectively.

K. Installing Branch Lines and Light Fixtures

Installation of the branch lines and light fixtures should be accomplished by attaching insulators to expansion bolts on either side of each light fixture location. The branch line is attached to these insulators and the light fixture attached to the wire. Additional insulators should be installed as needed to prevent sagging of the branch lines between light fixtures.

A typical branch line installation is illustrated in Figure 12.

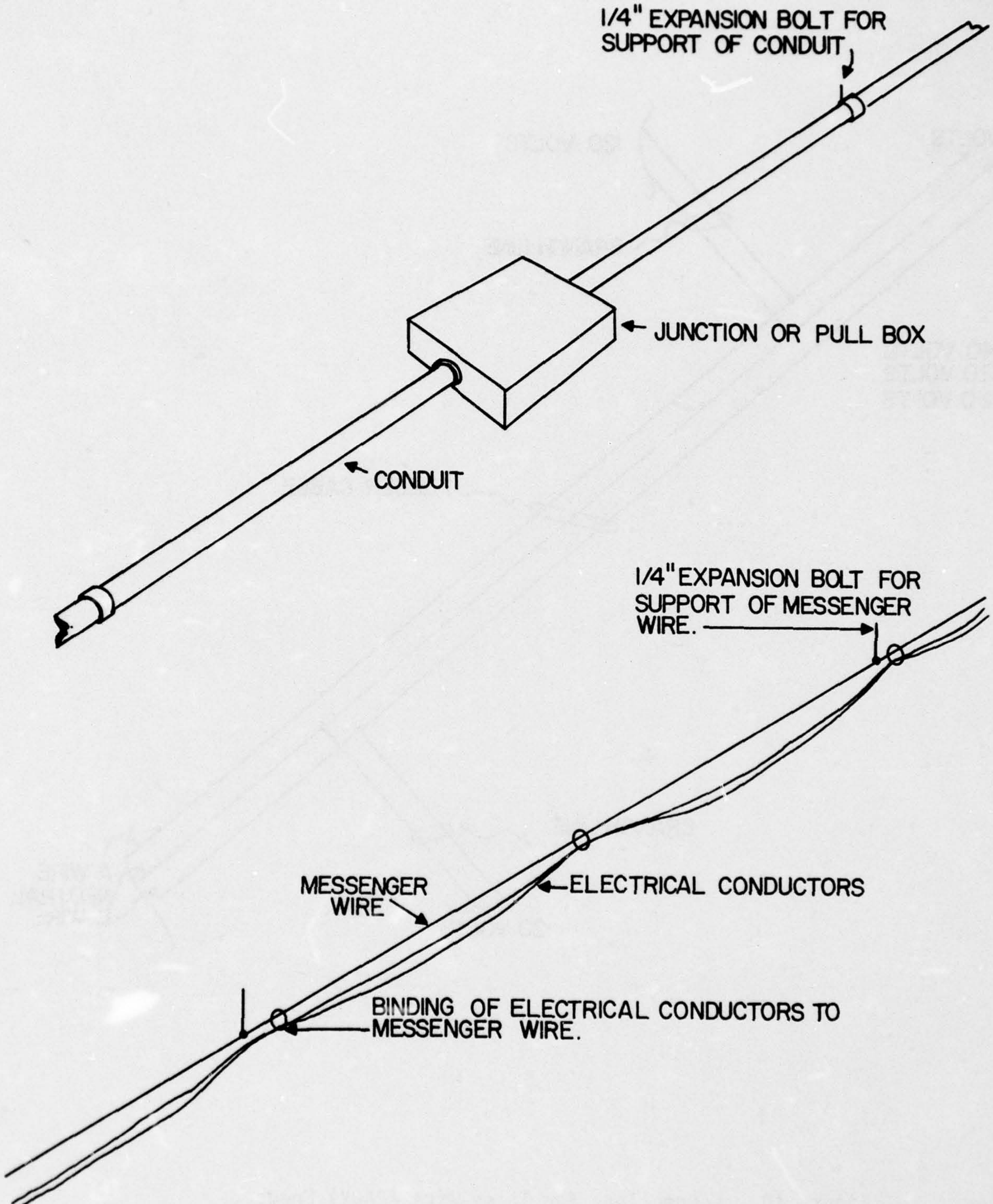


Figure 9. Illustration of Conduit and Messenger Wire Installation.

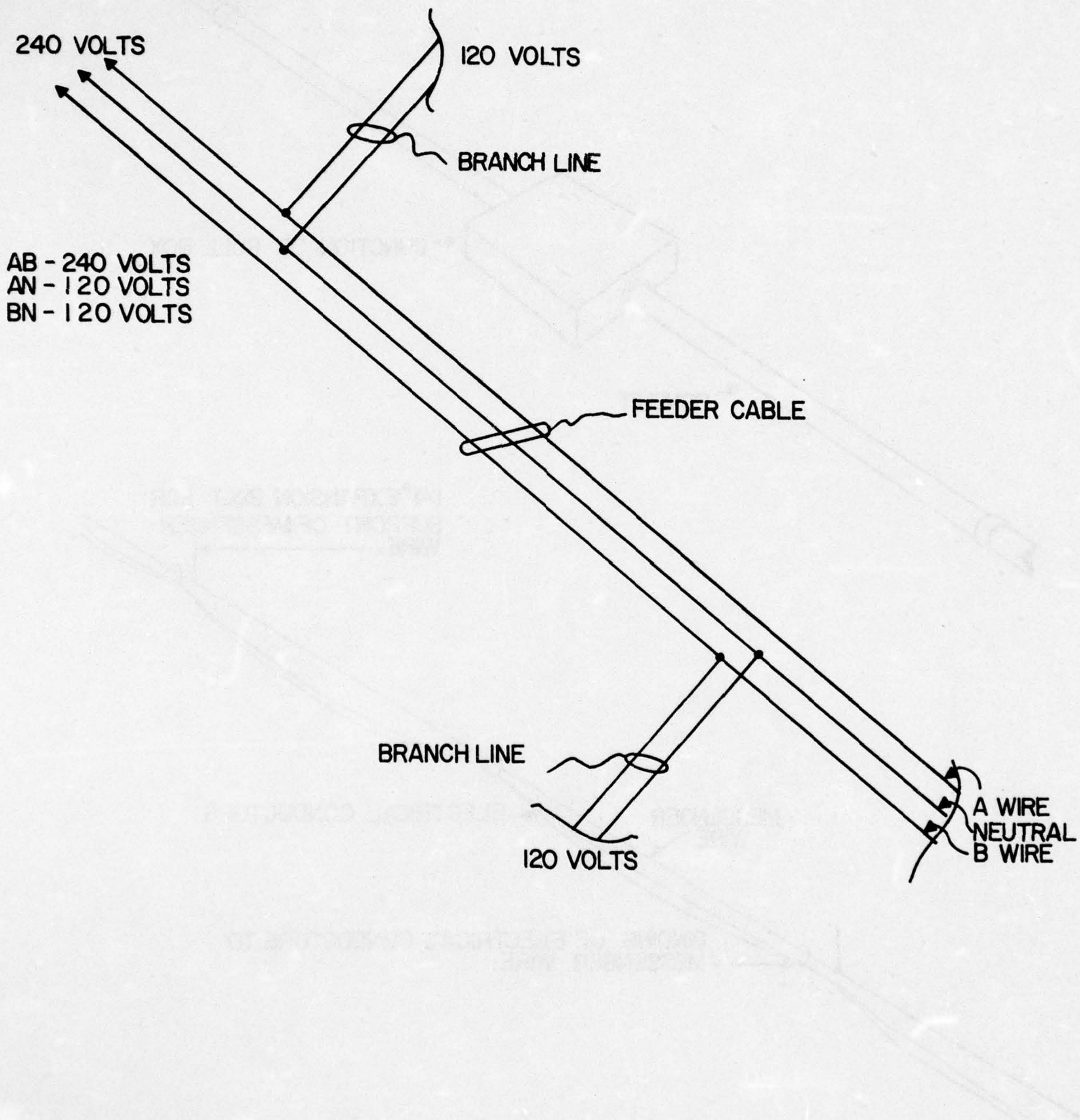


Figure 10. Connections for Three-Wire (240V) Feeder.

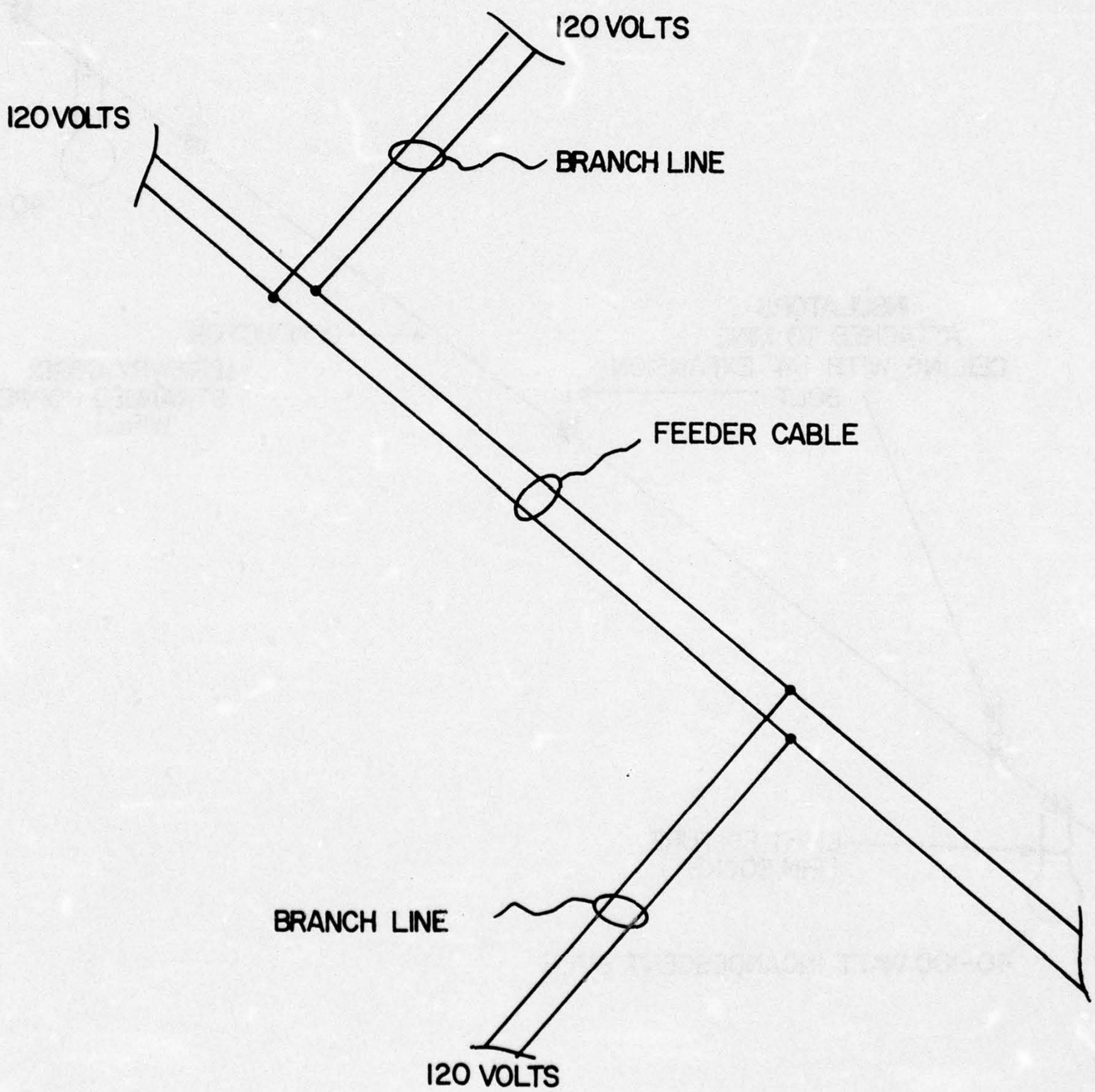


Figure 11. Connections for Two-Wire (120V) Feeder.

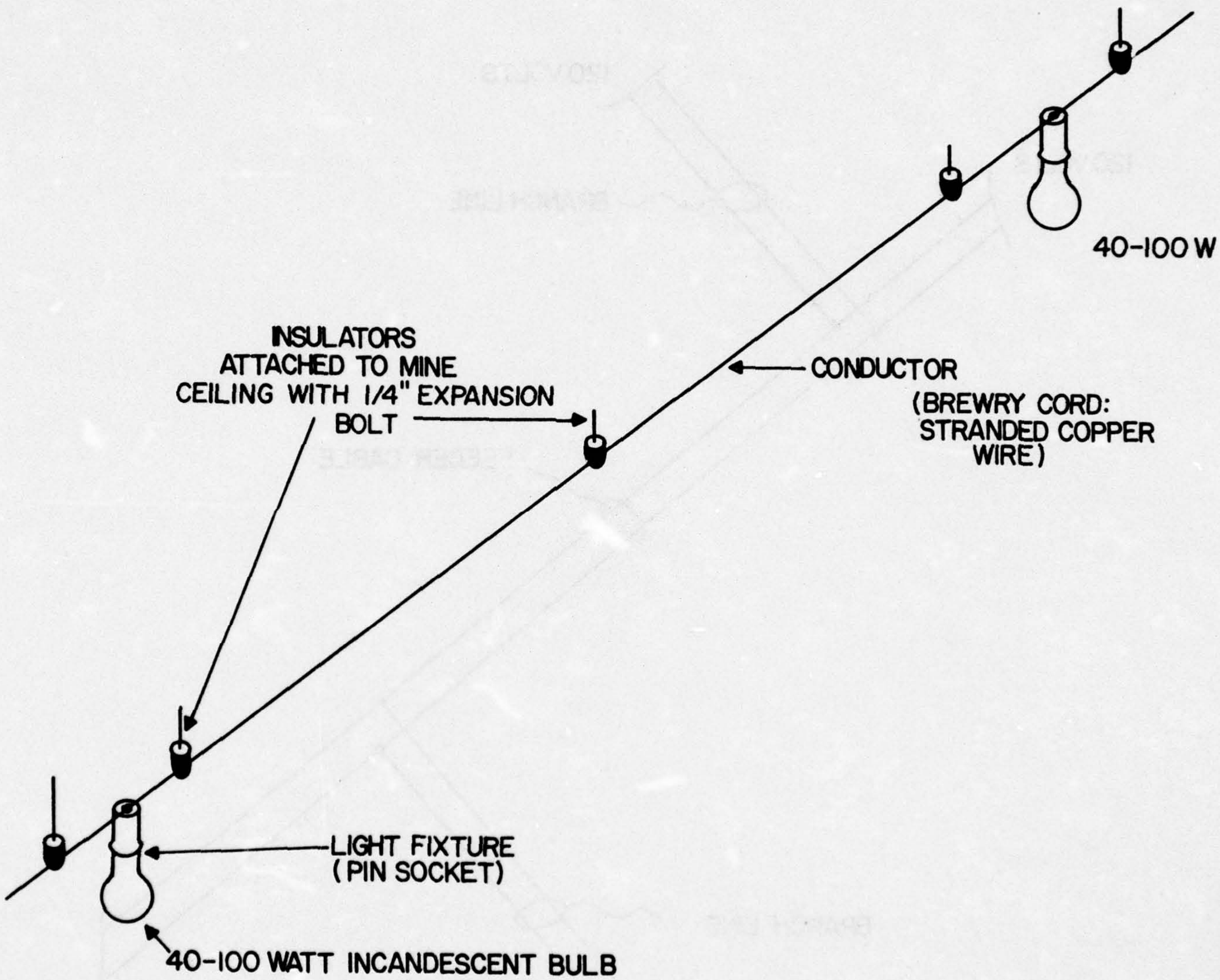


Figure 12. Typical Branch Line Installation.

L. Connecting Generators to Lighting Circuits

If small generators are used to supply power for each circuit separately, this step consists merely of attaching the feeder line to the generator terminals. If large generators are used to supply power to several circuits, it is preferrable that a distribution panel with circuit breakers be used between the generator and the lighting circuits. In such cases, it will be necessary to match the distribution panel with the generator output, i.e., if the generator has a three-phase output, a three-phase panel must be used. It is important that this step and the operation of the generators be accomplished by an experienced person.

III. Ventilation

The manner in which ventilation is provided in a mine shelter depends primarily on four factors: (1) the nature of existing ventilation, (2) the volume of air required, (3) the size and number of openings into the mine, and (4) the location of the openings relative to the location of the usable floor area.

Most active underground mines contain forced ventilation systems, which, in many cases, will be adequate to meet the needs of the shelter occupants; however, in others the existing system will need augmentation. Most underground mines which do not have forced ventilation systems have at least small amounts of fresh outside air flowing through them as a result of the temperature differential between the inside and outside of the mine. In some cases this natural ventilation is sufficient to meet the need of the shelter occupants but in most cases, installation of a complete ventilation system will be required.

The amount of ventilation needed in mine shelters is only that required to maintain the quality of the air at acceptable levels. Temperature control is not generally required because of the high heat absorbing capacity of the rock surfaces. A ventilation rate of three cfm per occupant is adequate to keep oxygen and carbon dioxide levels close to normal and 1.3 cfm per occupant will maintain the carbon dioxide concentration below one percent, which is the submarine occupational limit and well below objectionable concentrations (2 percent). At either ventilation rate, proper distribution of the ventilating air is required in order to achieve the stated goal. Distribution is, of course, more critical at the lower ventilation rate, and in view of this the design objective of a shelter ventilation system should be to provide 3 cfm per occupant when feasible and otherwise to provide at least 1.3 cfm per occupant. In cases where the lower ventilation rate is used, an effort should be made to achieve a uniform distribution of the air over the shelter area.

The amount of ventilation which can be provided in a mine shelter may be limited by the size and number of exterior openings. In such a case, the capacity of the mine as a shelter may also be limited. Limitations on shelter capacity may also be imposed if the ventilating air is not adequately distributed over all parts of the mine which are usable as shelter. For example, in mines having all of their openings located close together, air probably will not flow throughout the mine without incorporating air distribution devices or techniques, some of which are described in subsequent paragraphs in this section.

The steps that follow outline a procedure by which the ventilation requirements of a mine shelter can be determined and a system designed and installed to meet these requirements. Steps A through G should be completed, preferably with the aid of a ventilation specialist, prior to a crisis if the mine is to be effectively utilized. The remainder of the steps are concerned with the augmentation or installation of a ventilation system during an actual crisis situation. During installation, it is highly desirable to have an electrical engineer or an experienced electrician available to supervise the work.

A. Estimate Required Volume of Ventilation

Three cfm per person is the volume of air required to maintain the oxygen and carbon dioxide concentrations near the normal levels. The total amount of ventilation needed to provide this volume of air for the total number of people that can physically be accommodated in a mine should be calculated on this basis. This volume of air will be the design capacity of the ventilation system.

B. Measure Existing Ventilation

The amount of air delivered by the existing ventilation system if a system exists, or the amount of air that flows naturally through the mine should be measured and compared with the required volume to determine if additional ventilation is needed. This measurement should be taken at the air inlet openings. In a mine which has only natural ventilation, the volume of air flow will vary with the temperature differential between the inside and the outside of the mine. This temperature differential is mainly a function of the outside temperature since the temperature inside remains fairly constant throughout the year. Consequently, ventilation measurements should be taken at different times over the span of a year if possible to determine the minimum air flow which might be expected. If this volume of air, or the volume being delivered by the forced ventilation system is equal to or greater than the design capacity, determined in Step A the existing ventilation may be considered to be adequate.

C. Chart Flow of Existing Ventilation on Mine Map

As an aid in determining the adequacy of air distribution in a mine shelter, the flow of existing forced or natural ventilation through the mine should be plotted on a floor plan of the mine. A mine map or sketch drawn roughly to scale should be used for this purpose. All exterior mine openings should be identified and marked on the floor plan as either inlets or outlets for the ventilating air and any usable areas of the mine which are outside the flow of ventilating air identified. If such areas exist, one or more of the methods presented in Step D should be considered as means of distributing air into these areas. If the capacity of the existing ventilation system does not need augmentation and no large stagnant areas are identified, Steps D and E may be disregarded.

Step D outlines methods of upgrading the existing ventilation system, and includes techniques for improving air distribution. Part 1 of Step D is concerned with the augmentation of an existing forced ventilation system; part 2 deals with the installation of a forced system in a mine where none exists, and part 3 presents two alternative methods for improving the internal distribution of the ventilating air. The existing conditions within a particular mine determine which method or methods should be employed.

D. Augment and/or Distribute Existing Ventilation

1. Augmentation of existing forced ventilation system

In a mine with an existing forced ventilation system which delivers less than the design volume of air, the maximum capacity of the fan or fans that are in place should be compared to the ventilation measurement taken in Step C. If the fans are operating below capacity, it may be feasible to provide the desired ventilation by increasing the output of the fans to capacity by replacing the existing drive motor with a more powerful one or by replacing the existing fans with fans having a higher capacity. If neither of these options are feasible, it will be necessary to install additional fans at other openings if they exist. An experienced electrician or electrical engineer should be consulted during this phase of the planning.

2. Development of a complete ventilation system

In mines having natural ventilation at a volume below the design capacity, plans should be made to install a forced ventilation system. If the mine has two or more widely separated openings, fans may be installed to exhaust air through one or more of the openings with the remaining openings functioning as air inlets. Large industrial-type fans are the preferred type for this application if they are available. These will normally have to be removed from existing installations and transported to the mine intact along with the drive motors and motor controllers. To effectively utilize an opening for exhausting air, a frame is needed to support the fans and maintain their position within the opening Figure 13 illustrates one possible design for such a frame. This particular frame was designed for use in a 12-foot square opening to support four 5-foot diameter fans. Figure 14 shows the four fans mounted in the frame. The frame is constructed of ordinary dimensioned lumber and nails with the fans mounted to the frame using lag bolts. Similar frames could be constructed to fit openings of different sizes and to support most fan sizes. The fans shown in Figure 14 are powered by 10-horsepower 3-phase motors. These same fans may be utilized in combination with other motor sizes ranging from 2 to 20 horsepower. The power required to drive a fan increases as the third power of the fan speed, which is an approximate measure of the volume of air delivered. In view of this, if sufficient exterior openings are available to accommodate several low-volume fans, the smaller motors may be more desirable because of their lower power requirement and better efficiency. Another consideration in selecting a motor is the available generating equipment. Motors with up to a 10-horsepower rating are available for operation on 240- or 120-volt single-phase power. However, motors larger than 2 horsepower usually require a 3-phase power source.

