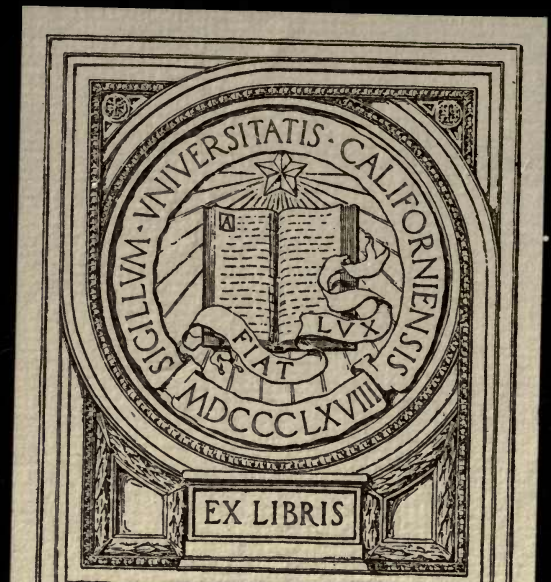
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The Efficient Purchase and Utilization of Mine Supplies

BY

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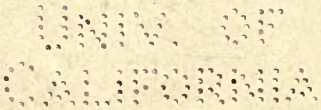
Mining Engineer

FIRST EDITION

FIRST THOUSAND



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THE EFFICIENT PURCHASE AND UTILIZATION OF MINE SUPPLIES

INTRODUCTION.

In the past, the stores department of the mining and smelting industries has been given but little attention, although materials constitute an important cost item in these industries. One of the principles of good management is economy in the purchase and consumption of supplies. Material costs constitute an integral part of the total production costs, and are often a basis for good or bad management. A great number of our mines and smelters are situated at a distance from the large manufacturing centers, so that the time of delivery of materials is long, and the cost of transportation is high, which adds to the total cost of materials. It is of utmost importance that supplies be on hand when needed, otherwise a serious loss in working time may occur due to waiting for material which should have been on hand.

The store should be considered as a separate department or an entirely separate business. It should have complete charge of buying, receiving, storing, and local delivery of all supplies.

Mining men are, as a rule, technical men, and unfortunately many of them have no training as to business methods and forms. In the following discussion the entire subject, from purchasing to use, will be described in detail, with hopes that it will give suggestions of some use to men engaged in the mining and metallurgical fields. Stress is laid on systems for large operating companies, with simplified methods for smaller concerns. Many illustrations and suggestions are given. They must be looked upon as suggestive, and must not be rigidly followed without considering whether some modification should not be introduced to meet the requirements of the particular case in point.

The greater part of this material has been gathered from observations and notes, and some has been taken from articles in current technical magazines and extracts from books on the Science of Management.

THE LAWS OF MAXIMUM ECONOMY.

To insure maximum economy, the following laws must be complied with:

1. Materials must be purchased from the lowest priced firms when materials are at their lowest prices.
2. Materials must come up to the contracted excellence in quality.
3. The quantity purchased must be obtained.
4. Materials must be delivered at the specified time.
5. Materials must be properly housed and stored.
6. There must be no unnecessary waste of material.
7. No losses must occur, except through waste.

In order to comply with the above laws, we must have:

(*a*) A well-organized purchasing department.

(*b*) An efficient receiving and testing department.

(*c*) A proper stores system, with accurate accounting.

(*d*) An issuing system which fixes the responsibility.

(*e*) Reports which show the consumption of materials.

(*f*) Methods which will prevent waste in the use of materials.

(*a*) Purchasing Department.

There should be a special function of Purchasing in charge of a competent purchasing agent. The resident agent should attend to the purchase of all general supplies such as are used in everyday consumption. For large, special orders, he should co-operate with an agent in the city office, who may be able to obtain quotations and deliveries on special large orders more expeditiously and economically than the resident agent. In the following, Purchasing is discussed as a function and does not imply that this should be the sole duty of one man, in all cases.

The purchasing agent is the man who acts as the safety valve of the company. He should have a working knowledge of the particular industry for which he is to purchase materials. If he has a working knowledge of the properties of materials, of their use, of the production or manufacturing of the materials, it is so much the better. The average foremen or department heads would buy according to their own judgment without considering the condition of the market, the reliability of the firms from whom they would purchase, the comparative

prices of materials, etc. To secure the most desirable delivery involves a knowledge of business methods and forms. It is impossible for the purchasing agent of a large concern to possess technical knowledge of all the work, therefore he must depend upon written records, and have these instantly available. If the function of buying is centralized in one man or department, he is usually blamed if the materials do not arrive on time and the work is delayed; hence, in order to protect himself, he should take no verbal orders, but in each case require a properly filled out and signed requisition blank, which shows the originating date of calls for material. Also, written requisitions have the advantage that the man who wants supplies is more careful in ordering over his own signature than through a simple verbal order.

Catalogue Files. As an aid to the purchasing agent, there should always be on hand and properly filed and indexed, catalogues of several supply companies, together with complete price lists.

There are five general methods of filing:

1. Alphabetic — by name.

2. Numeric — an arbitrary number assigned to each firm or subject.

3. Automatic Index — a combination of alphabetic and numeric.

4. Geographical — by names of places.

5. Subject Classification — classified numeric or letter system, in which materials are arranged by correlated subjects so that related matter is grouped in numeric or alphabetic letter order, based on the principles of

the Dewey Decimal Classification or the Mnemonic Classification.

The alphabetic filing of catalogues and price lists would be the simplest, since no index would be necessary; however, it has the great disadvantage that the filing space cannot be arranged properly. Catalogues vary in size from a mere sheet of paper or pamphlet, to large, elaborate volumes. An alphabetical arrangement would promiscuously mix large volumes and small pamphlets, so that a dictionary-sized book might have to be placed next to a small pamphlet. Filing space could not be efficiently utilized.

The most adaptable method is filing according to the number system. By this method, a letter is assigned to each group, " A " to the largest size, " B " to the next in size, etc. In the " A " file compartments, the catalogues are numbered consecutively from " 1 " up. Similarly with the " B " compartments and the remaining compartments. The compartment letter and catalogue number is written on a gummed label, and this pasted on the corner of the catalogue.

Each catalogue is now indexed in two ways:

1. By name of the dealer or manufacturer issuing it.
2. By name of the article.

The Dealers' cards should show the name and address of the dealer, the articles which they sell, the file compartment letter and the catalogue number. See Fig. 1. The cards are filed alphabetically according to the dealer's name.

A simple card register should be kept for each series

of catalogue numbers, with the name of the dealer who issued the catalogue after each serial number. This is for the purpose that one may know what numbers have been used, and what number will be assigned to the next.

Name *Mining Supply Co,*

Address *Denver, Colo.*

Articles	*Dr. No.*	*Cat. No.*
Shovels	*A*	8
Picks	*A*	8
Cars	*B*	1

FIG. 1.

Generally a requisition gives only the name of the article, without telling the make, or it may be made by several concerns, hence an article index should be made. A card is used for each article which is likely to be called for. The name of the article appears on the card, followed by names of the different concerns that make it, and giving the file compartment number, the catalogue number, and the page. See Fig. 2. These cards are filed alphabetically according to the name of the article.

Where a considerable number of books and lists have accumulated, they may be classified according to the

Dewey System, and arranged numerically. The Dewey System of classification, applied to engineering subjects, is fully described in bulletins issued on that subject by the Colorado School of Mines and the University of Illinois. It is used to a large extent, as an aid in filing

Article *Shovels*

Name	*Page*	*Dr. No.*	*Cat. No.*
Mining Supply Co.	56	A	8
Wyoming Shovel Co.	7	C	2

FIG. 2.

clippings from technical periodicals, and has proved entirely practical. Another method of classification which is rapidly coming into use is the Mnemonic System, used in the classification of stores, tools, charges, etc., in shops operated under Scientific Management. This is a splendid method, since it is an aid to the memory in recalling names, and also when the classified subjects are filed alphabetically according to the classification, like subjects will be brought together in the file.