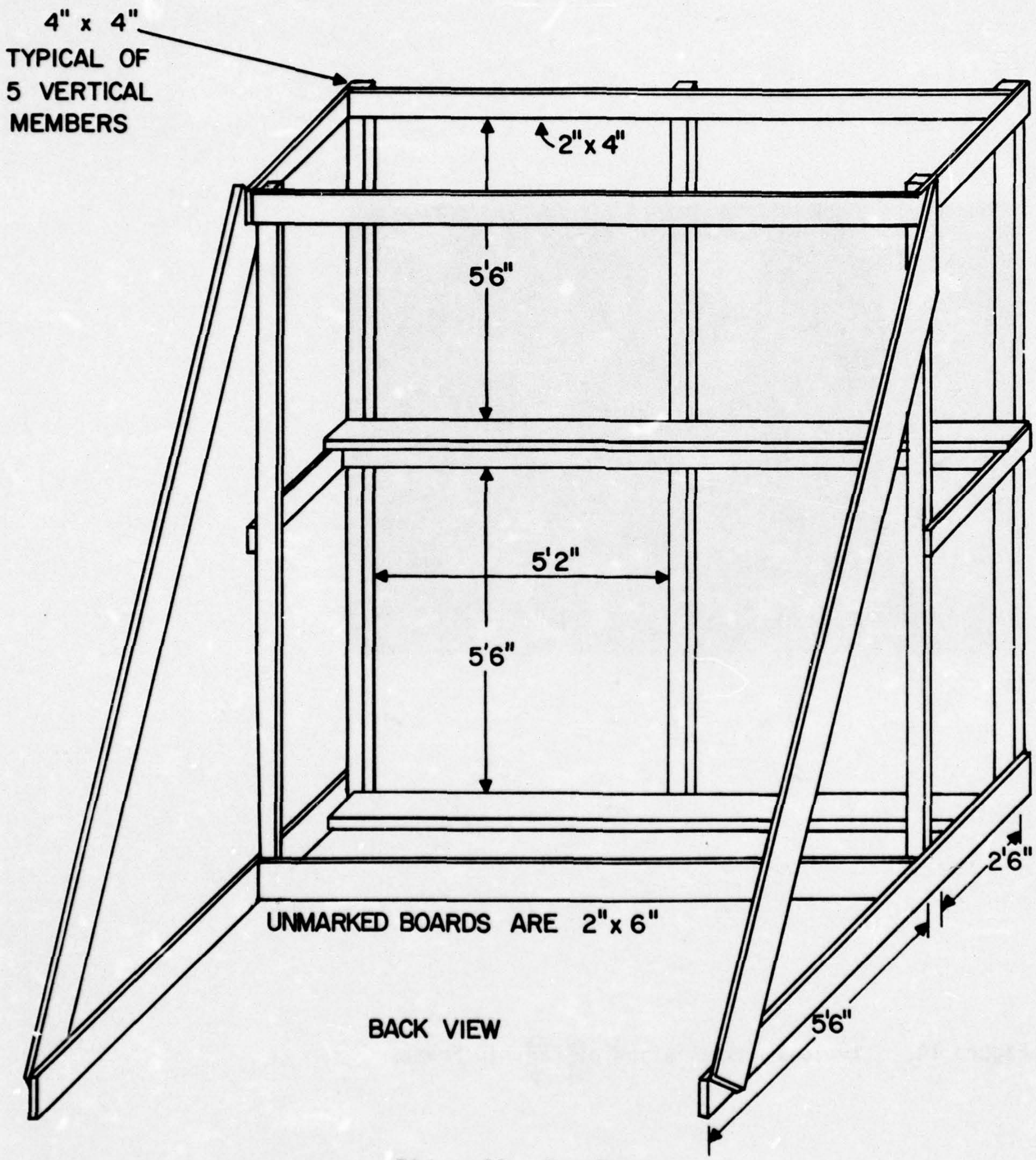


Figure 13. Fan Frame

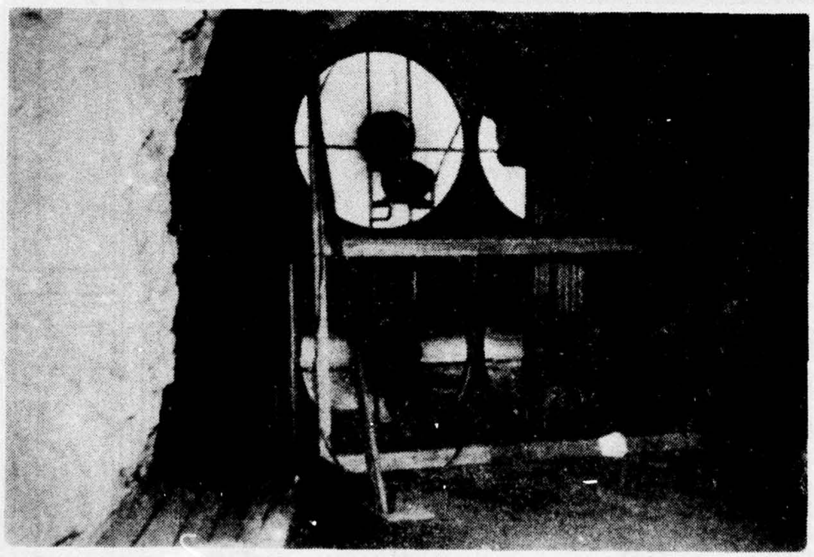


Figure 14. Typical Installation of Fans in Frame.

If large industrial fans are not available for use in a shelter, smaller fans may be used in a similar way. These might include exhaust fans in small shops or other areas and home window fans or attic fans. In using such fans, the support frame should be built to accommodate the available fan sizes.

In matching engine-generators to fans, it is necessary that the generating capacity be large enough to start and drive all the fan motors. Trouble may be encountered if the generator output is not greater than the sum of all motor running currents plus twice the running current of the smallest motor. More precise calculations must take into account the starting current of each motor as well as the transient response characteristics of the engine-generator set.

In positioning the fans, more than one opening may be used if necessary provided there are additional openings to serve as air inlets. No more than half of the openings should be used for fan installations. During fan installation, it is important that the discharge opening be blocked except for the area occupied by the fans.

3. <u>Air Distribution in mines</u>

a. For mines having all openings in close proximity, a means is needed to prevent air from short circuiting between the inlet and outlet opening. In many cases, this can be accomplished by constructing a partition, extending from floor to ceiling, with one end butted against the wall between the inlet and outlet openings and extending into the mine as far as necessary. An example of the location of such a partition is illustrated in Figure 15 for a hypothetical mine. A partition

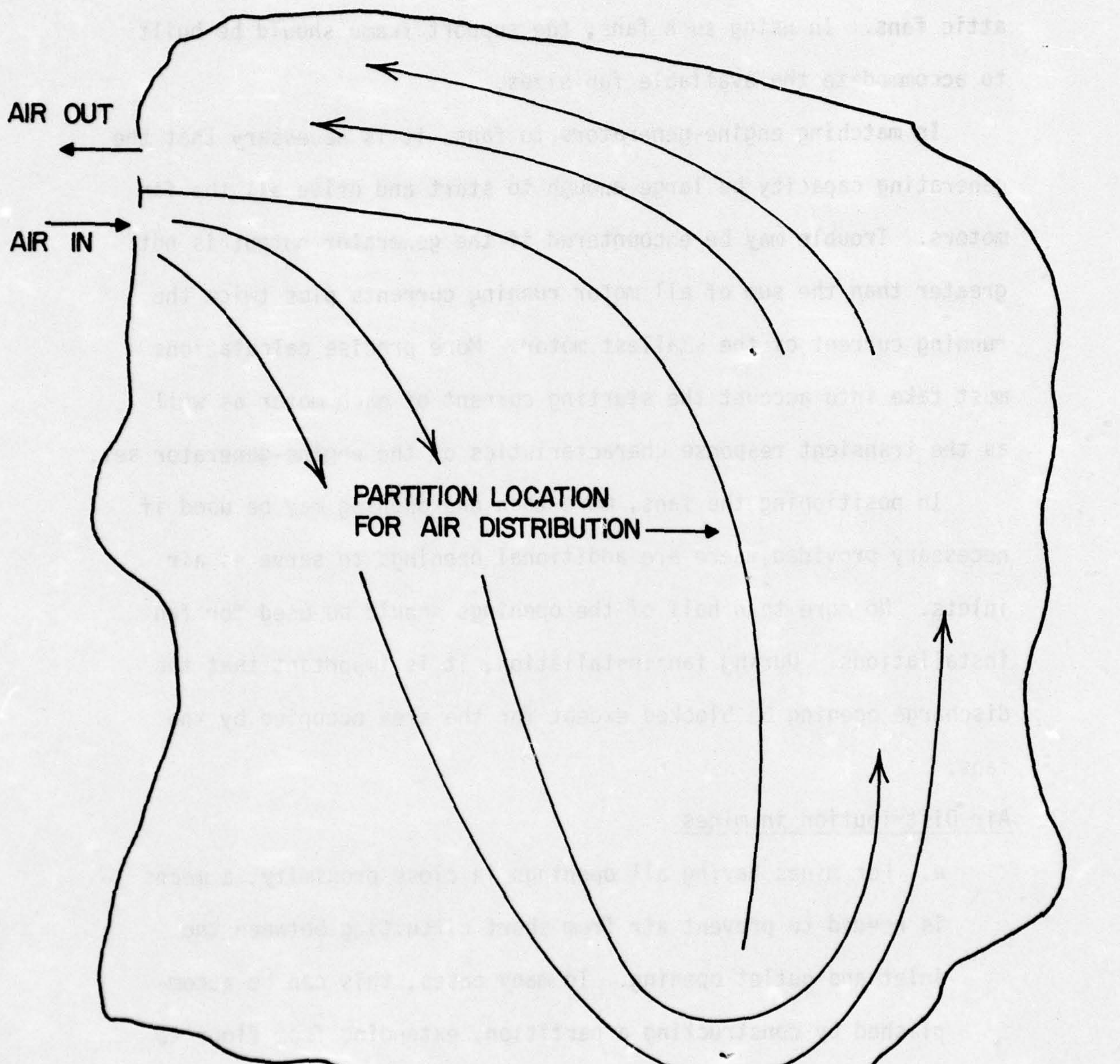


Figure 15. Illustration of Partition Used To Distribute Air in a Mine.

for this purpose can be constructed using small dimensioned lumber and polyethylene film plastic. The partition should be constructed in sections, and the sections installed end-to-end to form a continuous wall. Figure 16 shows one possible pattern for constructing the panel frames. The frames may be used with plastic of various widths by appropriate sizing. The frame width for the panels should be approximately 6 inches less than the width of the plastic used. When the plastic is attached to the frame, it should be extended around the vertical members on each end and stapled. The height of the panels should be determined by measuring the distance from floor to ceiling and the plastic should be allowed to extend approximately 2 feet past the top and bottom members of each panel. The wood frame for each panel is assembled using ordinary nails and the plastic is fastened to the frame by stapling to all frame members. Installation of the partition should be such that the wood frame is on the low pressure or exhaust side of the plastic. Prior to setting each panel into position, glass wool, rags, or foam rubber should be wrapped with the polyethylene which extends beyond the top member of the frame. This material is then compressed between the frame and the mine ceiling to prevent excessive leakage along the top of the partition. The top of the partition is then fastened to the ceiling of the mine by drilling through the top frame member into the rock and inserting an expansion bolt. The bottom of the partition is fastened to the floor by drilling through the bottom frame member into the

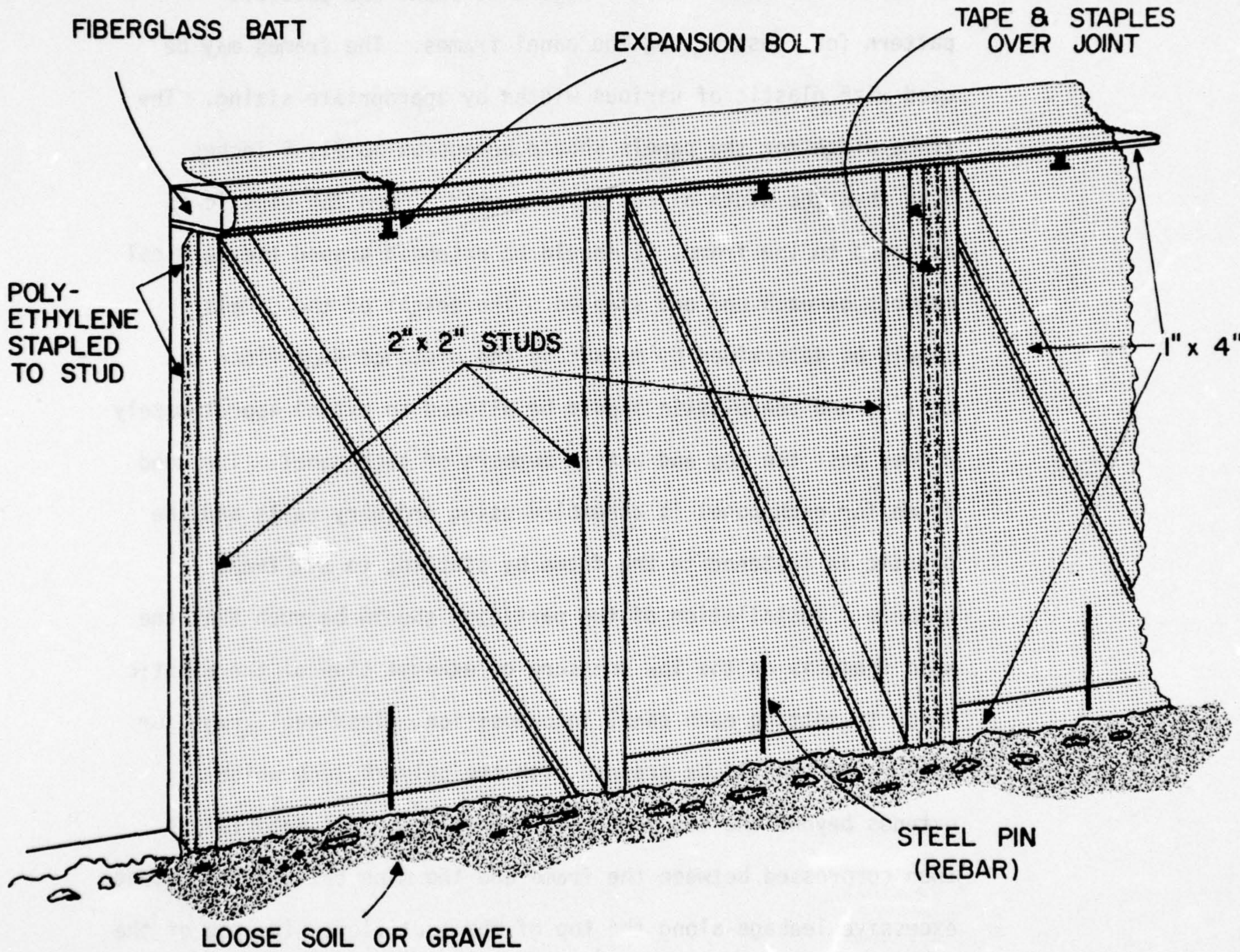


Figure 16. Typical Pattern for Partition Construction.

floor and inserting a steel pin or long bolt. A seal is obtained along the bottom of the partition by piling dirt or loose gravel on the polyethylene which extends beyond the bottom member of each panel. These items are illustrated in Figure 16. As adjacent panels are installed, abutting members should be nailed together and the joint then taped and stapled as also illustrated in Figure 16. Variations in the floor and ceiling of the mine can be handled by bending the top member of the partition to follow ceiling contours and by placing shims under the bottom of the partition. Figures 17 through 22 illustrate the actual construction and installation of a partition in a mine and show expedient means of coping with floor and ceiling variations.

b. In some mines, having all openings in close proximity, it will not be feasible to construct a partition in the manner described above. The floor or ceiling may be too irregular or the ceiling height too great to permit expedient construction of such a partition. In a mine where this is the case, it may be possible to construct a ventilation system utilizing flexible plastic ducts or ducts fabricated with wooden frames covered with polyethylene to direct air into regions of the mine that would otherwise be stagnant. If a system of this type is needed, it should be designed by a person with experience in ventilation. Extreme care should be taken in specifying the duct size and in identifying the path of the duct through the mine. If the duct becomes too long, or contains a large number of bends, the resulting static and dynamic pressures will greatly reduce the flow of air through the duct.

Figure 17. Assembling Partition Panels.

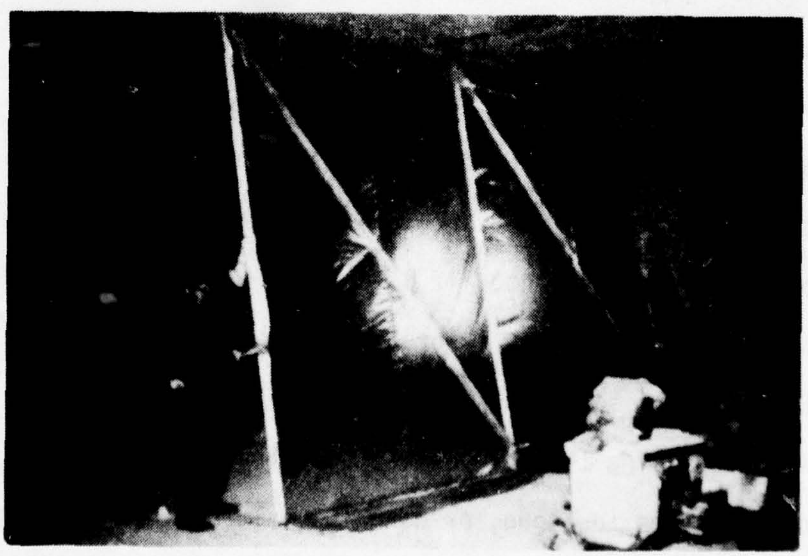


Figure 18. Completed Partition Panel.

Figure 19. Installation of Panels to form Continuous Wall.

Figure 20. Fastening Partition Panel to Mine Floor.

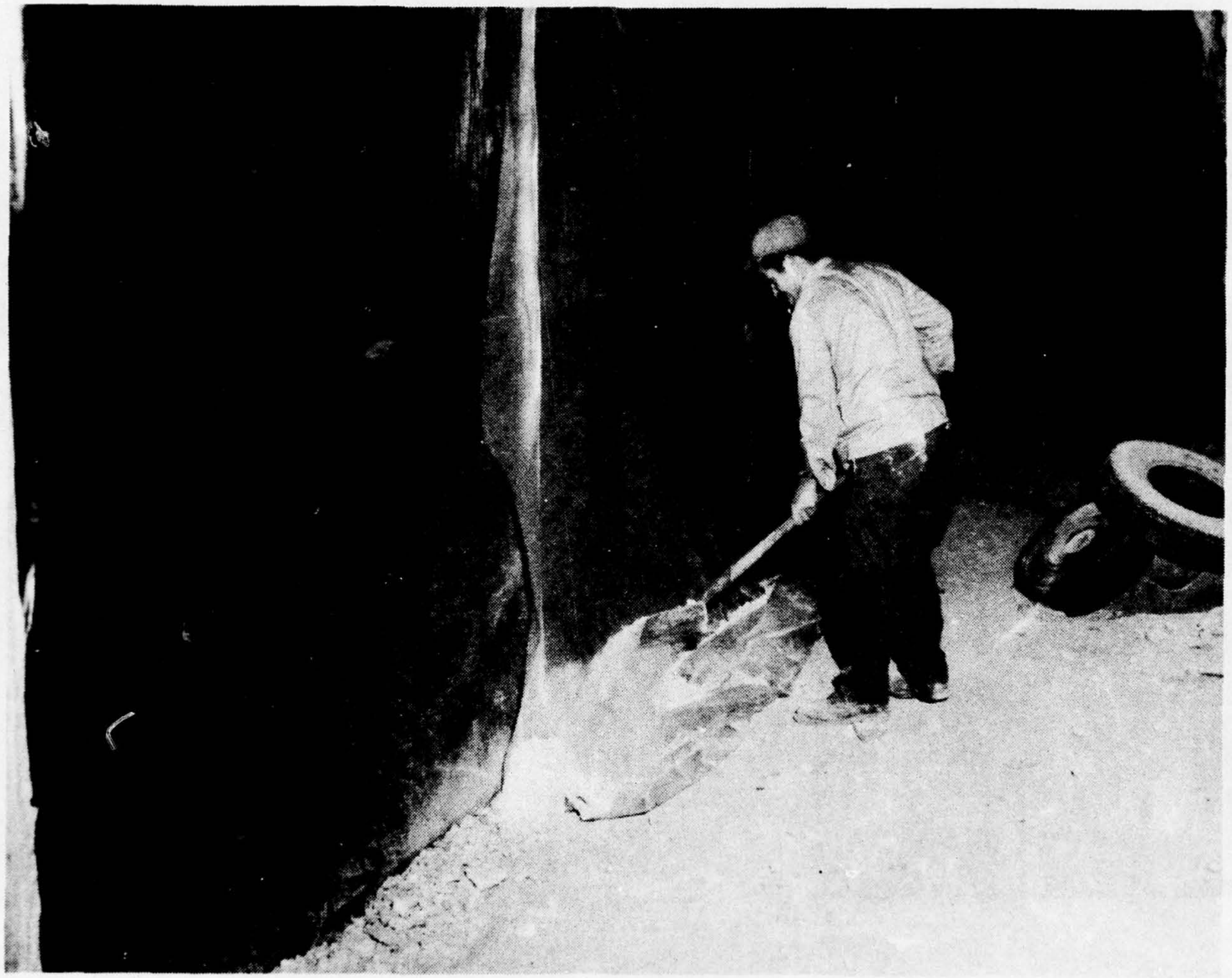


Figure 21. Application of Loose Gravel to Seal Bottom of Partition.

Figure 22. Portion of Completed Partition.

E. Identify Required Equipment, Materials and Labor

To successfully implement either of the alternatives listed in Step D in a crisis situation, the following phases of planning should be completed beforehand. The sizes of equipment and quantities of materials needed should be estimated, sources of these items identified, and, if possible, arrangements made for their use. Most importantly, the locations of fans and engine-generators should be identified. This could be accomplished through surveys of local industries using either personal visits, telephone contact, or a mailed questionnaire. After identifying locations, planners should discuss the possible use of the equipment in a crisis, and arrange to have someone responsible for removing the fans and engine-generators from the installation and transporting them to the mine where they are to be used. Estimates should be made of the quantity of fuel that would be required to keep the engine-generators running for two weeks, and sources of fuel should be identified.