The system of classification and filing for such subject matter should be considered from the volume of material to be filed. If the amount and number of sub-

jects are small, a simple system will give entire satisfaction, while where large amounts are to be handled, a more detailed and extensive method must be considered. The entire object of a filing system is to see that materials are easily located, and any method may be considered that gives satisfaction in that manner.

Special Quotations. In some cases, quotations are requested, at intervals, for such materials as are regularly used. To secure uniformity, printed cards are made out, which list all materials, and sent to different sellers. Another method is to send out schedules of requirements and to request bids. There are two cases:

1. Where a bid is requested for a particular article or lot of goods, and
2. Where a bid is requested for the regular supply of certain goods for a period of six or twelve months.

Bids differ only from quotations in that they are more formal. For a bid, various instructions and conditions are given, and a form of bid is appended.

Contracts are almost always made for the supply of the principal, regular requirements of a mine, for six or twelve months, i.e., for timber, dynamite, coal, etc. Even for a supply of such things as oils and cotton waste, it is good to contract for a period, since usually a little is saved thereby, and it also relieves the purchasing agent of the trouble of constant buying.

The prices of some materials are subject to market fluctuations. Where the items are of importance, a study and record should be kept of these fluctuations, so that advantages may be taken of the market.

Correspondence and General Price List. If there is a good central filing department, the purchasing agent need not file his correspondence separately. If not, he can easily arrange one of his own. Letters are usually filed alphabetically according to the name of the concern. This groups letters from each firm, and the letters of each group are arranged chronologically.

Some agents file quotation letters separately, arranged alphabetically according to the article on which the price is quoted. This, however, has its disadvantages, in the fact that there is other needless correspondence in the same letter, and also the quotations may be on several kinds of articles. The best method of keeping quotations is to have a separate card file. General groups are made of all articles, and these groups arranged alphabetically. The group separation is shown by means of a " sign post " on the group card. A card is filled out for each kind of material on which a quotation has been received. The name of the article appears on the top, and underneath is a list of concerns which offer the quotation, together with prices, terms, etc. See Fig. 3. These cards are arranged alphabetically according to the name of the article, after each main group.

It is well that a company knows what it paid for the material before, and also have quotations from different concerns on the same article grouped together. This will help to promote judicious buying.

Economic Amount to be Purchased. In many cases, a better price per unit can be obtained if purchased in large quantities. Also, a reduction in freight rates or

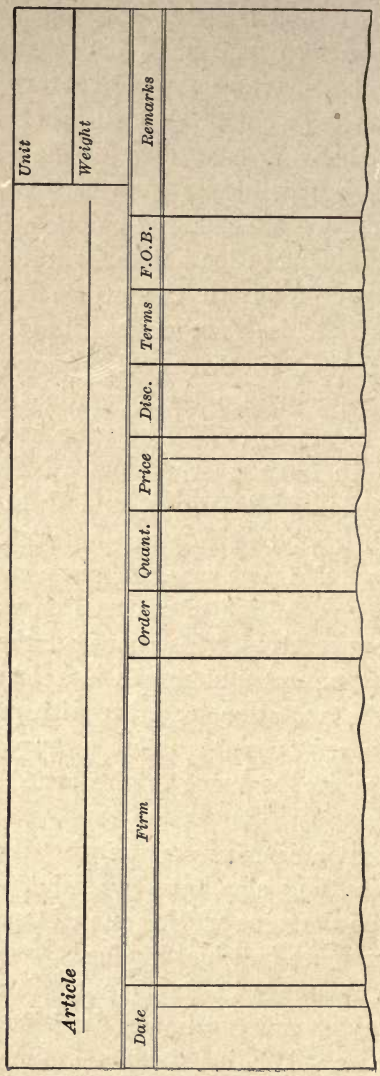
Article
Unit
Weight
Date
Firm
Order
Quant.
Price
Disc.
Terms
F.O.B.
Remarks

FIG. 3.

more rapid transportation delivery may be obtained, if car load lots are gathered together. In the purchase of large lots considerably in advance of their actual use, one must consider several added factors of expense. These are, generally, interest on the capital involved, storage expense, depreciation, insurance, etc. These factors of expense must be added to the large lot price to determine the actual price. If, after considering all these factors, the unit price is still lower than the unit price if purchased in small lots, and unless some special factors enter the case, it will be economically advantageous to purchase in large lots. It will be noticed that this subject entails a detailed study of many conditions.

Book of Standards. A standard, applied to materials, is a carefully drawn specification or description of a unit of material, which is best and most economical for the use to which it is applied. It does not imply perfection. When, after rigid tests, some new kind of material is better than the present standard, it supersedes this as the new standard. A standard, however, should never be changed unless it is proved beyond doubt that the new kind is better. In compiling a book of standard materials, considerable investigation and testing is necessary. Materials which are used daily in large quantities should be considered first. Each article is studied separately and an investigation carried on to see whether or not a better one than the one in use at the present time can be obtained. In general, this study involves the use to which the material is put, its connection with other materials in use, number

of uses to which it can be put, life of the article, its purchase price, delivery time, ease of storage and handling, etc. In the study, the comparative method is used, in which similar articles made by different manufacturers are compared as to their advantages and disadvantages. It will be noticed that this method may also be used to advantage in the selection of machines and mechanical equipment.

After the best material for the purpose has been determined, a complete description of it is made on a sheet of loose leaf paper, and filed in a loose leaf book. A card system may be used, but the paper has the advantage that several carbon copies can be made, so that several copies of the book can be produced at the same time. The filing, or arranging in the book, is usually done alphabetically, although a card index method may be used. A copy of this book, kept up to date, should be in the hands of the purchasing agent, one for the store-keeper, one for the auditor, and one which is available to all. When anything is to be purchased, the purchasing agent must refer to the Book of Standards, and if the article is already specified in that book, he must purchase according to those specifications. In case any new kind of material is needed, the book should first be consulted to see whether or not an already specified standard could be used for the purpose.

Many direct and indirect advantages are gained by the use and maintenance of standards.

1. The best quality for each purpose is obtained.

2. The lowest purchase price, since a standard can usually be ordered in larger lots.

3. Storage place permanently fixed.

4. The workmen become accustomed to that particular type.

Purchase Orders. Purchase orders are usually made out on a regular purchase order blank, and signed by the purchasing agent or an authorized representative. A simple method is one in which the order is made out in duplicate. The original is sent to the firm from whom the purchase is to be made, and the carbon copy retained in the purchase order book. When the goods arrive, they are checked on the order in the book, and any mistakes noted. This method is sufficient for small concerns, but for large concerns, where the connection between the buyer and the receiver is not so close, a more elaborate method must be used.

A good system, used by many, is one in which three forms are used, the original, the duplicate, and the acknowledgment. These are made out in triplicate by means of carbon paper. Each order made out is given a consecutive number. Referring to an order by number is the easiest way. The original and the acknowledgment are sent to the purchasee, and the duplicate kept in the office as a permanent record. The firm which receives the order is requested to fill out the acknowledgment and return it at once. On this acknowledgment they are to place the promised delivery date, and when it is returned, it is filed by the purchasing agent. When the person who requisitioned the goods wants to know when they will arrive, the agent can give him definite information. An order register is kept, so that knowing the number, one can easily tell

what the order is. This order register consists of a list of the orders arranged in sequence according to the order number. The duplicate orders are filed alphabetically according to the name of the purchasee. When the acknowledgment is returned, it is clipped to the duplicate order, and checked out when the goods are received.