In the event of a crisis, electrical contractor personnel should be used to supervise the installation of the fans and engine-generators. Local civil defense planners should therefore meet with one or more local electrical contractors to discuss and define specific assignments such as delivering needed materials to the mine and installing the ventilation system. It may be assumed that the contractors will supply sufficient numbers of hand tools (hammers, pliers, etc.), but surveys should be conducted to locate sources of the following materials:

1) Lumber,
2) Nails,
3) Polyethylene (if needed),
4) Glass wool, rags or foam rubber (if needed), and
5) Flexible plastic duct (if needed).

F. Verify Shelter Capacity

As previously stated, the design objective of a ventilation system is to provide 3 cfm of air per person with a minimum of 1.3 cfm per occupant. At this point, a calculation should be made to determine if the minimum requirement is being met. If, because of limitations on the number or size of openings and/or the availability of equipment, the minimum air volume cannot be supplied, then the capacity of the shelter must be reduced to the point where the minimum requirement of 1.3 cfm per person will be supplied with the available equipment. It should be re-emphasized at this point that achieving a uniform distribution of air over the entire shelter area is much more important at the lower ventilation rates.

G. Position and Connect Engine-Generators

The engine-generator location or locations should be identified taking two factors into consideration:

1. Sufficient space must be available to physically accommodate all of the engine-generators, leaving walkways at least 3 feet wide between them. This will facilitate both the installation and maintenance of the engine-generators.

2. The location must be in the proximity of an opening through which air will be exhausted from the mine so that exhaust fumes from the engine-generators will be drawn outside. All wiring to connect engine-generators to existing fans or to newly installed fans should be accomplished by an electrical engineer or experienced electrician to insure that a proper match is made between the fan motors and the engine-generators, and to insure that the work is performed accurately and safely.

H. Verify Air Distribution in the Mine

In order for a mine to be fully utilized, it is important that the ventilating air be distributed over as much of the mine area as possible. During the design of the ventilation system, provisions should be made to insure adequate distribution of the ventilating air over the usable floor area in the mine utilizing any distributional devices deemed necessary. After the fans and any partitions or ducts have been installed, all of the mine area to be used as shelter should be checked for air movement. This may be accomplished using an anemometer or, in the absence of these, with vertical strips of tissue paper. The tissue paper will not, of course, give any quantitative indication of the speed of air movement, but should suffice to determine whether or not any movement of air occurs. If areas (such as stopes or individual rooms) are identified which have no air movement, it may be possible to move air into these areas using large Kearny-type air pumps.

I. Distribution of Air with Kearny Pumps

A *Kearny pump (illustrated in Figure 23)* is an oscillating, unidirectional air pump consisting of a series of overlapping flap valves stretched across a frame which is hinged at the top. The device illustrated in Figure 23 is designed to fit in a standard doorway; however, these devices may be constructed in other sizes and can be constructed using readily available materials, such as wood for the frame and stand, and polyethylene for the flap valves. Figure 24 illustrates one configuration in which these devices might be used to aid air distribution. Kearny pumps have been shown to be effective in diverting air up to 50 to 60 feet away from the normal path of air flow. In cases where it is necessary to move the air over greater distances, consideration should be given to the use of powered fans and flexible plastic ducts to improve air distribution.

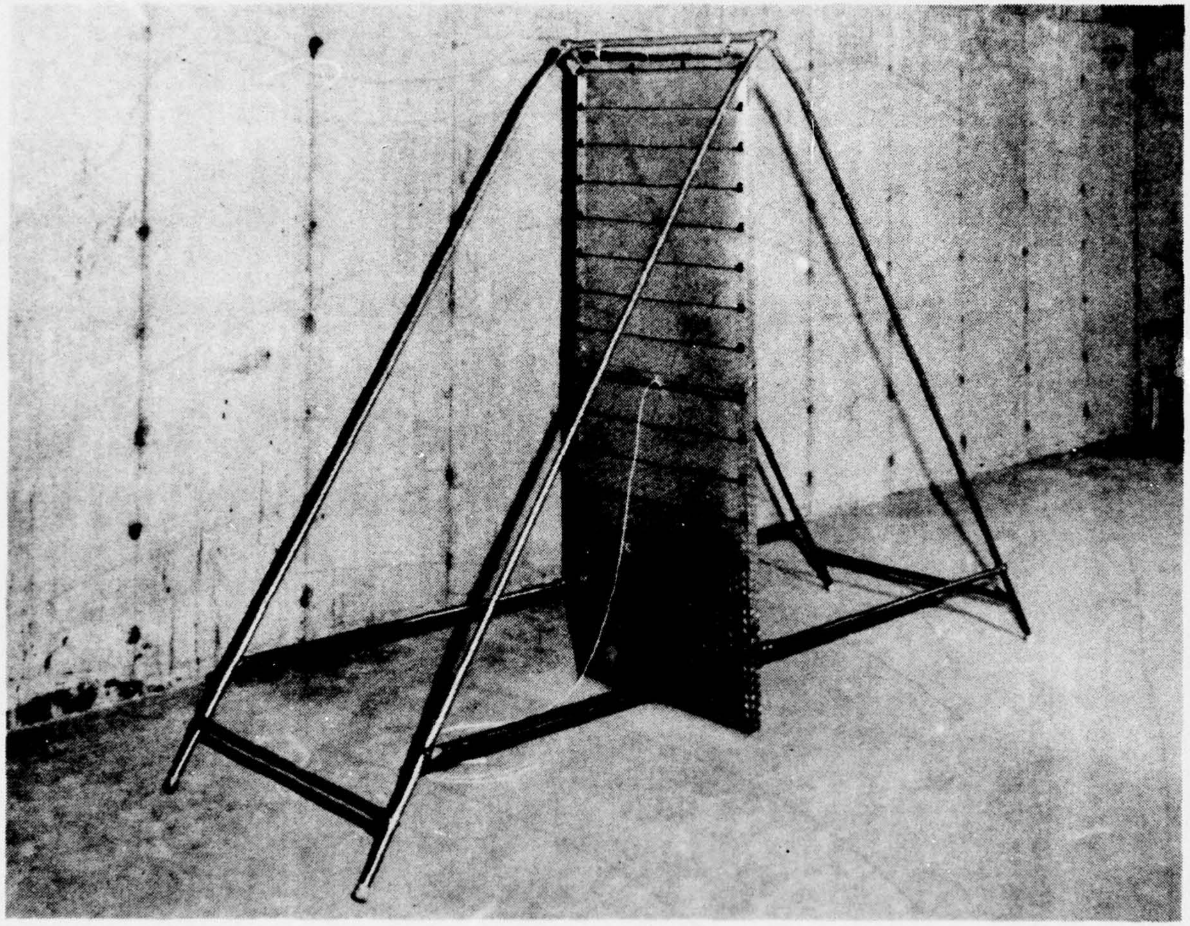


Figure 23. Kearny Pump.

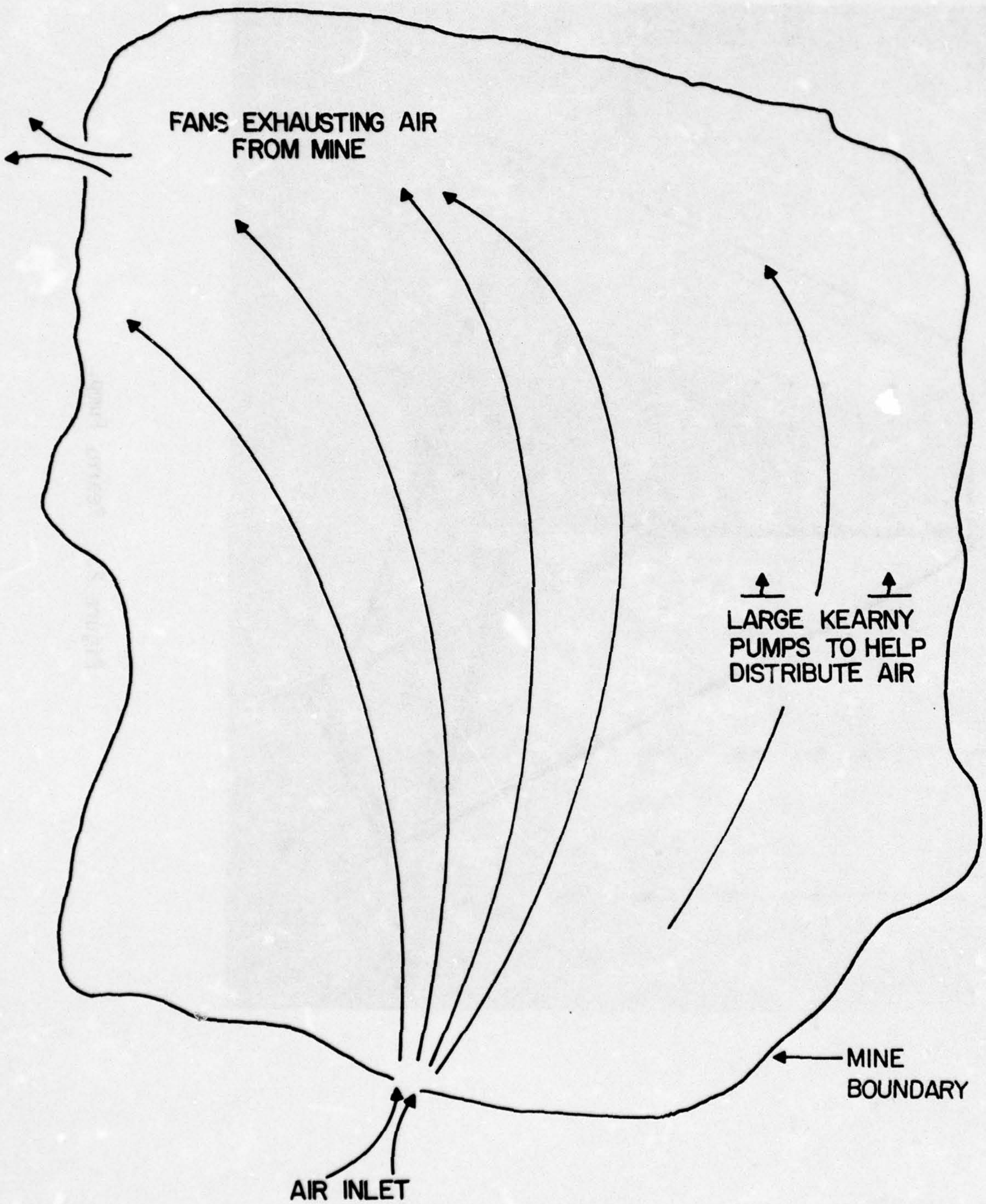


Figure 24. Example of Kearny Pumps Used to Aid Air Distribution in a Mine Shelter

IV. WATER SUPPLY

This section provides some preliminary guidance for the civil preparedness planner concerned with providing potable water for populations sheltered in mines during a crisis.

The need for a clean, safe supply of water in order to support life and avoid outbreaks of communicable diseases is, of course, obvious and will not be discussed further here. Per capita water requirements are given and methods of augmenting existing mine water supplies are discussed. Guidance on water disinfection is also included.

Water supplies for mines include springs and drilled wells and, in those cases where distances are not prohibitive, municipal distribution systems. Ground water supplies such as springs and drilled wells may or may not be protected from surface contamination and may or may not be chlorinated or otherwise disinfected. Spring water supplies are frequently found within the mine, while drilled wells are typically located outside the mine. At some mines, water is piped into the mine; at others, it is not. Indeed, in many mines, bottled water is the only supply of safe drinking water inside the mine.

As with all of the other aspects important in the upgrading of mines, i.e., ventilation, lighting and waste disposal, the ability to successfully augment water supplies is dependent to a great extent on adequate advanced planning. It is advisable, therefore, that early in the planning process the civil preparedness planner seek the assistance of someone who is well acquainted with the technical aspects of water supply systems. A public health specialist, e.g., a sanitary engineer, is such an individual and can usually be contacted through a local or regional health department. The state health agency also may be able to provide technical information and guidance on the problem of providing potable water for mines.

A. Quantitative Requirements

The physiological requirement for water is about 84 ounces/day or .03 ounce for each calorie of food ingested (Ref. 3). Actual usage data for the U.S., however, indicate that about 2.5 gallons/capita-day are used for drinking water (Ref. 4). The Federal Civil Defense Guide (FCDG) calls for a minimum of 3.5 gallons of water per shelter occupant (Ref. 5). For most people, the shelter stay would be less than 14 days (an average of about 7 days), thus providing an average of 2 quarts per day per shelter occupant. A World Health Organization report recommends 4-5.3 gallons/capita-day as a minimum water requirement for drinking, cooking and basic cleanliness in temporary shelters and camps (Ref. 6). If mass feeding is to be done the requirement becomes 5.3-7.9 gallons/capita-day and for hospital and first aid services, it increases further to 10.6-15.9 gallons/capita-day.

Based on a consideration of the above data, it is recommended that an absolute minimum of 34 ounces and as near as possible to 4-5.3 gallons of potable water per day be provided for each mine occupant during the in-shelter period.

If, as a result of crowding, air temperatures and relative humidities increase, drinking water consumption may be expected to increase well above the austere level of 34 ounces/capita-day. One watering point (faucet, if piped water supply) should be provided for each 50 occupants.

For planning purposes, the amount of water to be provided during the in-shelter period should be correlated closely with the capacity of the mine's sewage system. Nearly all of the water that is utilized for personal hygiene and cooking as well as water that is consumed to satisfy physiological needs, eventually becomes waste and must be disposed of in a sanitary fashion.

B. Augmenting Mine Water Supplies

Knowing the number of occupants to be assigned to a mine, the water requirement can be calculated as follows:

$$\text{no. occupants/mine X desired gallons } H_2O\text{/capita-day} = \text{gallons } H_2O\text{/mine-day}$$

If the water requirement exceeds the capacity of the existing supply, it will be necessary to augment that supply. Considering the possibility of fallout contamination, surface supplies (stream, ponds, etc.) were not considered for augmentation. If, however, during the in-shelter period, it can be demonstrated that no fallout contamination has occurred, then nearby surface supplies should be used if needed, with proper disinfection, of course. For planning purposes it is best to assume that a mine normally supplied by a municipal system will not be so served during crisis relocation and should therefore be augmented for water supply. Mine water supplies can be augmented either by providing piped water or by storing water in containers in the mine. In a number of cases it also will be necessary to disinfect the water prior to use.

Four general water supply situations for augmentation are discussed below: 1) mine with drilled well, 2) mine with spring, 3) mine with small entrance-way, and 4) mine with drive-in entrance.

The Civil Preparedness planner is advised to enlist the aid of the health department sanitarian and/or waterworks personnel in any activities directed toward augmenting mine water supplies. It is noted also that these individuals can arrange to have a candidate water supply tested for bacterial contamination.

1. Mine with drilled well

Many mines obtain water from drilled wells located on the mine site, but usually outside of the mine itself. If the yield of the well is adequate to meet the water supply requirement of the anticipated population, then augmentation, in the case of a well within a mine, will involve only expanding the distribution system and providing any additional faucets required. A well outside the mine can be utilized as a source of supply by piping the water into the mine. In this connection, plastic pipe, which is widely available, is quite suitable. Again, it will be necessary to provide a distribution system and faucets within the mine. Electric power for the pump, whether in- or outside of the mine, should be provided by portable generators located inside the mine.

A well that is to be used as a source of drinking water should be cased, properly drained, and otherwise protected so that contamination by surface water is prevented. Particular caution should be exercised in considering a well (or spring) where limestone strata are present, since polluted water frequently has been observed to travel considerable distances through fissured limestone, with resulting contamination of a water supply.

2. Mine with spring

Springs in mines can be protected so that they can serve as safe water supplies. This involves bricking up the spring and providing an overflow pipe in a manner similar to that shown in Figure 25. By protecting the spring, it is possible to prevent contamination of the water.

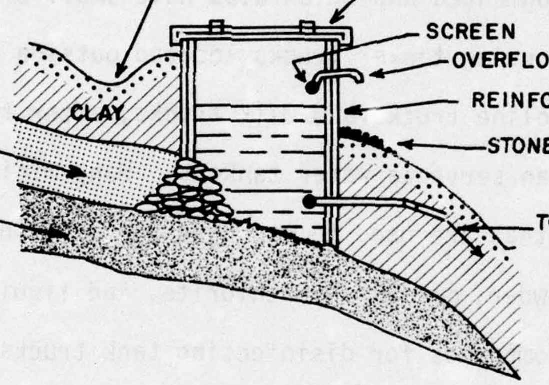
3. Mines with small entrance or shaft entry

Providing water in mines that have neither springs nor drilled wells that can be augmented and which also have small or shaft entry ways may be accomplished using tanker trucks located outside with hoses leading into the mine. Gasoline trucks and milk trucks, after thorough cleansing and disinfection, can serve as water tankers. Many mining companies also have water tankers that are used to wet down the dust on roads at the mine site. Bleaching powder, calcium hypochlorite, and liquid bleach are all suitable chlorine compounds for disinfecting tank trucks prior to filling them with drinking water. The proper amounts of these chemicals for various water volumes are shown in Table 3.

Water supplies also may be augmented by storing containers of potable water in the mine during the immediate pre-shelter period. Potable water can be stored in cans, barrels, etc. in the number and volume required to support the sheltered population for the duration of the shelter period.

4. Mine with drive-in entrance

Augmentation of mines with entry ways large enough to accommodate tank trucks is particuarly easy, assuming that tank trucks can be located and commandeered for this purpose.



Source: V.M. Ehlers and E.W. Steel, Municipal and Rural Sanitation, 6th ed., New York: McGraw-Hill Book Company, 1965.

Figure 25. A Protected Spring.

TABLE 3

Amounts of Chemicals Required for a Strong Chlorine Solution[a] to Sterilize Wells, Reservoirs, Tankers, etc., Prior to Bringing them into Service

Water		Bleaching Powder (25-30%)		High Strength(70%) Calcium Hypochlorite		Liquid Bleach (5% Sodium Hypochlorite)	
Gal.	M^3	Lbs.	G.	Lbs.	G.	Fl. Oz.	ml
26.4	0.10	.022	10	.009	4.3	2.03	60
31.7	0.12	.026	12	.011	5.2	2.43	72
39.6	0.15	.033	15	.014	6.5	3.04	90
52.8	0.20	.044	20	.019	8.6	4.06	120
66.0	0.25	.055	25	.024	11.0	5.07	150
79.3	0.30	.066	30	.029	13.0	6.08	180
105.7	0.40	.088	40	.037	17.0	8.11	240
132.1	0.50	.110	50	.049	22.0	10.14	300
158.5	0.60	.132	60	.057	26.0	12.17	360
184.9	0.70	.154	70	.066	30.0	14.20	420
211.3	0.80	.176	80	.075	34.0	16.23	480
264.2	1.00	.220	100	.095	43.0	20.28	600
317.0	1.20	.265	120	.115	52.0	24.34	720
396.3	1.50	.331	150	.143	65.0	30.42	900
528.3	2.00	.441	200	.190	86.0	40.57	1200
660.4	2.50	.551	250	.243	110.0	50.71	1500
792.5	3.00	.661	300	.287	130.0	60.85	1800
1057.0	4.00	.882	400	.375	170.0	81.13	2400
1321.0	5.00	1.102	500	.485	220.0	101.41	3000
1585.0	6.00	1.323	600	.573	260.0	121.70	3600
1849.0	7.00	1.543	700	.661	300.0	141.98	4200
2113.0	8.00	1.764	800	.750	340.0	162.26	4800
2642.0	10.00	2.205	1000	.948	430.0	202.83	6000
3170.0	12.00	2.646	1200	1.146	520.0	243.39	7200
3963.0	15.00	3.307	1500	1.433	650.0	304.24	9000
5283.0	20.00	4.409	2000	1.896	860.0	405.66	12000
7925.0	30.00	6.614	3000	2.866	1300.0	608.49	18000
10567.0	40.00	8.818	4000	3.748	1700.0	811.31	24000
13208.0	50.00	11.023	5000	4.850	2200.0	1014.14	30000
15850.0	60.00	13.228	6000	5.732	2600.0		
18492.0	70.00	15.432	7000	6.614	3000.0		
21134.0	80.00	17.637	8000	7.496	3400.0		
26417.0	100.00	22.046	10000	9.480	4300.0		
31700.0	120.00	26.455	12000	11.464	5200.0		
39626.0	150.00	33.069	15000	14.330	6500.0		
52834.0	200.00	44.092	20000	18.960	8600.0		
66042.0	250.00	55.115	25000	24.251	11000.0		
79251.0	300.00	66.138	30000	28.660	13000.0		
105668.0	400.00	88.184	40000	37.478	17000.0		
132085.0	500.00	110.230	50000	48.501	22000.0		

[a]Approximately 30 mg of applied chlorine per litre of water. This is not suitable for drinking purposes.

Instructions for chlorinating with strong chlorine solutions

(1) Stop supplying the public with water from the source (well, reservoir, etc.) that is to be disinfected. For reservoirs and tankers, clean the inside thoroughly by brushing and flushing.

(2) Use one of the chemicals listed in the table. The amount of chemical should correspond to the maximum capacity of the reservoir (tanker).

(3) First dissolve the chemicals in a bucket (not more than about .22 lb (100 g) of calcium hypochlorite or bleaching powder in one bucket of water).

(4) For wells, pour the solution (one or more bucketsful one after another) into the well. If possible, agitate the water to ensure good mixing. For reservoirs and tankers, pour the solution into the tank when it is half full of water and top it up competely afterwards.

(5) Leave the strongly chlorinated water for at least 12 hours in the well or tank. This water should not be used for drinking purposes.

(6) For wells, pump the strongly chlorinated water from the well and reject it until the residual chlorine level is below .0000058 lb per gallon (0.7 mg per litre) of water. For tanks, empty the tank completely and let the water run to waste. Then restart normal operations and supply the public.

Source: S. Rajagopalau and M. A. Shiffman, Guide to Simple Sanitary Measures for the Control of Enteric Diseases. Geneva: World Health Organization, 1974.

Where it becomes necessary to use water that is known to be polluted or is of questionable purity, the water should be disinfected prior to use. Disinfection can be accomplished by heating water until it begins to boil, treatment with iodine (2 drops of a 2% ethanol solution of iodine will disinfect a liter of clear water) or, more commonly, with a chlorine compound. Appropriate dosages of chlorine compound are shown in Table 4. Note that turbid water may require additional disinfectant and/or increased contact time to achieve proper disinfection.

Steps to reduce the water requirements should accompany the augmenting of existing supplies. As an example, the water needs for personal hygiene could be reduced through the use of commercially available handtowels prepackaged in a mild cleansing solution (e.g., Wipe and Dry). Another method for reducing water use might involve the use of fiber board on mine floors for sleeping and sitting purposes. Persons would not get dirty as quickly, thus, reducing the frequency of washing required.

C. Identify Required Resources

Estimates should be made of the quantities required and sources identified for the particular tools and materials needed to implement the water supply system. Required resources might include hand tools; plastic pipes, faucets, pumps, engine-generators; water tankers, gasoline trucks and/or milk trucks; bleaching powder, calcium hypochlorite, and/or liquid bleach; and jerry cans, barrels, etc. Arrangements should be made to have these resources delivered to the mine in the event of a crisis situation.

TABLE 4

AMOUNTS OF CHEMICALS NEEDED TO DISINFECT WATER FOR DRINKING[a]

Water		Bleaching Powder (25-30%)		High Strength(70%) Calcium Hypochlorite		Liquid Bleach (5% Sodium Hypochlorite)	
Gal.	M^3	Lbs.	G.	Lbs.	G	Fl. Oz.	ml
264.2	1.0			.0022	1.0	.47	14
317.0	1.2			.0026	1.2	.57	17
396.3	1.5	.008	3.5	.0033	1.5	.71	21
528.3	2.0	.011	5.0	.0044	2.0	.95	28
660.4	2.5	.013	6.0	.0055	2.5	1.18	35
792.5	3.0	.015	7.0	.0066	3.0	1.42	42
1057.0	4.0	.020	9.0	.0088	4.0	1.89	56
1321.0	5.0	.026	12.0	.0110	5.0	2.37	70
1585.0	6.0	.031	14.0	.0132	6.0	2.84	84
1849.0	7.0	.035	16.0	.0154	7.0	3.31	98
2113.0	8.0	.042	19.0	.0176	8.0	3.72	110
2642.0	10.0	.051	23.0	.0220	10.0	4.73	140
3170.0	12.0	.062	28.0	.0265	12.0	5.75	170
3963.0	15.0	.077	35.0	.0331	15.0	7.10	210
5283.0	20.0	.110	50.0	.0441	20.0	9.46	280
7925.0	30.0	.154	70.0	.0661	30.0	14.20	420
10567.0	40.0	.198	90.0	.0882	40.0	18.93	560
13208.0	50.0	.265	120.0	.1102	50.0	23.66	700
15850.0	60.0	.309	140.0	.1323	60.0	28.39	840
18492.0	70.0	.353	160.0	.1543	70.0	33.12	980
21134.0	80.0	.419	190.0	.1764	80.0	37.18	1100
26417.0	100.0	.507	230.0	.2205	100.0	47.32	1400
31700.0	120.0	.617	280.0	.2646	120.0	57.46	1700
39626.0	150.0	.772	350.0	.3307	150.0	70.98	2100
52834.0	200.0	1.036	470.0	.4409	200.0	94.64	2800
66042.0	250.0	1.279	580.0	.5512	250.0	118.30	3500
79251.0	300.0	1.543	700.0	.6614	300.0	141.96	4200
105668.0	400.0	2.072	940.0	.8818	400.0	189.28	5600
132085.0	500.0	2.579	1170.0	1.1023	500.0	236.60	7000

[a] Approximate dose = .0000058 lb of applied chlorine per gallon (.7 mg per litre) of water.

Instructions for chlorinating drinking water

(1) Use one of the chemicals listed in the table and choose the amount according to the quantity of water in the distribution tank, cistern, or tanker.

(2) Dissolve the chemicals first in a bucket of water (not more than about 100 g of calcium hypochlorite or bleaching powder in one bucket of water) and pour the solution into the tank. If possible, agitate the water to ensure good mixing.

(3) This chlorination procedure should be repeated as soon as the level of residual chlorine in the water drops below .0000017 lb per gallon (0.2 mg per litre).

Source: S. Rajagopalau and M. A. Shiffman, Guide to Simple Sanitary Measures for the Control of Enteric Diseases. Geneva: World Health Organization, 1974.

D. Surveillance

Surveillance of water supplies during the in-shelter period should be performed at regular intervals to guarantee the continued potability of supplies. Absence of disease causing organisms and radioactive fallout from the water supplies is of major concern. A chlorine test kit is recommended for determing the chlorine residual of disinfected water. An acceptable chlorine residual indicates that enough chlorine has been added to the water for disinfection purposes and that a margin of safety exists. A public health specialist could provide assistance in this. In addition, a device for radiation monitoring is recommended to determine if fallout contamination of water supplies has occurred.

V. HUMAN EXCRETA AND SOLID WASTE DISPOSAL

This section addresses the problem of waste disposal (both the disposal of human excreta* and other liquid waste from bathing and working, and solid waste) in a mine shelter. The need for the proper disposal of waste is especially important in the prevention and control of common vehicle- and vector-borne communicable diseases. Simply stated, excreta disposal practices must prevent fecal contamination of soil, and ground and surface water, and prevent flies and other pests from coming in contact with excreta. Similarly, solid waste disposal practices must avoid creating harborage for flies, rodents, and other pests. In this section, quantitative excreta and solid waste requirements are given and methods of augmenting existing waste disposal systems are discussed. The success of efforts to upgrade existing mine sanitation facilities during a crisis depends largely on the completeness of advance planning. Guidance is given here for use by the planner in developing internal readiness procedures. These are actions that should be taken prior to the receipt of advice to evacuate people to the mine and upgrade mine facilities.

It is advisable that local planners enlist the assistance of a public health specialist or other person knowledgeable in the technical aspects of excreta and solid waste disposal early in the planning process. Sanitarians and sanitary engineers are familiar with the many aspects of waste disposal and would be of invaluable assistance during the planning stages. During the actual in-shelter period, the public health specialist would be responsible for the surveillance and monitoring of waste disposal

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*No provisions are made in this section to deal with the additional excreta load caused by pets brought by their owners into the mine during the crisis period.

sites to ensure their proper and sanitary operation. To obtain the assistance of a public health specialist, the planner should turn first to the local health department, where such individuals are usually employed. In addition, the resources of state and regional health agencies are usually available to local planners. These agencies would be able to provide technical advice through consultation on matters of excreta and solid waste disposal.

A. Quantitative Requirements

1. Excreta Disposal

The quantitative requirements for excreta disposal will help the planner determine the extent to which facilities must be provided. Per capita production of excreta is linked closely with water intake. Based on the physiological requirement for water of about 84 ounces/day, each person can be expected to produce about the same quantity (84 ounces) of excreta per day. This does not take into consideration, however, waste (mostly in the liquid form) that is produced as a result of water used for personal hygiene practices and cooking. Water requirements for drinking, cooking and personal hygiene practices in temporary shelters and camps are 4-5.3 gallons/capita-day (Ref. 4). Sewage disposal facilities should be adequate to handle this load. However, the Federal Civil Defense Guide (FCDG) calls for only 2.1 gallons of human waste disposal capacity/shelter space stocked (Ref.3). For a 14-day in-shelter period, this would provide only .151 gallon/day of capacity.

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*Although the disposal of human excreta is the primary concern of this section, consideration is also given to the disposal of other liquid waste produced as a result of water using activities, e.g. bathing and cooking.

In general, planners should base the sewage disposal requirements on available water since the amount of excreta and other liquid wastes produced will correspond closely to water usage.

The number of toilet seats required will be a function of the population to be sheltered. The number of toilet seats recommended in the FCDG is two toilets per 100 shelter occupants. This should be viewed as the absolute minimum. A more desirable figure would be seven toilets per 100 shelter occupants.* Table 5 gives the planning factors for the provision of excreta disposal; FCDG recommendations should be considered as absolute minimums. Planners should attempt to upgrade existing facilities as near to the "desired" levels as is feasible.

2. Solid Waste Disposal

The method chosen for solid waste disposal in mines should prevent the creation of health hazards and odors. Obviously, disposal by burial will not be feasible in hard rock.

Solid waste is normally generated at a rate of seven pounds per capita per day (Ref. 6). It is likely that this rate will decrease during the in-shelter period. Solid waste containers of 15-25 gallon capacity should be provided at the rate of 3 to 4 containers per 100 occupants (Ref. 3). The Federal Civil Defense Guide (FCDG) does not contain specifications relating to the disposal of solid waste generated during in-shelter periods. Table 6 includes planning factors for solid waste disposal.

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*This is based on requirements by the Occupational Safety and Health Administration of one privy seat for each fifteen persons for migrant labor camps (Ref. 4).

TABLE 5.

Planning Factors for the Disposal of Excreta in Mines.*

Factor	FCDG	Desired
Human waste disposal capacity (gallon/capita-day)	0.151	.660**
Toilet seats (number per 100 occupants)	2	7

*Assuming a 14-day in-shelter period

**Based on physiological requirement for water of 84 ounces/day.

TABLE 6.

*Planning Factors for the Disposal of Solid Wastes in Mines.**

Factor	FCDG	Desired
Solid waste disposal capacity (lbs./capita-day)	not specified (assume < 7)	7
Solid waste collection containers, 15-25 gallons or less (number per 100 occupants)	not specified (assume < 3)	3-4

*Assuming a 14-day in-shelter period.

B. Planning Guidelines

Contained herein are planning guidelines to assist planners in upgrading excreta and solid waste facilities in mines in the event of a crisis. The guidelines intentionally do not dictate strict procedures to be followed by planners for fear of limiting their usefulness. Instead, they suggest waste disposal alternatives and general planning functions for the planner's consideration.

1. Excreta Disposal

a. Ascertain Existing Facilities

A survey of existing sewage disposal facilities should be performed initially. Information on the method and capacity of the existing disposal system will later assist the planner in determining the most suitable disposal method and the quantitative requirements for upgrading the mine.

b. Select a Suitable Method

Determine the most suitable method (or methods) for the disposal of human excreta. In general, any method of excreta disposal that is considered should confine excreta; prevent contamination of water supply; provide convenience and privacy; and be clean and relatively odor free. From a practical standpoint, the disposal method chosen should be simply and quickly constructed, easily maintained, operable with a minimum reliance on the individual user, reliable over an extended period of time, and utilize resources in a cost effective manner.

Selecting the most suitable method for the disposal of human excreta will depend primarily on two factors: 1) the availability of running water and, 2) nature of the disposal site where running water is not available. A water-borne sewage disposal system is the most desirable. However, it is assumed that most mines will not have sufficient running water to support such a system and will have to rely on a waterless disposal system. The second important factor to consider is the disposal site. Preparation of a disposal site by excavation or digging in the rock floor will not be practical. This fact eliminates several disposal methods that employ soil for containment and/or absorption purposes.

Table 7 gives several alternative sewage disposal methods that do not require running water and would be suitable for many crisis situations. Several of these methods require that soil be available and are, thus, not practical for use in mines. This list is not exhaustive; it is intended only as a planning aid.

A walk-through inspection of the mine should be helpful in determining what method(s) listed in Table 7 are most feasible. Where other methods of excreta disposal are impractical due to time limitations, excavation or soil requirements, shortage of resources, etc., two methods should have widespread applicability. They are chemical toilets and removable pail privies.

In chemical privies, a metal tank, generally of 125- to 250-gallon capacity is the receptacle, although smaller capacity tanks may be used. This method relies upon the action of a chemical, usually caustic soda (NaOH) to disintegrate the excreta and kill

TABLE 7.

Sanitary Excreta Disposal Methods

FACILITY	SUITABILITY	LOCATION	CONSTRUCTION	MAINTENANCE
Sanitary earth pit privy	Where soil available and ground-water not encountered. Earth can be mounded up if necessary to bring bottom of pit 2 ft above groundwater or rock.	Downgrade, 100 ft or more from sources of water supply; 100 ft from kitchens; 50 to 150 ft of users; at least 2 ft above ground-water; 50 ft from lake, stream.	Deep pit; insects, rodents, and animals excluded; surface water drained away; cleanable material; attractive; ventilated pit and building. Pit 3'×4'×6' deep serves average family 3 to 5 yr.	Keep clean and flytight; supply toilet paper. Apply residual fly spray to structure and borax, fuel oil, or kerosene to pit. Natural decay and desiccation of feces reduce odors. Keep waste water out. Scrub seat with hot water and detergent.
ʼasonry vault privy	To protect underground and surface-water supplies.	Downgrade and 50 ft or more from sources of water supply; 100 ft from kitchens; 50 to 150 ft of users.	Watertight concrete vault; flytight building; cleanable material; ventilated vault and building. Capacity of 6 ft^3 per person adequate for 1 yr.	Keep clean, flytight, and attractive. Supply toilet paper. Apply residual spray. Clean pit when contents approach 18" of floor. Scavengers can be used.
;eptic privy Lumsden, Roberts, ınd Stiles: LRS ›rivy.)	Where cleaning of pit is a problem and odors unimportant.	Same as pit privy.	Watertight vault with tee outlet to leaching pit, gravel trench, filter, vault, etc. Provide capacity of 250 gal plus 20 gal for each person over 8 yrs.	Add 2 gal water per seat. Keep clean and flytight. Supply toilet paper. Agitate after use. Clean vault when depth of sludge and scum = 12" to 18".
xcreta disposal pit	For disposal of pail privy and chemical toilet contents.	Downgrade and 200 ft from sources of water supply; 100 ft from kitchen.	Shored pit with open-joint material. Tight top and access door.	Keep flytight and clean. Drain surface water away.
hemical toilet (cabiet and tank-type)	A temporary facility. To protect water supply, where other method impractical. Temporary camp, vehicle, boat.	May adjoin main dwelling. Tank type same as masonry vault privy.	Same as masonry vault privy. Tank may be heavy gauge metal with protective coating. Provide capacity of 125 to 250 gal per seat.	Use ½ lb lye for each ft^3 of vault capacity made up to 6" liquid depth in vault, or 25 lb caustic per seat in 15 gal water. Keep clean. Clean vault when 2/3 to 3/4 full. Odor control. Empty and recharge as directed.
ncinerator toilet	Where electricity or gas avail.	Within the facility.	Enclosed compartment.	Keep clean and supply toilet paper.
ecirculating toilet	Airplanes, boats, fairgrounds, camps.	Within the facility.	Enclosed prefabricated unit.	Keep clean. Empty contents in approved facility and recharge with chemical.
emovable pail privy ›ucket latrine)	A temporary facility; to protect water supply, where pit privy impractical.	Same as masonry vault privy.	Same as masonry vault privy. Provide easily cleaned pails.	Provide collection service, excreta disposal pit, and cleaning facilities, including hot water (backflow preventer), long-handled brushes, detergent, drained concrete floor.
rtable box, earth t, latrine	At temporary camps.	Same as pit privy. Army recommends latrine 100 yd from kitchens.	Earth pit with portable prefabricated box.	Same as earth pit privy. Provide can cover to keep toilet tissue dry.
red-hole latrine	In isolated place or when primitive, inexpensive, sanitary facility is needed.	Same as earth pit privy.	Bored hole 14 to 18" diameter and 15 to 25 ft deep with bracing if necessary. Seat structure may be oil drum, box, cement or clay tile riser with seat, or use squatting plate. Platform around hole.	Same as earth pit privy. Line upper 2 ft of hole; in a caving formation line hole to support earth walls.
raddle trench rine	At temporary camp for less than one day.	Same as earth pit privy.	Trench 1 ft wide, 2½ ft deep, and 4 ft long for 25 men.	Frequent inspection. Keep excreta covered. Provide toilet paper with waterproof cover.
hole	On hikes or in field.	Same as earth pit privy.	Hole about 1 ft deep.	Carefully cover hole with earth.
atting latrine	Where local conditions and customs permit.	Same as pit privy.	Similar to privy or bored-hole latrine.	Same as privies and latrines.

Note: If privy seat is removable and an extra set is provided, it is easier to scrub seats and set aside to dry. A commercial plastic or composition- e seat is recommended in place of improvised crudely made wooden seats. Deodorants that can be used if needed include chlorinated lime, cloroben, iron phate, copperas, activated carbon, and pine oil. Keep privy pits dry. Solutions for chemical toilets include lye (potassium hydroxide), caustic soda or ash (sodium hydroxide), chlorinated lime (1 lb in 2½ gal water), copper sulfate (1 lb in 2½ gal water), and a chlorinated benzene.

rce: Salvato, Joseph A., Jr., Environmental Engineering and Sanitation, Second Edition, New York: Wiley-Interscience, 1972.

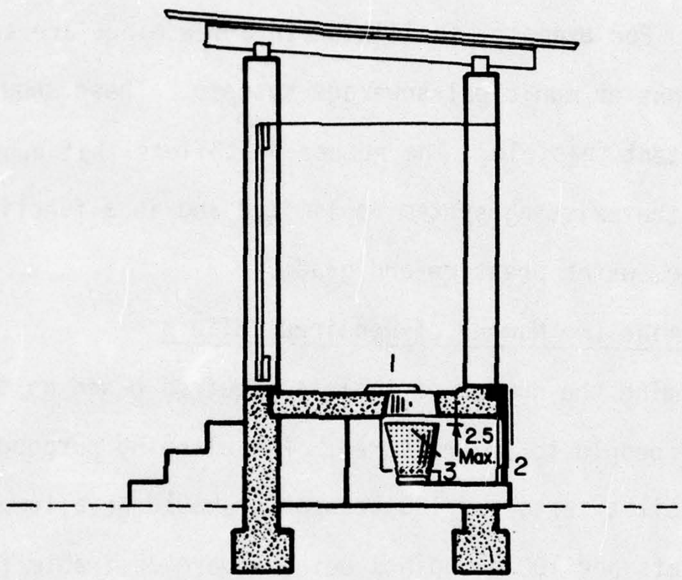
pathogens. A charge of 25 pounds of caustic is added to 10 to 15 gallons of water and placed in the tank. The spent chemical and accumulating liquids must be removed from time to time. In chemical tanks provided with an overflow, 3 to 4 pounds of caustic in 5 gallons of water should be added monthly. The tank can be drained into a holding pit if one exists.

The removable pail privy employs a watertight receptacle, preferably a metal can, enclosed in a box usually made of wood. The lid of the box serves as the toilet seat. The can is removable, facilitating frequent removal and replacement of the can.

The success of the box and can privy depends upon regular and reliable scavenging; daily or tri-weekly the cans are removed and hauled to a central point for disposal of excreta and sanitizing. A simple modification is the addition of a caustic solution to the receptacle. This converts the can privy into a commode type chemical toilet. Generally, caustic is added to the can in the amount of 2 pounds dissolved in a small amount of water per 10 gallon capacity. A removable pail privy is illustrated in Figure 26. It is housed in a fairly elaborate wood structure; simpler material, e.g. cloth, may be used to partition-off the privy.

A slightly different approach to the use of chemical and removable pail privies would be the use of plastic bags inserted to catch the excreta. The bags could then be tied-off and disposed of elsewhere. Caution should be exercised to avoid filling the bags full enough to result in their tearing open.

Another alternative is the masonry vault privy. This method is used where there is a danger of contaminating a nearby water supply.



Features:

1. Seat Cover
2. Self-closing, Flytight Chamber Door
3. Guides for Positioning of Bucket

Adapted From: Rajagopalan, S. and M. A. Shiffman, Guide to Simple Sanitary Measures for the Control of Enteric Diseases, Geneva: World Health Organization, 1974.

Figure 26. Removable Pail Privy.

The masonry vault privy is identical to the earth pit privy except that a watertight concrete vault is substituted for the earth pit. Common problems with this privy include overflows, high urine concentrations in the vault which hinder the decomposition of feces, and long construction time.

Other disposal methods mentioned here are available to local planners. For example, facilities in a few mines are connected to septic tanks or municipal sewerage systems. These should be expanded to the extent feasible. The number of toilets that can be added to the existing system is limited and is a function of available water, water pressure and grade.

c. Determine the Number of Required Toilets

Determine the number of toilets required based on the proposed number of people to be sheltered. For planning purposes, a minimum of two (2) toilet seats per 100 occupants should be allowed with seven (7) toilet seats per 100 occupants being a more desirable figure. Excreta disposal facilities already in-place inside the mine should be taken into consideration when estimating the shelter requirements. The ability to provide toilets in excess of the minimum will be a function of the local situation.

d. Determine Sites for the Location of Toilets

The planner should select suitable sites in the mine for the placement of toilets. Assuming the people are fairly evenly distributed in the mine, toilets should be placed in clusters of approximately 20-30 throughout the mine located conveniently to as many people as possible. In room and pillar type mines it should not be difficult to identify areas large enough to accomodate clusters of toilets. However, in mines with the usable floor area located mainly in haulage drifts, it may be necessary to either place the toilets in stopes or to place them in smaller groups. To reduce the chances of contamination, care should be taken to avoid locating toilets too closely to food handling and water supply areas. Toilet facilities for men and women should be segregated and partitioned off, using wood, canvas, cloth, or any material that will ensure privacy. In addition, it is preferred that individual toilets also provide some degree of privacy through the use of partitions.

e. Locate Disposal Site

It will be necessary to empty the contents of chemical and removable pail privies to avoid overflow. A site(s) for the disposal of sewage as well as for the cleaning of buckets and other equipment associated with excreta disposal facilities should be identified. Depressed areas in the mine (e.g., sumps) or areas located at lower elevations than the habitable floor area could serve as holding tanks for the sewage. Sumps equipped with pumps can be used to pump waste water from the mine but should not be used to remove excreta. Sites to be used as holding tanks for sewage should be selected to prevent health hazards and to avoid creating odor problems for the sheltered population. Persons not assigned to work in this area should not be allowed access.

In mines with no sumps or low areas, it will be necessary to store the sewage in cans, buckets, plastic bags, etc. The storage containers should be located at the toilet sites to facilitate emptying and reduce handling. In mines with drive-in entries, sludge tank trucks could be used to empty receptacles. The trucks could then be emptied outside the mine when radiation levels become low enough to permit exposures for short periods of time. It will generally be possible for people to go outside for short periods of time after one or two days in shelter.

In some mines the disposal capacity will be severely limited by a shortage of holding tank sites and containers. An option in mines with this problem is to restrict the water supply to quantities in the low end of the allowable range (e.g., .26 gallon to 1.32 gallons per capita-day rather than 3.96 to 5.28 gallons). Commercially available hand towels prepackaged in a mild cleansing solution (e.g. Wipe and Dry) may be used to maintain basic cleanliness and cooking may be limited or eliminated. Therefore, there should be little or no waste water other than excreta to dispose of.

f. *Identify Required Resources*

Identify and locate the resources necessary to implement the appropriate mine sewage disposal method. Necessary materials might include:

- Saws
- Picks
- Shovels
- Hammers
- Lumber
- Plywood
- Buckets, cans, metal tanks, concrete vaults
- plastic bags
- Disinfectants (e.g., caustic soda, lye, potash, chlorine, bleach, hypochlorite)
- Toilet paper
- Pipe (cast iron, concrete, plastic)
- Sludge pumps
- Sludge tank trucks
- Prefabricated temporary toilets (e.g, port-o-lets)
- Insecticides

Where certain items are considered likely to be in short supply, alternatives for augmenting the supplies should be considered.

2. Solid Waste Disposal

a. Ascertain Existing Facilities

A survey should be performed initially of existing garbage and rubbish disposal facilities. This will aid the planner later in determining a suitable disposal method and the quantitative requirements for the in-shelter period.

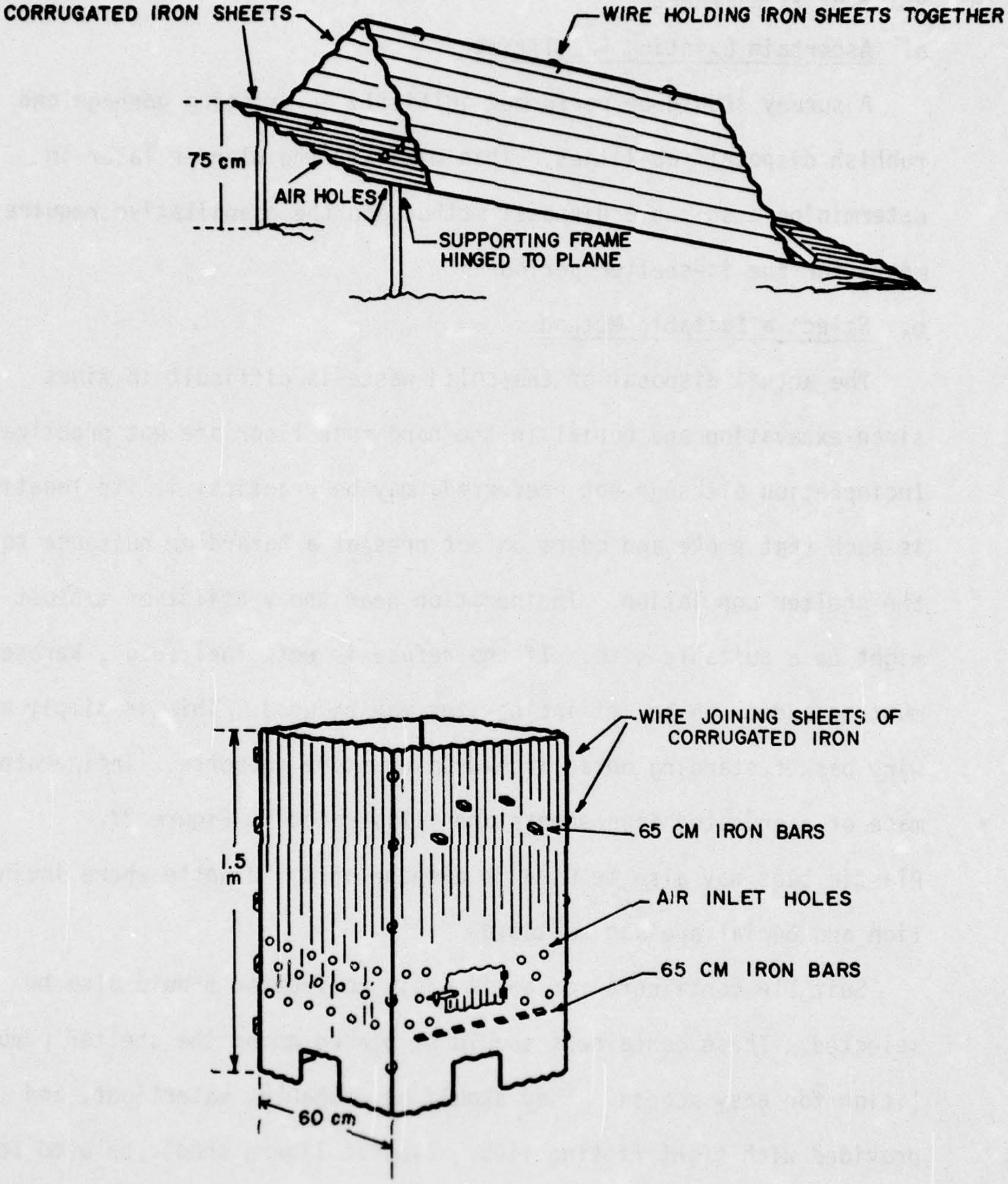
b. Select a Suitable Method

The actual disposal of the solid waste is difficult in mines since excavation and burial in the hard rock floor are not practical. Incineration although not preferred, may be practical if its location is such that smoke and odors do not present a hazard or nuisance to the shelter population. Incineration near the ventilation exhaust might be a suitable site. If the refuse is wet, fuel (e.g., kerosene) must be added. A basket incinerator may be used. This is simply a wire basket standing on an iron drum or stone supports. Incinerator made of corrugated iron sheets are illustrated in Figure 27. Plastic bags may also be used to dispose of solid waste where incineration and burial are not suitable.

Suitable containers for solid waste collection should also be selected. These containers should be placed among the shelter population for easy access. They should be washable, watertight, and provided with tight fitting lids. Plastic liners should be used to facilitate the collection and cleaning of containers. If containers are in short supply and are needed for holding water and/or excreta, plastic bags should be used for solid waste collection.

c. Determine the Number of Collection Containers Required

The planner should plan to provide a minimum of two (2) and as near to 4, 15-25 gallon containers as possible for every 100 persons



Source: Assar, M., Guide to Sanitation in Natural Disasters, Geneva: World Health Organization, 1971.

Figure 27. Inclined-Plane Incinerator (top) and Open Corrugated-Iron Incinerator (bottom).

sheltered. The total number of containers depends on the number of people to be sheltered.

d. Determine Sites for Location of Collection Containers

Collection containers should be located coveniently to as many people as is feasible. Containers should be put in groups of approximately 20-30 in order to facilitate their emptying by maintenance workers.

e. Locate Disposal Site

The planner should locate a site(s) for the disposal of waste and the cleaning of containers. This site(s) may be in conjunction with the excreta disposal site to facilitate the cleaning process. This site(s) should be selected to prevent health hazards and to prevent odors from becoming a problem. In this context, an area in close proximity to the exhaust ventilation might be suitable. In addition, exposed waste should be sprayed systematically with insecticides, and rodent control measures instituted. A strong disinfectant should be applied to waste before its disposal. Persons that have not been assigned to work in this area should not be allowed access.

In drift entry mines which are accessible to trucks, garbage trucks can be used to collect the solid waste. It can then either be stored in the trucks, or the trucks can be used to transport the solid waste to the disposal site(s). When radiation levels become low enough to permit exposure for short periods of time, the trucks can be used to dispose of the solid waste outside the mine.

f. Identify Required Resources

Identify and locate the resources necessary for the collection and disposal of solid waste. Necessary resources might include:

Containers with tight-fitting lids (15-25 gallons)	Saws
Disinfectants (e.g., chloride, of lime)	Picks
Fuel (e.g., kerosene)	Wire Baskets
Corrugated iron sheets	Shovels
Plastic trash can liners	Hammers
Handsprayers	Lumber
Insecticides	Plywood
Rodenticides	

C. Maintenance and Surveillance

During the in-shelter period, the maintenance and surveillance of solid waste and excreta disposal facilities and operations are vital to ensure a relatively disease-free environment. A large number of people will be required to maintain the facilities, e.g., emptying and cleaning filled receptacles. A public health specialist (e.g, someone from the local health department) should be in charge of this effort. He or she should also be responsible for instructing these individuals on the significance of sanitation and personal hygiene prior to the initiation of maintenance tasks related to the waste disposal facilities. It will also be important to maintain a surveillance on the health and well being of the sheltered population with special attention given to the isolation of any communicable disease outbreaks to prevent further spreading.

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APPENDIX A

Example Mine Utilization Plans

APPENDIX A

Example Mine Utilization Plans

Appendix A contains three examples of the use of the manual for developing mine utilization plans. On-site surveys were made at each mine, and the results of these surveys are used to develop example utilization plans. Each example contains a general description of the mine and mine site; factors that will limit the capacity of the mine as a shelter; and plans for providing or upgrading lighting, ventilation, water supply, human excreta and solid waste disposal systems where needed.

Resource requirements in the examples are calculated for the maximum in-shelter period of 14 days. In most cases, the stay-time will be much less than this (an average of about 7 days); however, the examples are used to illustrate the most severe requirements.

EXAMPLE NUMBER 1

Seneca Lake Mine

I. General

The Seneca Lake Mine is an active underground rock salt mine owned by Morton Salt Company. It is located in Himrod, Yates County, New York. The mine can be reached by car by driving south on State Route 14 from its intersection with County Road 608, turning right on Severne Road and following it for about one half of a mile to the mine portals and plant. Both State Route 14 and Severne Road are paved two-lane roads. There are about five acres of paved parking within 100 yards of the portals and several hundreds of acres of fields within one mile of the portals. Use of these fields for parking could be limited depending on the stage of growth of the crops and on the amount of rainfall. In case access by car is limited, alternative modes of transportation may be required. One such possibility is the railroad serving the site. Also, the nearest airfield is a grass strip in Dundee (about four miles) and there is a paved airfield in Penn Yan (about nine miles).

Access to the Seneca Lake Mine is through two 18-foot-diameter shafts, each of which is approximately 2,000 feet in depth. The No. 2 shaft is used primarily for hoisting men and materials and is equipped with a double-deck 100-man capacity hoist. The No. 1 shaft is used primarily for hoisting ore and is equipped with a 15-man hoist and two balanced ore skips suspended on opposite ends of the hoisting cable. A ladderway has also been installed in this shaft. The two shafts are located about 350 feet apart and are interconnected for ventilating purposes.

Room and pillar mining methods have been employed in extracting the salt from the ore level (2,000 feet) of the Seneca Lake Mine. The rooms are about 32 feet wide and provide a total floor area of approximately 6,000,000 square feet. The pillars are competent throughout the mine but the roof is not being cared for in areas that are not producing; therefore, only about one half of the floor area is usable for crisis relocation. The floor is virtually horizontal and is very dry.

A fan driven by a 350-horsepower motor provides 310,000 cfm of forced ventilation to the Seneca Lake Mine. Bulkheads and smaller fans inside the mine serve to distribute the flow of air. The temperature is a relatively hot 80 degrees Fahrenheit and the relative humidity is a low 15 percent. Seneca Lake water is chlorinated and filtrated and pumped to the mine at a rate of 35 gallons per minute. Four faucets have been installed inside the mine and ten on the surface in the offices and mill. On the surface there are forty-four showers, twelve wash basins and five water heaters, with a total capacity of 1,175 gallons. Alternative sources of water include several low producing wells utilized by the farmers in the area and three streams within one mile of the portal. The streams flow at rates of 500 gallons per minute, 1,000 gallons per minute and 5,000 gallons per minute. Morton Salt maintains a sewage disposal system with tertiary treatment (aeration pond and chlorination) on the premises. The capacity of this system is 15,400 gallons per day. There are eight chemical toilets inside the mine and twenty permanent toilets on the surface. Garbage is collected by Seneca Lake Mine and taken to the town dump every two days. The site is served by outside telephone and electric lines. Emergency power is available from a 3,400 kw diesel generator.

II. Limitations on Spaces

The use of the Seneca Lake Mine as a shelter during a nuclear crisis is most severely limited by its shaft entries. Assuming a period of 72 hours duration for the loading and implementation, the hoists can transport

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90,510 people into the mine. Sufficient floor area exists to allow over 31 square feet per occupant for this number of shelterees. There is also an adequate ventilation system (more than 3.4 cfm per occupant could be supplied) presently in place. Figure A-1 illustrates the path of air flow along with the bulkheads and booster fans which distribute the ventilation throughout the mine. For the Seneca Lake Mine to be suitable for temporary occupancy by 90,510 people, it will be necessary to install lights and to upgrade the water supply and waste disposal systems. The following sections will describe the procedures to be followed to achieve these contingencies.

III. Lighting System

Figure A-2 illustrates the plan for lighting the Seneca Lake Mine. Presented below is the step-wise procedure that was followed in developing the plan. Only Steps B, C, E, and F from the manual are included. The planning associated with the remaining steps is dependent on the contacts made with local contractors and on the results of the surveys in the host area associated with the mine.

The mine map is used to identify light fixture locations throughout the mine. Locations are marked at the centers of each quadrangle defined by sets of four pillars in regions of the mine with regular spacing of the pillars, and at 100-foot intervals in regions with very large, irregularly spaced pillars. This results in the light fixtures being placed on 100-foot centers throughout all of the usable sections of the mine.

Compact groups of lights (circuits) ranging from 32 to 37 each are identified. Each of these circuits will have a separate feeder line and can be powered by a single portable engine-generator. Every circuit is bordered by at least two others, so that if one circuit should fail, its associated area will receive some light from neighboring areas. A total

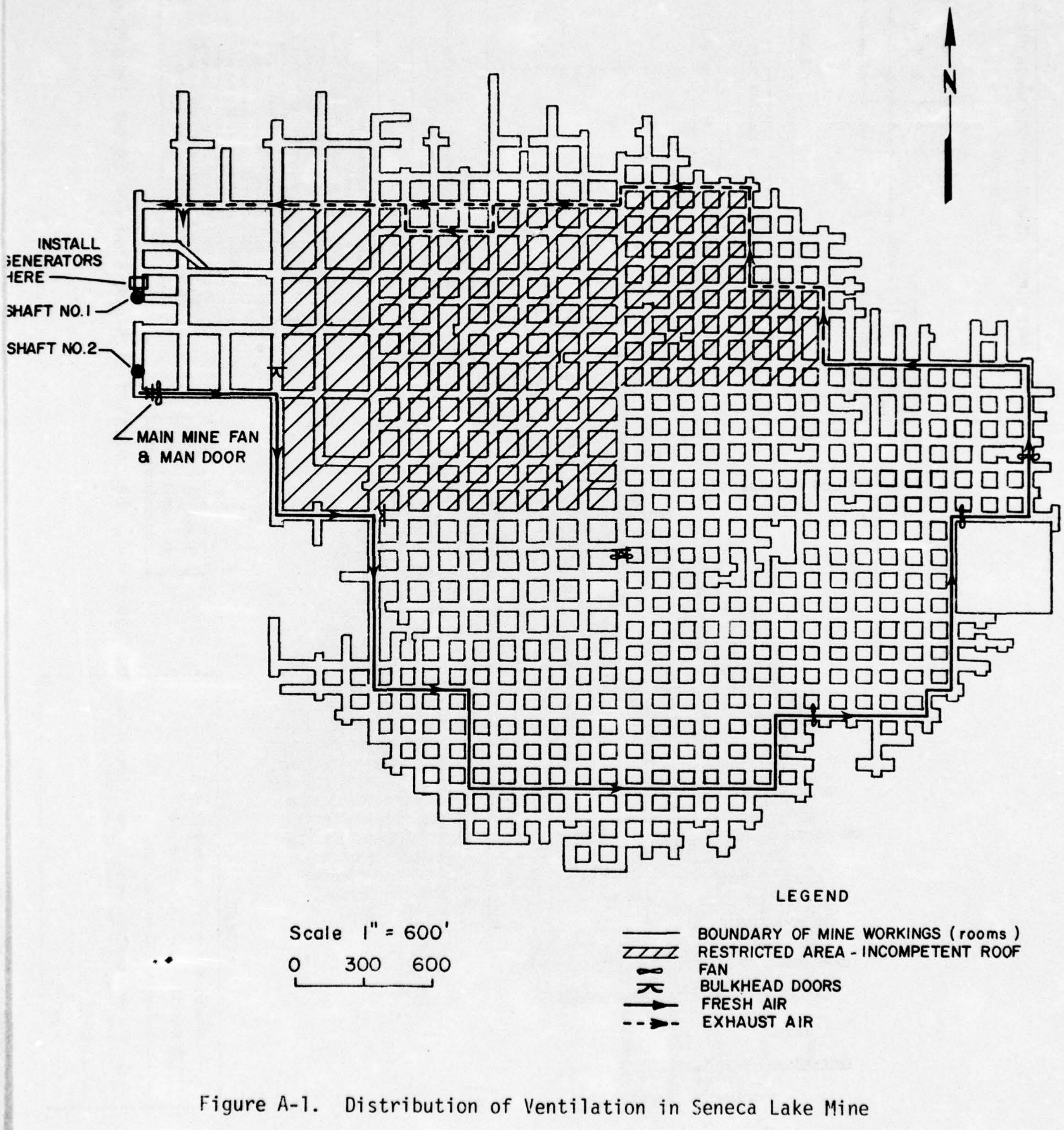
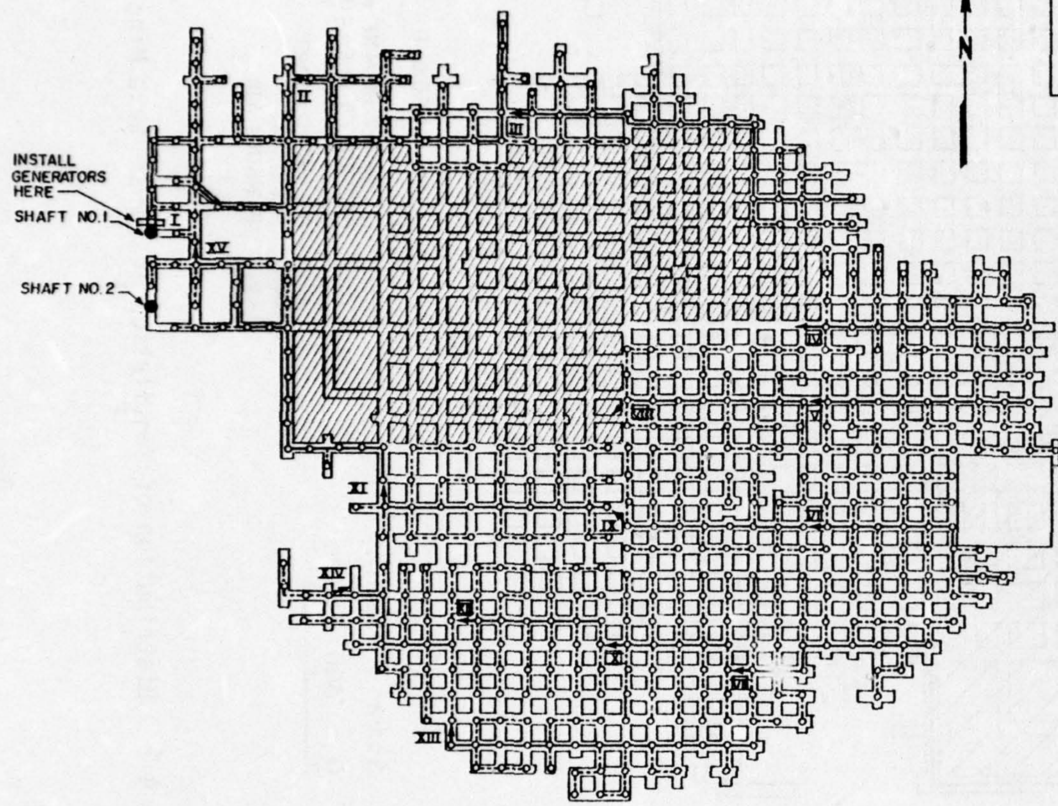


Figure A-1. Distribution of Ventilation in Seneca Lake Mine

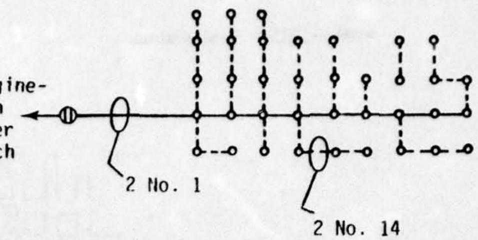


LEGEND

- ——— Boundary of mine workings ("rooms")
- ▨ Restricted area – incompetent roof
- —o— 40-watt incandescent light bulb
- —⦶— 2 conductor, 2A plug and outlet used in place of disconnect switch; use "twist-lock" if available
- ——— Feeder line
- - - - - Branch line

Scale 1" = 600'
0 300 600

SINGLE LINE DIAGRAM OF TYPICAL BRANCH CIRCUIT
(Not to Scale)



SPECIFICATIONS OF CONDUCTOR SIZES

CIRCUIT NO.	AWG FEEDER SIZE	NO. 40w LUMINAIRES	LOAD (WATTS)
I	6	36	1440
II	4	36	1440
III	2	36	1440
IV	1	37	1480
V	2	37	1480
VI	2	37	1480
VII	1	37	1480
VIII	3	36	1440
IX	3	36	1440
X	2	35	1400
XI	4	35	1400
XII	3	36	1440
XIII	2	32	1280
XIV	3	34	1360
XV	4	32	1280

NOTES: 1. All cable is type UF.
2. Copper conductor assumed in calculating conductor size.
3. All branch lines are AWG No. 14 or No. 12.

Circuit No. I, northeast of Shaft #1
Circuit No. II, north of restricted area
Circuit No. III, northeast of restricted area
Circuit No. IV, east of restricted area
Circuit No. V, east of restricted area
Circuit No. VI, southeast of restricted area
Circuit No. VII, south of restricted area
Circuit No. VIII, south of restricted area
Circuit No. IX, south of restricted area
Circuit No. X, south of restricted area
Circuit No. XI, south of restricted area
Circuit No. XII, south of restricted area
Circuit No. XIII, south of restricted area
Circuit No. XIV, south of restricted area
Circuit No. XV, southeast of Shaft #2

Figure A-2. Recommended Lighting Plan for Seneca Lake Mine of 15 different circuits are needed to illuminate the usable floor area in the Seneca Lake Mine.

The engine-generator location is identified in the vicinity of Shaft No. 1. There is sufficient floor area and the exhaust fumes will be drawn outside the mine.

Table 2 is used to specify the sizes of feeder wires to be used with each circuit. Figure A-2 contains the table which lists these specifications.

IV. Potable Water

Presented below is a plan for providing potable water to the Seneca Lake Mine during its use as a shelter.

If water is to be available for cooking and basic cleanliness as well as for drinking, at least 15 liters per capita-day should be supplied. The design capacity of the water supply system is based on this figure. Also, one watering point is to be provided for each 50 people.

Sufficient quantities of water should be supplied to the Seneca Lake Mine to sustain 90,510 people for the assumed 14-day* shelter stay. This will require 358,664 gallons per day; a total of 5,021,296 gallons for the duration of the shelter stay. This quantity is also approximately the amount of excreta and waste water which must be disposed of.

Existing sources of water within the proximity of the Seneca Lake Mine include Seneca Lake, three streams, and several low producing wells utilized by the farmers in the area. During a nuclear crisis it is likely that the surface water supplies will be contaminated and that there will not be enough time to access the limited supply of well water. Therefore, all of the potable water should be provided from other sources.

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*No provisions are made for the loading and unloading periods.

Due to the 2,000 foot depth of the mine, the only feasible method of supplying water appears to be storage in containers. A piped water system is in place in the mine with the capacity to chlorinate, filtrate and pump Seneca Lake water into the mine at the rate of 35 gallons per minute. During the 72-hour implementation period, 151,200 gallons of water can be pumped into the mine from this source, which is only about three percent of the total water requirement. Empty containers with this capacity should therefore be transported into the mine via the ore skips to be filled from the existing water system. The remainder of the water requirement must be transported into the mine in containers filled on the surface.

A total of 1,810 watering points are needed in the mine shelter. These should be placed at convenient locations throughout the mine. Special care should be taken not to locate watering points close enough to toilets or waste disposal sites to risk contaminating the water supply.

A survey should be conducted to identify any locations having large numbers of containers which could be used for water storage. It is also very important that the shelter occupants bring waste cans and plastic bags along with them. These can be used initially for water storage or later for waste collection and storage. Depending on the cleanliness of the available containers, purification of water for drinking may be required. Consequently, sources of chlorine compounds should also be identified. Arrangements should be made at this time to transport containers and chlorine compounds to the mine in the event of a crisis.

V. Human Excreta and Solid Waste Disposal

Following is the step-by-step development of plans for human excreta and solid waste disposal systems for the Seneca Lake Mine.

The Seneca Lake Mine will accomodate 90,510 shelter occupants. Plans for the excreta disposal system are based on this factor in conjunction with the other planning factors identified in the manual for the disposal of excreta in mines, including the capacity of the water supply system. From these factors, estimates are made of the number of toilets needed and the required capacity of the disposal site. Also, the planning factors for the disposal of solid waste in mines are used along with the mine shelter capacity to calculate the required capacity of the disposal site and the frequency that collection containers will need to be emptied and cleaned.

The survey of the Seneca Lake Mine indicated that there are eight chemical toilets inside the mine. A sewage disposal system with tertiary treatment (aeration pond and chlorination) is maintained on the premises. The capacity of the system is 15,400 gallons per day. However, there is presently no access to the sewage disposal system from the inside of the mine.

A sanitation engineer is needed to determine the extent to which the aboveground sewage disposal system can be utilized, if at all. Even if the full capacity of the system is used, additional capacity is needed. For the purpose of this example, it is assumed that the sewage disposal system cannot be accessed within a period of 72 hours, making it necessary to rely on a waterless disposal system.

The floor of the Seneca Lake Mine is solid rock, which limits disposal to those methods which do not require excavation. Two methods are recommended: chemical toilets and removable pail privies. Chemical toilets are the preferred option and should be used to the extent that the local supply of toilets and chemicals permit, with any remaining requirements satisfied by removable pail privies.

The number of toilets needed ranges from 1,810, based on the minimum requirement of 2 toilets per 100 people, up to 6,340 based on the more desirable ratio of 7 toilets per 100 people. The larger figure should be approached as nearly as possible depending on the availability of toilets and the time to install them.

Assuming that the toilets are placed in groups of 30, the number of groups could range from 60 to 211 depending on the total toilets provided. These groups should be placed at regular intervals throughout all of the habitable areas of the mine, spaced at distances ranging from 400 feet to 1400 feet depending on the number of groups. It is very important that the toilets not be located in close proximity to food handling or water storage areas.

The floor of the Seneca Lake Mine is dry and hard and relatively level and has no sumps or other areas which could serve as holding tanks for sewage. Furthermore, the depth of the mine precludes the installation of a system to pump sewage to the surface in the time allotted for upgrading activities. As a result, it will be necessary to store the sewage inside the mine using cans, buckets, plastic bags, etc. These containers should be located at the toilet sites. One convenient arrangement is to place the toilets to form a square with the storage containers enclosed in the square. This will limit accessibility to the disposal site and help to contain the odor.

Since the water supply system in this mine is based on the storage of water in containers, these same containers can be used to store sewage and solid waste as they are emptied of water. Plastic bags, brought in by the shelter occupants, can also be used for this purpose. The use of disinfectants will be very important in this case and sufficient supplies should be identified beforehand and transported into the mine during the initial stages of the crisis.

A survey of the local area should be conducted to identify sources and quantities of resources available. This should be performed concurrently with the choice of a disposal method, since the availability of resources will affect this choice. When the disposal method(s) has been determined, material and tool requirements can be estimated.

Existing garbage and rubbish disposal facilities at the Seneca Lake Mine are very limited. Garbage is currently taken off site to the town dump. Therefore, a complete solid waste disposal system will be needed.

Solid waste will be produced in such large quantities that incineration inside the mine will not be practical. The solid waste cannot be buried because of the rock floor. For these reasons, plastic bags should be used to store the solid waste inside the mine.

To accomodate 90,510 shelter occupants, at least 1,810 collection containers and preferably as many as 3,620 collection containers will be needed.

Assuming that 3,620 collection containers are provided and that they are placed in groups of 30, a total of 121 groups of containers will be required. These should be placed at regular intervals (approximately

700 feet apart) throughout all of the habitable areas of the mine.

Due to the size of the Seneca Lake Mine, it will not be practical to designate one location for solid waste disposal. Instead, plastic bags for storage should be available at the collection sites. Disinfectants for cleaning the collection containers should also be made available at the collection sites.

A survey should be conducted of the local area to identify sources and quantities of required tools and materials. Estimates should be made of the quantities needed, and provisions made for substitutes if necessary.

Emptying and cleaning filled excreta and garbage receptacles will require a large number of people. Assuming that 7 chemical toilets with 125 gallon tanks are installed per 100 occupants, that the toilets get equal usage, and that 2.5 liters of excreta are produced per capita-day, each toilet will need to be emptied once during a 2-week shelter stay, after approximately one and one-half weeks of occupation. If about one-third of the chemical toilets are 250 gallon capacity, the tanks will not need to be emptied. On the other hand, if removable pail privies with 20 gallon cans are installed instead of chemical privies, they will need to be emptied once every two days. Similarly, if it is assumed that four 15-gallon solid waste receptacles are installed per 100 shelterers, that the receptacles get equal usage, and that 7* pounds of solid waste are produced per capita-day, the receptacles will need to be emptied 17 to 18 times daily. If 3 pounds of solid waste are produced per capita-day, a more likely quantity in a crisis situation, the receptacles should be emptied 7 to 8 times daily. As can be seen, the manpower requirement is dependent on the sewage disposal method and on the amount of solid waste expected.

* 135 pounds per cubic yard of solid waste.

EXAMPLE NUMBER 2

Danby Imperial Mine Quarry

I. General

The Danby Imperial Mine Quarry is an active underground marble quarry on Dorset Mountain, outside of Danby, Rutland County, Vermont. It can be reached by car by driving about two miles south of Danby along Route 7, a steep, narrow two-lane road. Parking space is limited to a maximum of one acre at the portal. The nearest railroad passes within a half mile of the mine.

Access to the mine is by a 15- by 20-foot drift entry. It was originally entered through a 30-foot deep vertical shaft (30 feet by 30 feet in cross section), but the stairs are no longer negotiable.

Marble has been extracted from the Danby Imperial Mine Quarry by means of room and pillar mining methods. Pillars about 30 by 30 feet (larger in some cases) on 70-foot centers have been left for roof support. The rooms measure approximately 40 feet in width and the ceiling is 50 feet high. The floor totals some fifteen acres in area and slopes eight degrees toward the back of the mine. There are a few wet areas and two sump holes, but most of the floor area is dry.

Natural ventialtion flows through the Danby Imperial Mine Quarry at about 22,500 cfm. The temperature on the inside remains between 48 and 50 degrees Fahrenheit year around and the relative humidity stays around 80 percent. Ground water is piped to the three faucets in the mine quarry and a 30 gallon water heater has been installed in the lunchroom. There are five permanent toilets located inside the mine. Sewage goes to a holding tank inside the mine from which it is pumped outside to a septic tank. The Danby Imperial Mine Quarry is lighted throughout and the mining company operates a hydroelectric plant to generate its own power.

II. Limitation on Spaces

The shelter capacity of the Danby Imperial Mine Quarry is limited only by its usable floor area. Twenty-thousand seven-hundred people can be accomodated at 30 square feet per occupant. The mine quarry is already adequately lighted, but upgrading will be required for the ventilation, water supply and waste disposal systems.

III. Ventilation

Following is the step-by-step development of a plan to ventilate the Danby Imperial Mine Quarry. All of the planning steps from the manual are included with the exception of Step E. Step E requires surveys and contacts with electrical contractors at the local level. The physical capacity of the mine is 20,700 people. Therefore, the design capacity of the ventilation system should be: 20,700 people x 3 cfm/person = 62,100 cfm.

Measurements taken during RTI's survey indicated an air flow through the inlet of approximately 22,500 cfm. Since this is less than the design capacity a forced ventilation system will be needed, and no additional ventialtion measurements are necessary during other seasons of the year.

Figure A-3 illustrates the flow of natural ventilation through the Danby Imperial Mine Quarry. Air enters the entrance portal and flows through about one third of the mine quarry before short circuiting to the outside through the old shaft at the southeast corner.

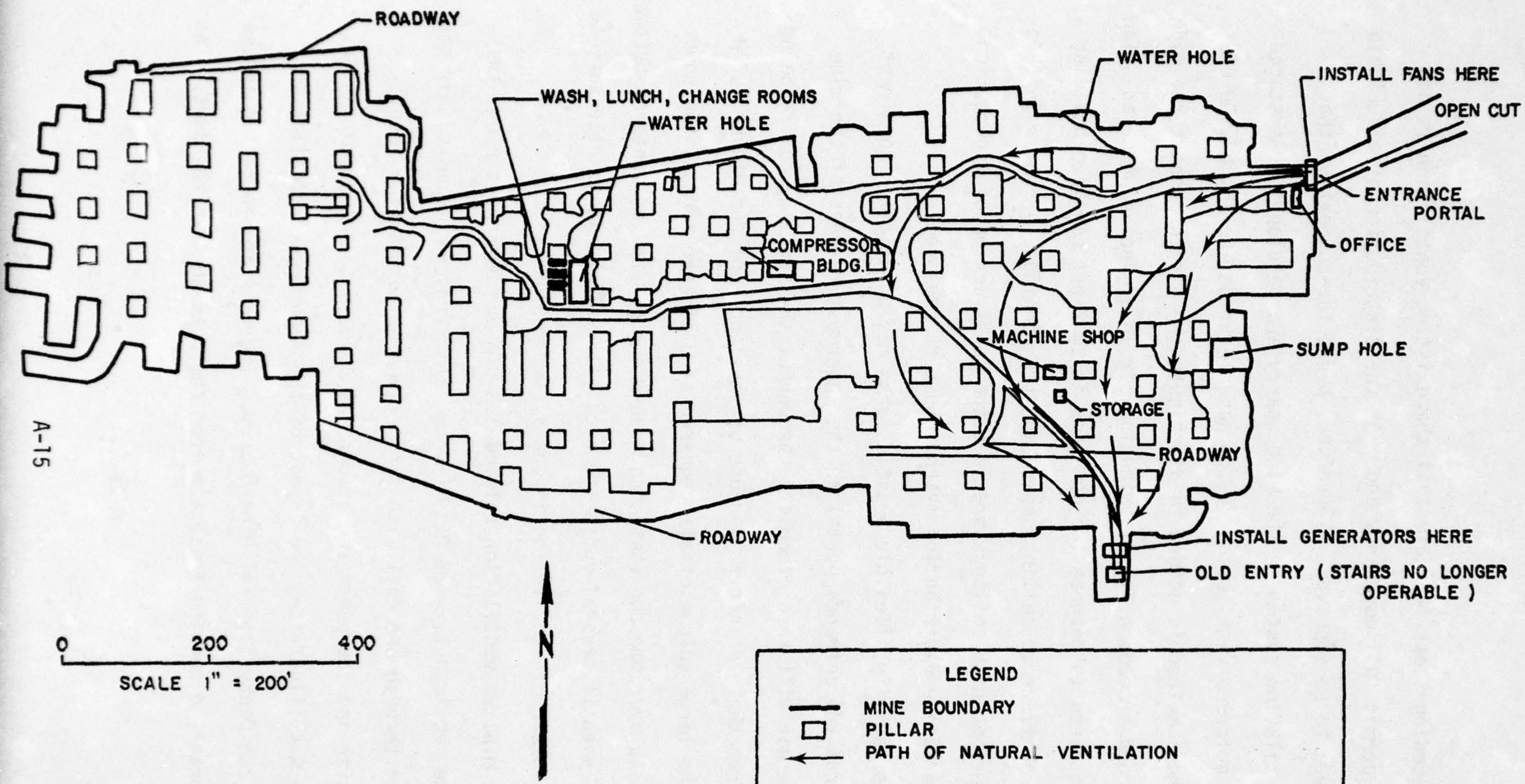

Figure A-3. Flow of Natural Ventilation Through Danby Imperial Mine Quarry

The preceding steps indicate that the existing ventilation is not adequate to permit full occupancy and that the distribution of air within the mine needs to be improved. Therefore, plans for augmenting the existing ventilation system in the mine quarry are developed. As stated previously, a forced ventilation system capable of delivering 62,100 cfm is needed and a method is needed to distribute the air throughout the mine. The recommended procedure for distributing air in a mine in which the flow of air short circuits between two openings is to first consider building a partition from floor to ceiling separating the openings. However in this case, the 50-foot high ceilings preclude the construction of a partition, so that alternative distribution methods must be employed.

In this facility, flexible plastic ducts may be utilized to direct fresh air from the entrance portal to the innermost reaches of the mine quarry. The air will then circulate throughout the facility before being exhausted from the old entry. Because of the length of duct (over 1,700 feet) and the large volume of air required at 3 cfm per person, the power requirement to overcome the static and dynamic pressures encountered becomes prohibitive even if several ducts are used. Therefore, it is necessary to revise the volume of ventilation in the system design.

If the minimum ventilation rate of 1.3 cfm per person is used, the total volume required becomes 26,910 cfm. This reduced amount of air can be delivered through one duct with fans driven by motors of a readily available size and the power requirement is reduced to an acceptable level.

Figure A-4 illustrates the layout of the recommended ventilation system for the Danby Imperial Mine Quarry. The fans are installed in the entrance portal, directing fresh air from the outside into the duct. The

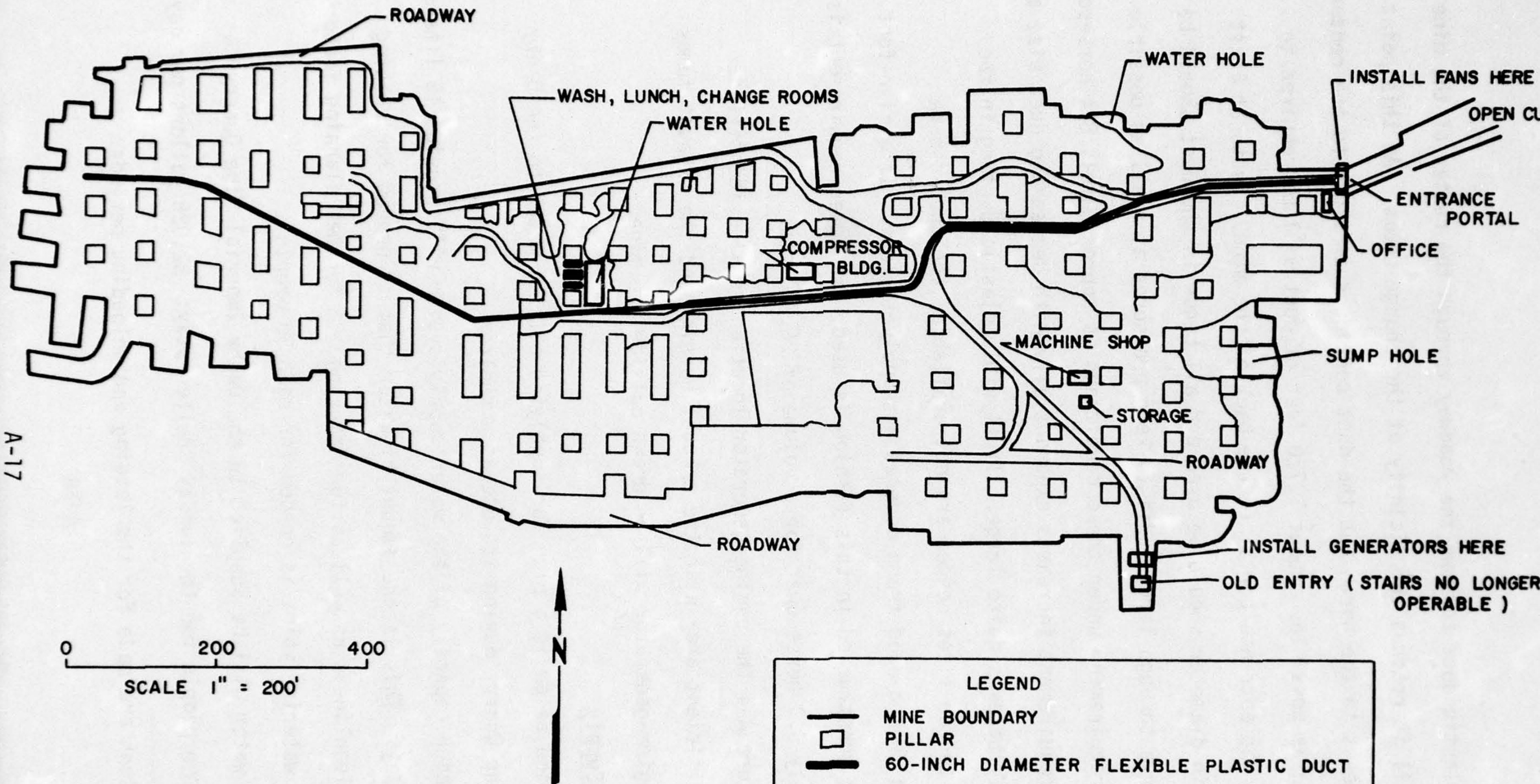

Figure A-4. Recommended Ventilation System for Danby Imperial Mine Quarry flexible plastic duct follows the roadway through the center of the mine quarry until it reaches the vicinity of the change rooms. At this point, the road veers to the north but the duct continues as close to the center of the mine as possible. About 1,720 feet of duct will be required to reach from the entrance portal to the back of the mine. Ducts at least 60-inches in diameter should be used and all bends in the duct should be made to curve through large radii to keep pressures as small as possible. The power requirement under these conditions is approximately 8.4 horsepower. The power requirement increases exponentially with decreasing duct size and very quickly becomes quite large. If flexible plastic ducting in the quantities and/or sizes needed are not available, the duct can be constructed from a wood frame covered with polyethylene. If a five-foot square duct constructed in this fashion is used, the power requirement is approximately 5.3 horsepower for a volume of 26,700 cfm.

In Figure A-4 the engine-generator location is also identified. There is sufficient area near the exhaust opening and the exhaust fumes from the engine-generator will be drawn outside the mine.

IV. Water Supply

Presented below is a plan for supplying potable water to the Danby Imperial Mine Quarry during its use as a shelter.

The design capacity of the water supply system will provide 15 liters per capita-day. This is the amount of water that is needed for cooking and basic cleanliness as well as for drinking. A further planning factor is that one watering point is needed for each 50 people.

Enough water will be supplied to the Danby Imperial Mine Quarry to support 20,700 people for the 14*day shelter stay: 82,028 gallons per day;

* No provisions are made for the loading and unloading periods.

a total of 1,148,392 gallons for the duration of the shelter stay.

There is presently ground water piped to 3 faucets in the mine quarry at the rate of 1,083 gallons per day. An additional 80,945 gallons of water are needed per day. Since trucks can be driven into the Danby Imperial Mine Quarry, milk trucks, gasoline trucks, etc., will be used to supply as much of this remaining water requirement as is feasible with the available capacity. If the required amount of water cannot be provided in this fashion, the remainder will be brought into the mine in containers.

A total of 414 watering points are needed in the mine shelter. These should be placed at regular intervals throughout the mine. A watering point should not be close enough to toilets or waste disposal sites to risk contamination.

Surveys should be conducted in the local areas to identify sources of tank trucks, bleaching powder, clacium hypochlorite, liquid bleach and large numbers of containers and to determine the quantities available. This should be done in conjunction with the selection of a suitable method(s) of supplying water since the availability of these resources will determine the exact method(s) of supplying water. Also at this stage of the planning process, arrangements should be made to have the disinfectants, trucks and containers delivered to the mine in the event of a crisis.

V. Excreta and Solid Waste Disposal

Presented below is the step-by-step development of plans for the disposal of excreta and solid waste in the Danby Imperial Mine Quarry shelter.

The planning factors for the disposal of excreta in mines, the capacity of the water supply system and the physical capacity (20,700 people) of the mine quarry are used to estimate the number of toilets needed and the required capacity of the disposal site(s). Also, the planning factors for the disposal of solid waste in mines are used along with the mine shelter capacity to calculate the required capacity of the disposal site(s) and the frequency that collection containers will need to be emptied and cleaned.

The survey of the Danby Imperial Mine Quarry indicated that five permanent toilets have been installed inside. Sewage goes to a holding tank from which it is pumped out to a septic tank of unknown capacity.

A sanitary engineer is needed to determine if the existing sewage disposal system can be used to a greater extent. However, for the purpose of this example it is assumed that the additional capacity needed will be attained through the use of a waterless disposal system.

The floor of the mine quarry is composed of solid rock, so that methods requiring excavation cannot be employed. Two methods are recommended under these conditions. The most preferable option is chemical toilets. They should be used to the extent that the local supply of toilets and chemicals permits. Any remaining requirements should be satisfied with removable pail privies.

Based on the minimum requirement of 2 toilets per 100 people, at least 414 toilets are needed. Depending on the availability of toilets and the time required to install them, as close as possible to 1,449 toilets should be installed.

Assuming that the toilets are placed in groups of 30, from 14 to 49 groups of toilets will be needed, depending on the number of toilets available. They should be placed at regular intervals throughout the Danby Imperial Mine Quarry. The intervals should range in length from 320 feet to 1,125 feet depending on the number of groups. It is very important that the toilets be located where food and water supplies will not be contaminated.

The entry to the Danby Imperial Mine Quarry is a drift with a roadway large enough to accomodate sludge tank trucks. Inside the mine there are 2 sumps and a water hole. Sludge tank trucks can be used to collect sewage from the toilets and waste water containers and deposit it in the sumps and water hole. However, sewage will be produced at approximately 82,028 gallons per day (4 gallons of water/capita-day x 20,700 people), all of which will not fit in the water hole and sumps. Sewage that the water hole and sumps will not accomodate should be stored in the trucks or in cans, plastic bags, etc. at the toilet sites. It will not be possible to use the sludge tank trucks to transport sewage outside of the mine, because the entrance will be blocked by the ventilation fans.

A survey of the local area should be conducted to identify sources and quantities of resources available. This should be done concurrently with the selection of a disposal method(s) since the availability of resources will affect this choice. When the disposal method(s) has been determined, material and tool requirements can be estimated. At this stage of the planning process, special emphasis is given to locating sludge tank trucks and arranging for their use in a crisis situation.

The Danby Imperial Mine Quarry presently has no garbage and rubbish disposal facilities. Therefore a complete solid waste disposal system will be needed.

To accommodate the 20,700 shelterees, a minimum of 414 collection containers and preferably up to 828 collection containers are needed. If 828 collection containers are provided and they are placed in groups of 30, 28 groups will be needed, spaced at approximately 640-foot intervals throughout the mine.

The disposal site is located in the southeast corner of the mine close to the exhaust opening. Basket incinerators and incinerators made of corrugated iron sheets can be set up in this area. Smoke and odors will be exhausted from the mine. Garbage trucks if available or pickup trucks, etc., should be used to collect the solid waste from collection containers throughout the mine and transport it to the incinerators. Assuming 3 pounds of solid waste per capita-day are produced, there will be 460 cubic yards (3 pounds/capita-day x 20,700 people x 135 pounds/cubic yard) of solid waste per day to dispose of. If the solid waste exceeds the capacity of the incinerators it should be stored in plastic bags. Trucks cannot be used to dispose of solid waste outside of the mine because the entrance will be blocked by the ventilation fans.

A survey should be made of the local area to identify sources and quantities of required tools and materials. Estimates should be made of the quantities needed, and provisions made for substitutes if necessary. At this planning stage it is particularly important to identify sources of garbage trucks, or substitutes, and to arrange for their use in a crisis situation.

Factors to consider in planning for maintenance and surveillance are contained in the last paragraph of Section V of the utilization plans for the Seneca Lake Mine.

EXAMPLE NUMBER 3

Balmat Mines

I. General

The St. Joe Minerals Balmat No. 2, No. 3, and No. 4 mines are active underground lead and zinc mines. They have been developed to work the extensive zinc- lead- iron sulphide-bearing veins which lie beneath Balmat, New York in St. Lawrence County. The entrance to Balmat No. 2 can be reached by car via St. Lawrence County Road No. 56, a paved two-lane road. The entrance to the No. 3 mine is located one mile northwest of the No. 2 shaft and the No. 4 entrance is about 2,000 feet southwest of No. 3. These mines can be reached by driving one mile east on Sylvia Lake Road from its junction with County Road No. 56. This is also a paved two-lane road. A total of approximately 20 to 25 acres of paved parking are available within a few hundred yards of the entrances to these mines and most of the surrounding land is cleared pasture. The New York Central Railroad serves each site and there is an airfield within 30 miles of the mines in Ogdensburg.

Access to the No. 2 mine is by a 3,500-foot long, 42-degree inclined shaft. This is equipped with an 18-man hoist and stairs have also been built for use in emergency situations. The No. 3 mine is entered through a three-compartment, 975-foot-deep vertical shaft. Two compartments are used for hoisting and are outfitted with two nine-man cages. The cages are connected through a system of pulleys so that when one is raised the other is lowered. The third compartment is a manway with ladders to be used as an emergency exit. The No. 4 mine also is entered through a vertical shaft which houses two 30-man cages operated in the same fashion as those in the No. 3 mine.

The Balmat No. 2, No. 3 and No. 4 mines are identical in character to the neighboring St. Joe's Edwards Mine and Gouverneur Talc's Mines No. 1 and No. 2. Open stoping methods with random pillars are being employed to extract the ore. Drifts have been developed at 200-foot intervals from the 300-foot level down to the 2300-foot level. As in the Edwards Mine, there are sublevels between many of the levels. These are connected by raises to the levels above. The No. 2, No. 3 and No. 4 mines are being considered together here because they are interconnected beneath the surface. A one-mile-long drift on the 900-foot level connects all three of the mines. No. 2 and No. 4 are also connected on the 1300-foot level.

Level drifts in the Balmat mines are nine feet high and vary from eight to fourteen feet in width. There are over 20 miles of level drifts winding throughout the Balmat mines and many large open stopes. For the mines to be usable as shelters considerable effort and large quantities of materials will be required. Due to the muddy and waste-rock littered condition of the floors, sitting and sleeping facilities must be constructed. There are also numerous vertical drops where the ore has been extracted or levels have been connected by raises. These should be fenced off to improve the safety of the mine.

Fans have been installed in each of the Balmat mines. They provide 120,000 cfm. to No. 2, 100,000 cfm. to No. 3 and 100,000 cfm. to No. 4. Chlorinated water is piped from Sylvia Lake at a rate of 3.8 mgd to over 1,000 faucets inside the mines. Underground there are also sources of potable ground water. Heated showers (approximately 70 total) are located on the surface at each change room. Sewage disposal is through a leach bed with sufficient capacity to accommodate 600 people. Thirty-two portable toilets have been installed inside the mines. A private garbage collection system is operated by St. Joe. The mines are served by outside telephone and electric lines. Emergency power is available from a 565 kw. diesel engine-generator which can be transported to any of St. Joe's mines in the Balmat area.

II. Limitations on Space

The tightest constraint on the use of the Balmat mines as shelter during a crsis situation will be floor area. It is estimated that there are available 1,118,000 square feet of usable floor area. Allowing 30 square feet per occupant, 37,267 people can be accomodated. The hoists at the three shafts can easily transport these people along with necessary supplies into the mines within a 72-hour crisis period. There is also more than adequate ventilation being provided by the fans presently in place and enough potable water available. Upgrading required will include the installation of lights and of systems to dispose of human excrement and solid waste.

III. Lighting System

For the sake of illustration, a plan for the illumination of the 900-level of the Balmat mines is presented. This level was chosen because it is the most extensive in the mine. It is the only level that connects all three shafts beneath the surface. Presented below is the step-wise procedure that was followed in laying out the lighting plan. Only Steps B, C, E, and F from the manual are included. The planning associated with the remaining steps is dependent on the contacts made with local contractors and on the results of the surveys in the host area associated with the mine. Lighting plans for the remaining levels of the Balmat mines could be developed in a similar form.

The mine map is used to identify light fixture locations at 100-foot intervals along all of the haulage drifts comprising the 900-level. Figure A-5 illustrates these locations.

Groups of lights (circuits) ranging from 20 to 38, 40-watt luminaires each are identified. Two circuits are identified in each drift with alternate lights connected to each circuit. Each circuit can be powered by a single portable engine-generator. In this manner, should one circuit fail, no section of a drift will be left completely dark. A total of eight circuits are needed to illuminate the 900-level. In Figure A-5 the light fixture locations are coded to indicate the different circuits.

Light fixture locations were also indentified for the other levels of the Balmat mines, though for the sake of clarity, these are not illustrated in Figure A-5. Table A-1 lists the shafts at which generators should be located and the load that must be powered at each level. It should be noted that some drifts will be lighted by only one circuit (e.g., the 2300-level requires a total of just 13 lights). In order to provide backup power for such levels auxiliary generators should be available at each shaft. These generators can then be transported to any of the levels accessed by that shaft should the need arise.

Three engine-generator locations are identified, one in the vicinity of each shaft. Figure A-5 also illustrates these locations. The generators to power circuits 1, 2 and 3 should be located near the No. 2 shaft, those

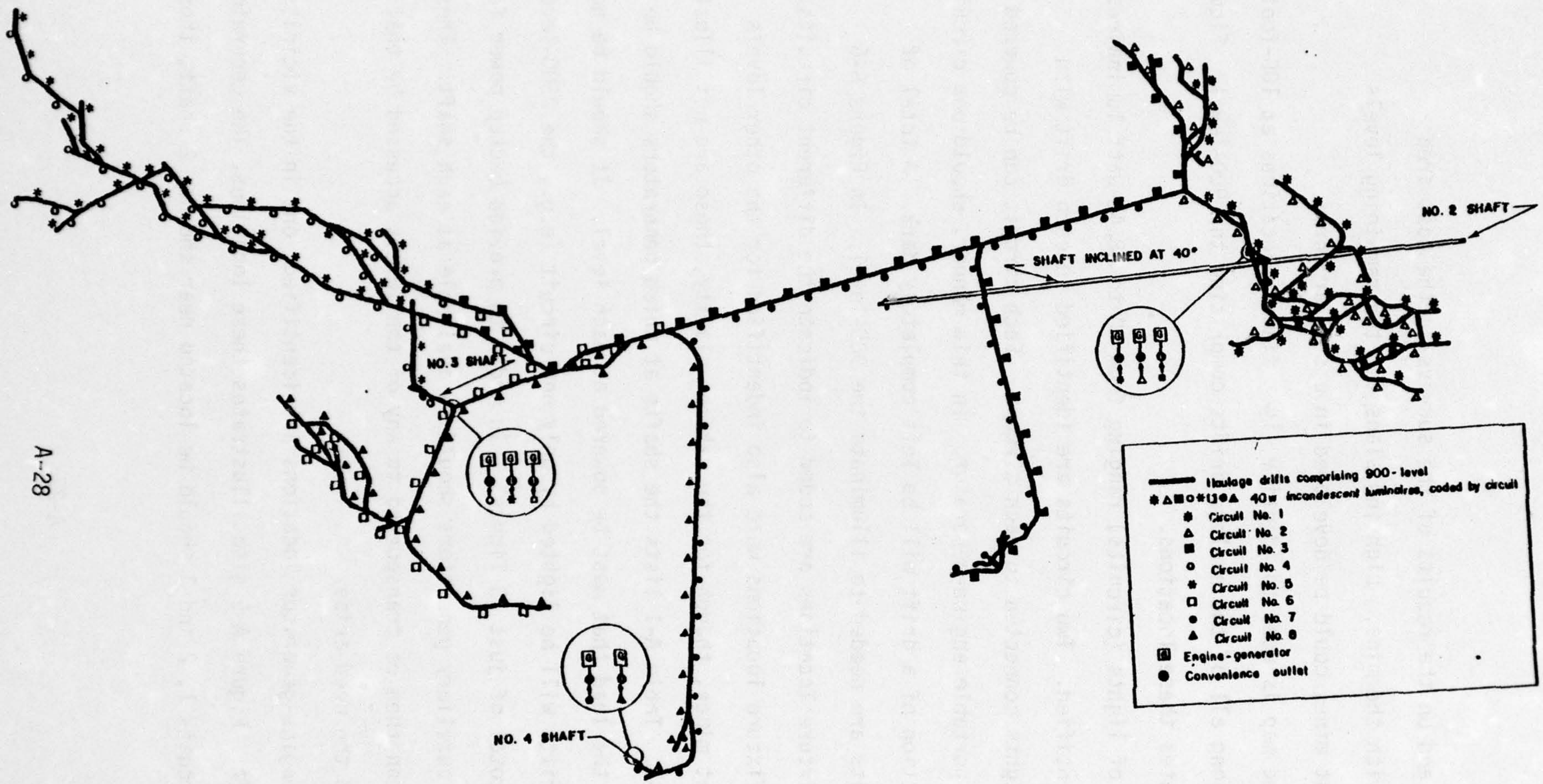

Figure A-5. Light Fxture and Generator Locations for 900-Level of Balmat Mines

TABLE A-1

Specifications for Balmat Lighting System

Level No.	Shaft No. At Which Generators Located	No. 40w Luminaires	Load
300	2	26	1,040
500	2	70	2,800
	3	16	640
700	2	84	3,360
	3	59	2,360
900	2	107	4,280
	3	99	3,960
	4	73	2,920
1,100	2	81	3,240
1,300	2	60	2,400
	4	60	2,400
1,500	2	59	2,360
1,700	2	59	2,360
	4	59	2,360
1,900	2	39	1,560
	4	90	3,600
2,100	2	59	2,360
2,300	2	13	520

to power circuits 4, 5, and 6 near the No. 3 shaft, and the generators to power circuits 7 and 8 should be located near the No. 4 shaft. Exhaust fumes from the engine-generators will be drawn outside the mine through the shafts.

The data in Table 2 are used to specify the sizes of feeder wires and branch lines to be used with each circuit. Figures A-6 thru A-13 contain wiring diagrams of each circuit indicating these specifications.

IV. Excreta and Solid Waste Disposal

Presented below is the step-by-step development of a plan for disposing of excreta and solid waste in the Balmat Mine shelter.

The planning factors for the disposal of excreta in mines, the capacity of the water supply system and the physical capacity (37,267 people) of the mine are used to estimate the number of toilets needed and the required capacity of the disposal site(s). Also, the planning factors for the disposal of solid waste in mines are used along with the mine shelter capacity to calculate the required capacity of the disposal site(s) and the frequency that collection containers will need to be emptied and cleaned.

The survey of the Balmat mines indicated that 32 portable toilets have been installed inside the mines. Sewage disposal on the surface is through a leach bed with sufficient capacity to accomodate 600 people.

There is presently no access to the leach bed from inside the mines. Though a sanitary engineer should make the final decision,for the sake of the example it will be assumed that a waterless disposal system must supply all of the excreta disposal capacity inside these mines.

The floors of the Balmat mines are solid rock so that methods requiring excavation cannot be considered. Two methods, chemical toilets and removable

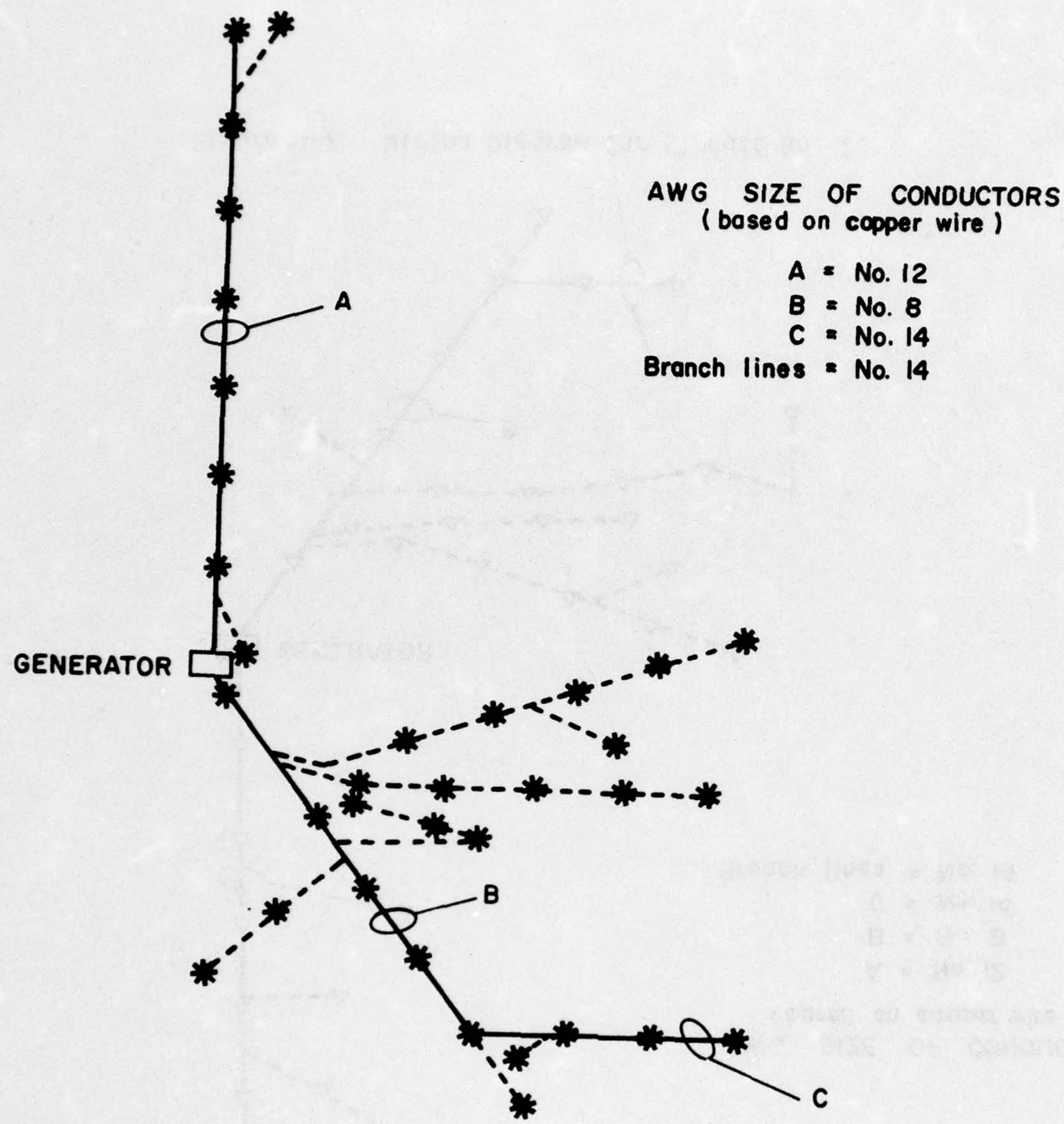

Figure A-6. Wiring Diagram for Circuit No. 1.

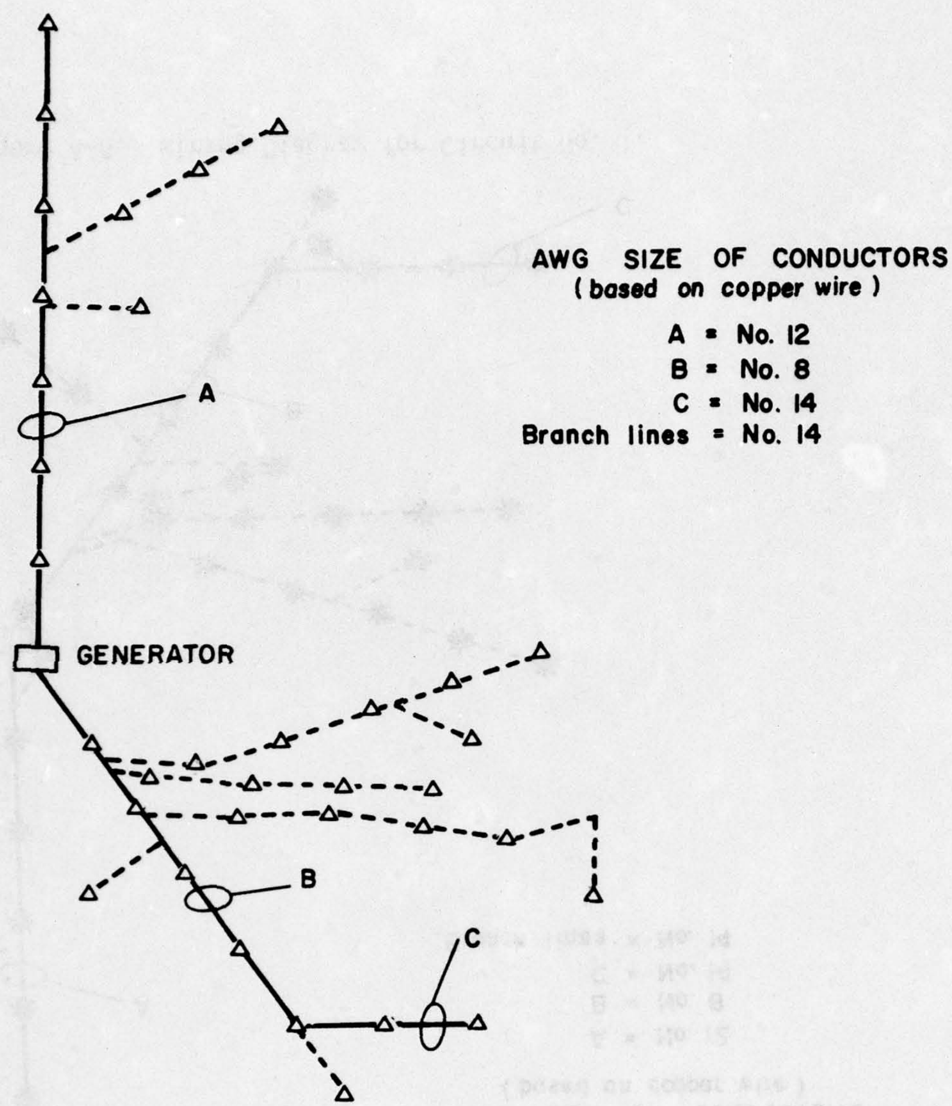

Figure A-7. Wiring Diagram for Circuit No. 2.

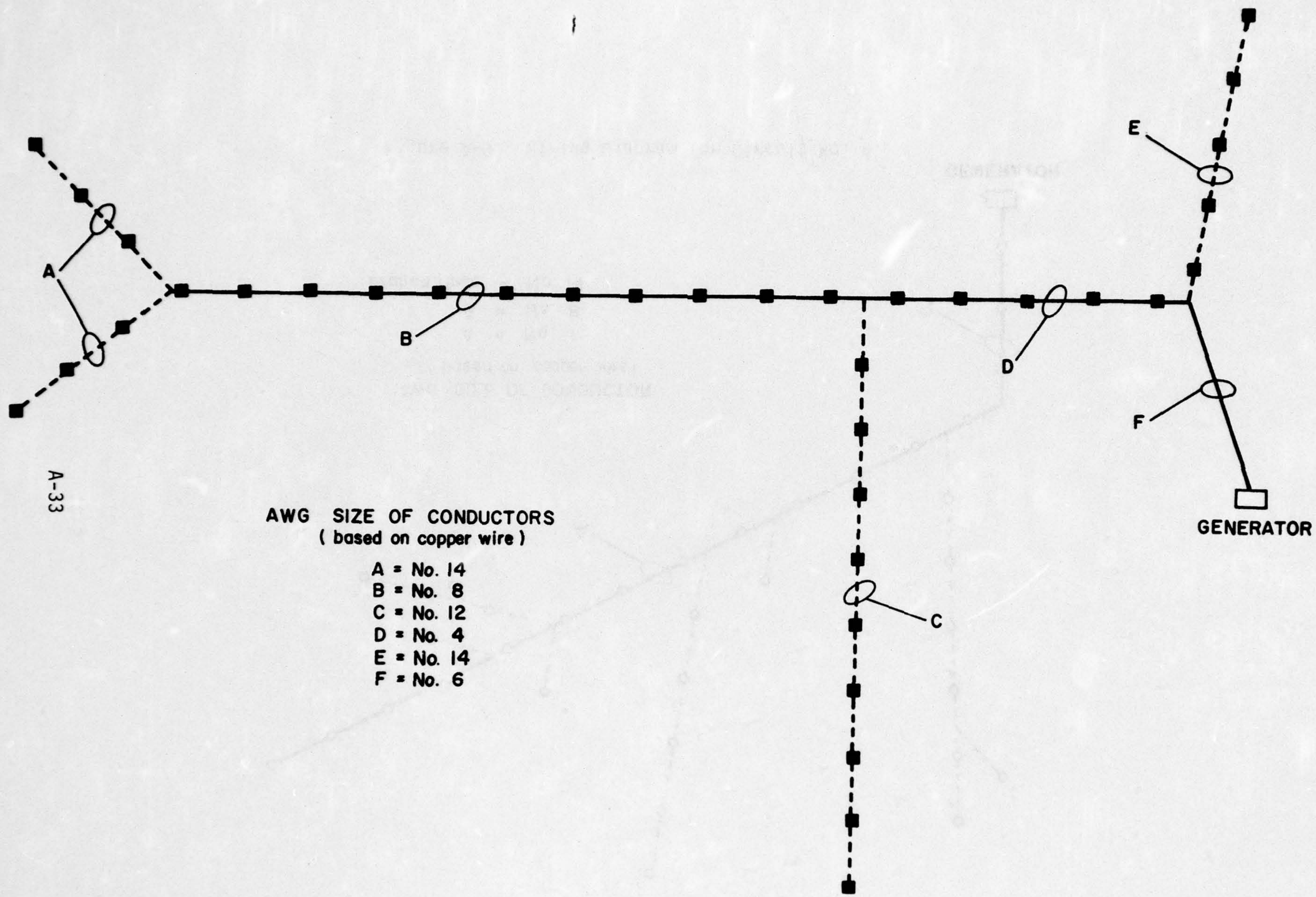

Figure A-8. Wiring Diagram for Circuit No. 3.

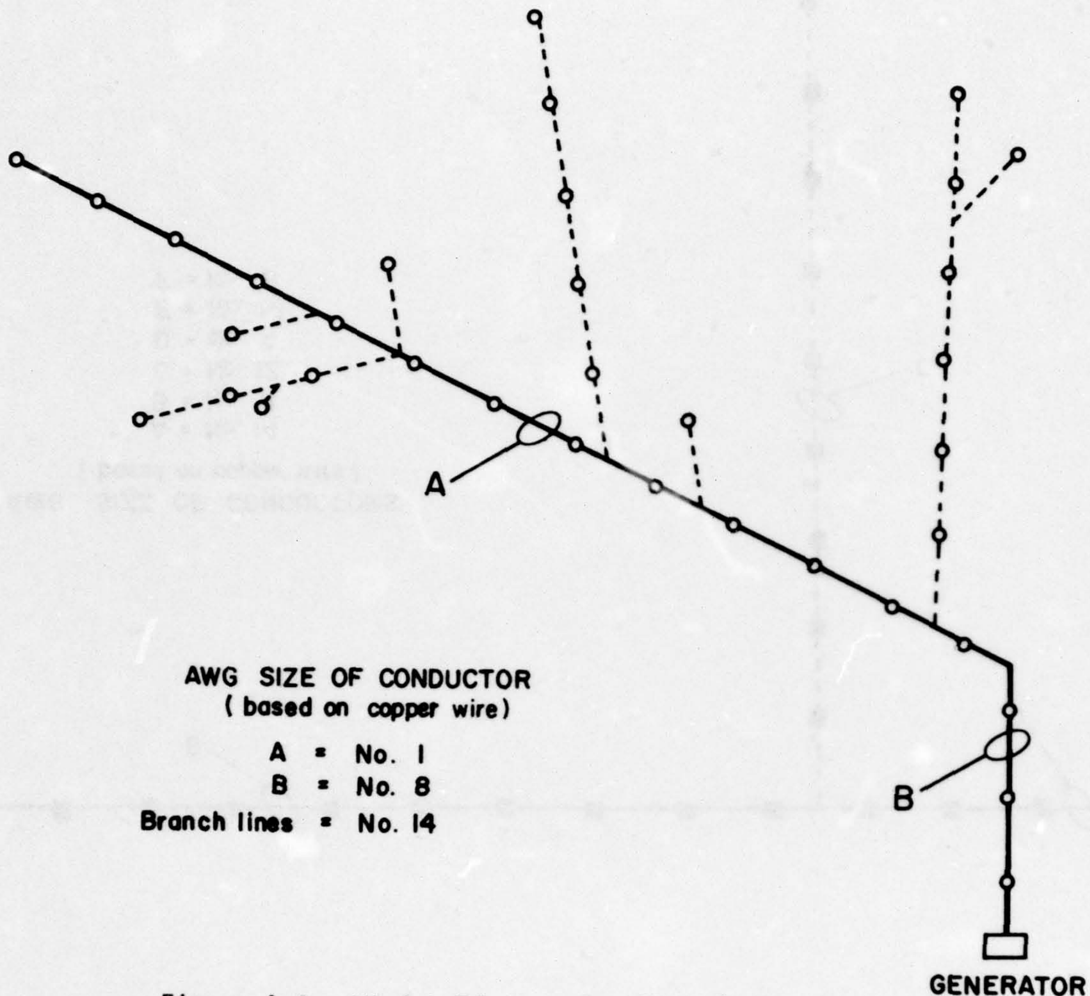

Figure A-9. Wiring Diagram for Circuit No. 4.

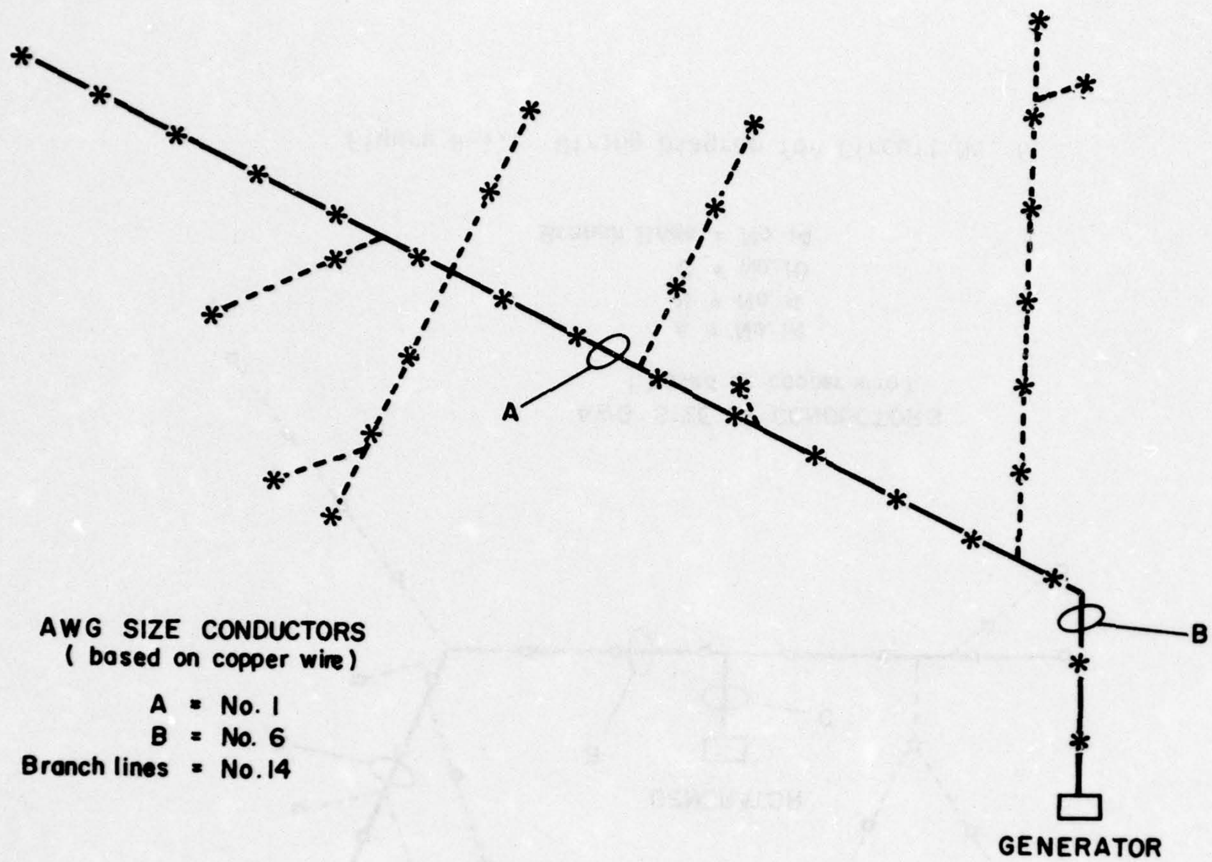

Figure A-10. Wiring Diagram for Circuit No. 5.

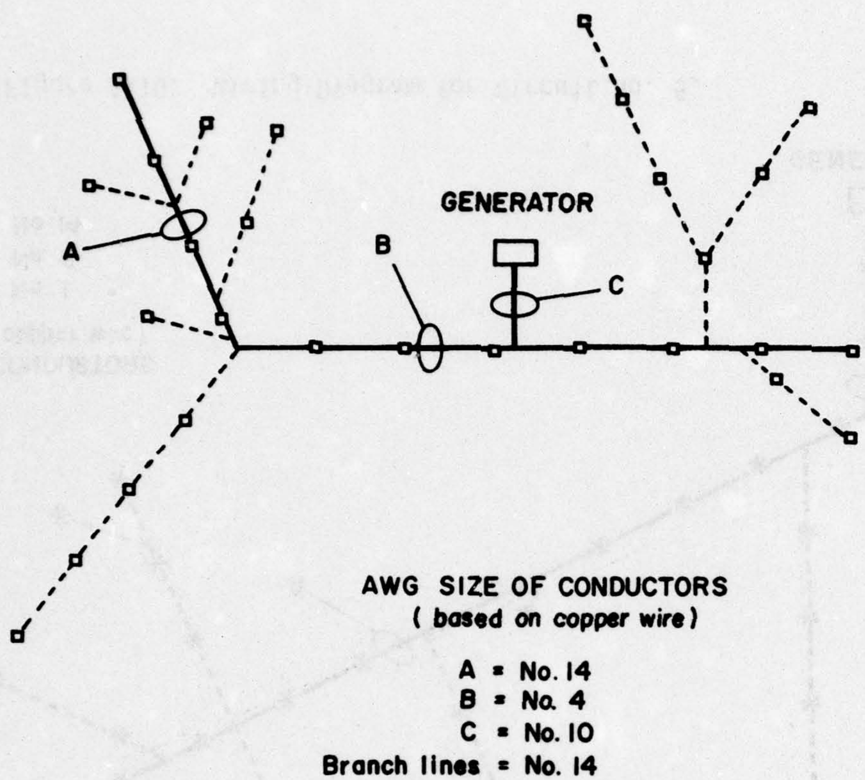

Figure A-11. Wiring Diagram for Circuit No. 6.

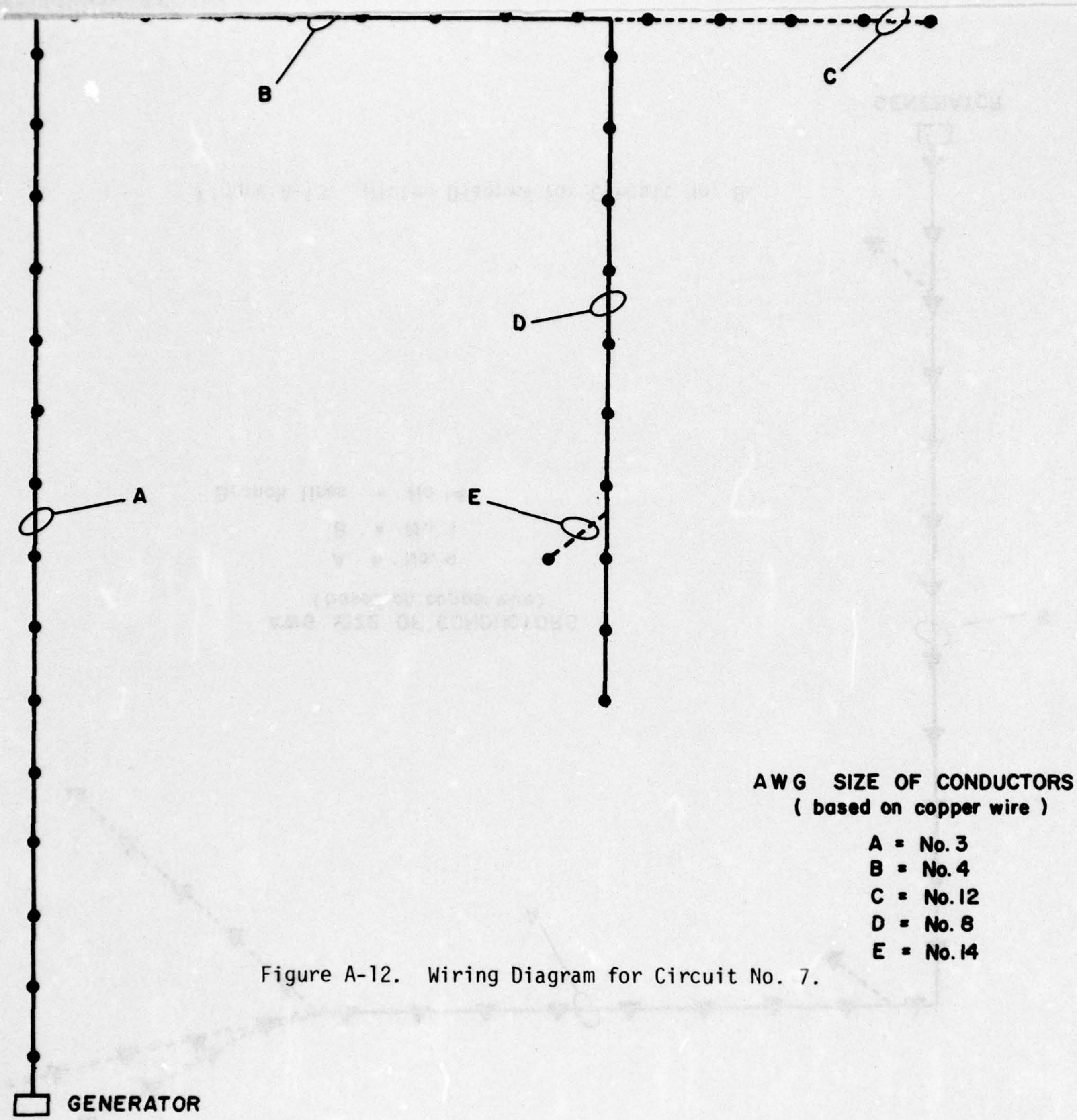

Figure A-12. Wiring Diagram for Circuit No. 7.

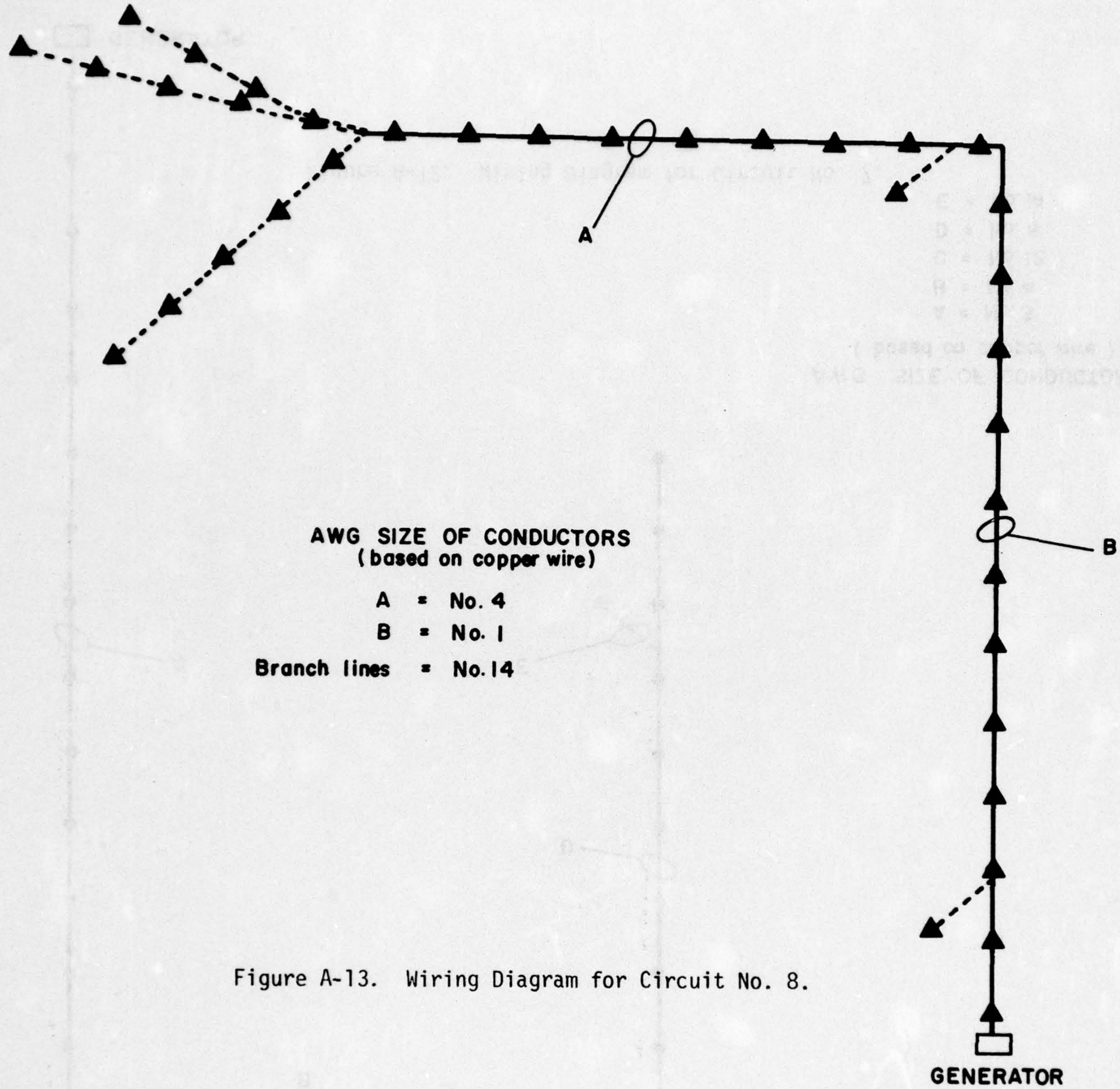

Figure A-13. Wiring Diagram for Circuit No. 8.

pail privies, are recommended for use under these conditions. Chemical toilets are the preferred option because they are prefabricated and have much larger capacities. They should be used to the extent that the local supply of toilets and chemicals permits. Any remaining requirements should be satisfied with removable pail privies.

To accomodate the 37,267 occupants of the Balmat mine shelter at least 746 toilets should be made available, or in other words, 714 more toilets than are presently in place. Ideally, as close as possible to 2,611 toilets should be provided.

Because the usable floor area in the Balmat mines is in the haulage drifts, the occupants of this shelter will be more widely scattered than in a room and pillar type mine. Therefore toilets should be placed in smaller groups than 20 to 30 so that they will be convenient to the shelterees. If toilets are placed in groups of 4, they will be spaced at regular intervals from 170 feet to 600 feet depending on the availability of toilets. The toilets should be placed in stopes where possible, because of the narrowness of the haulage drifts. It is very important that the toilets be located where food and water supplies will not be contaminated.

It will not be possible to set up a single sewage disposal site in the Balmat mines because of their size and complexity. Sewage should be stored in containers (cans, plastic bags, etc.) at the toilet sites that are in stopes and in stopes close to the toilet sites that are in haulage drifts. Sewage should not merely be dropped into the vertical raises since these connect with drifts deeper in the mine. For this reason, care should be taken in identifying disposal sites.

A survey of the local area should be conducted to identify sources and quantities of resources available. This should be done concurrently with the choice of a disposal method(s), since the availability of resources will determine the exact method(s) of disposal. After the disposal method(s) has been determined, material and tool requirements can be estimated. Special emphasis should be given to locating sources of large numbers of containers for the storage of sewage. If sewage storage capacity is limited, water usage will have to be limited correspondingly.

Garbage and rubbish are presently collected on the surface, but this service will not be operable during a crisis situation. Therefore a complete solid waste disposal system will be needed. Since there are no large areas close to the exhaust openings and convenient to all regions of the mines which could be used for incineration, and excavation is not possible in the rock floors, solid waste disposal will consist of storage in plastic bags.

To accomodate the 37,267 shelterees, a minimum of 746 collection containers and preferably as close to 1,492 collection containers as are available are needed. Collection containers, in the same manner as toilets, should be placed in groups of 4 at regular intervals throughout the mines, preferably in stopes. Depending on the availability of containers, from 187 to 373 groups will be required at intervals of from 340 to 170 feet.

Solid waste should be stored in plastic bags at the collection site if it is in a stope, or in a stope close to collection sites located in haulage drifts. As is the case for sewage disposal, bags of solid waste should not merely be dropped into the vertical raises.

A survey should be made to determine local sources of large quantities of plastic bags and arrangements made to deliver the bags to the mine in the event of a nuclear crisis.

Factors to consider in planning for maintenance and surveillance are contained in the last paragraph of Section V of the utilization plans for the Seneca Lake Mine.