A still more accurate and better method, which is especially adapted to large concerns, but may also be used to advantage by smaller concerns, is the one used in Scientific Management. The purchase order is made out in triplicate on a special blank. The original, which is sent to the purchasee, requests an acknowledgment of the order and a promised delivery date. This may be appended in the form of a detachable stub. When the promised date of delivery is received, it is entered on the two copies, and the copies filed in a "tickler" or reminder file, to come out at that date, or a time a little previous. When this time arrives, one copy is placed on the purchasing agent's desk, and the other sent to the store-keeper. The store-keeper's copy contains only the names of the articles, and not the number of each. The purpose of this is that the receiver must make a careful count, and enter the quantities opposite the names, not merely check off a given quantity. The carbon paper used for this copy is of a narrower width, so that the quantities are not written through from the first two slips. This copy notifies the store-keeper that goods are expected to arrive, so that he can make advance arrangements for receiving them. See Fig. 4.

The reminder file method is in use at a great many concerns for various purposes. A file compartment, or

PURCHASE ORDER — *THE REX MINING CO.*

*Purchase No.*_____ *Talca, Colo.*_____ *191*____

Charge to _____

*To*_____

*Gentlemen:- Kindly ship us the following material via*_____ *not later than*_____ *191*____

Amount	*Articles*

Price *Terms*

*Purchasing Agent*_____

Note: Our Purchase Number must appear on your invoice, otherwise invoice will be returned for correction.

ACKNOWLEDGEMENT — *THE REX MINING CO.*

Purchase No. *Talca, Colo.*_____ *191*____

Please fill in shipment date and return this stub at once.

*Date*_____ *Purchasee*_____

FIG. 4.

simply an envelope, is used for each day of the year, and the reminder slips filed in the compartment or envelope

which represents the day on which they are to be issued. For some purposes, one compartment or envelope is made out for each hour of the day, or even smaller subdivisions, and each morning the slips in that file are sorted in the hour, or fraction of an hour, file. The " tickler " file can be put to many uses.

Still another method of following and checking the progress of a purchase order is by means of a Purchase Schedule, as illustrated in Fig. 4a. The principles of this method have proved to be very efficient and they have a wide field of application. A complete chronological history of each order is obtained by this method.

(*b*) Receiving and Testing.

It is essential that the quantity and quality of the materials purchased is actually obtained. One of the most fruitful causes of losses in large concerns which do not have a good receiving system is shortness in weight, amount, or quality, due either to mistakes, negligence, or dishonesty on part of their employees or others. The person in charge of the function of Receiving should be held responsible for the accuracy of the statements of materials received which he forwards to the purchasing agent. The purchasing agent checks these figures against his copy of the purchase order and the invoice. When all is found correct, he notifies the auditor to that effect, who credits the shipping concern with the amount of the invoice. Where the store-keeper has a copy of the purchase order of the received material, it is best that the quantities are not shown, as previously explained, since he will be more

PURCHASE SCHEDULE

Note:- Place key letter in date column.	Bill of Material	B	Wanted	W	Shipped	S	Answer to Tracer	A
	Requisiton	Q	May Expect	E	Received	T		
	Ordered	O	Promised	P	Tracer Sent	R		

Order Number	Month of March																												
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	23	23	24	25	26	27	28	29	30	31
1026		B	Q	O			E	W																							
1027					B	Q O									P	W															

FIG. 4a.

careful in the count, and it will be easier to discover discrepancies. It is also well to notify the person who

*Name*_____ *Date*_____

*Materials ordered by you as per requisition No.*_____, *Purchase No.*_____ *have arrived, and are to be inspected.*

_____

Storekeeper

FIG. 5.

issued the requisition that the goods have arrived. Fig. 5 illustrates a form of notification. It is also best, at times, that the person who requisitioned the goods

PURCHASING AGENT: *Date*_____

*Materials as per Req. No.*_____, *Purchase No.*_____, *have been inspected by me this day and* { *do* / *do not* } *conform as to quality.*

*Signed*_____

FIG. 6.

inspects these goods as to quality or usefulness. Fig. 6 is a form of notification which he sends to the purchasing agent. After count and inspection, the filled-

in store-keeper's slip is sent to the person in charge of the stores records, so that he may enter the goods as received either on his card records or in his balance of stores book.

Some concerns have special testing departments in which many of the important materials are tested by experts, who see that they conform to the contracted excellence in quality, or are rejected. If the function of Testing is in use, and it should be at least to a minor extent, the person in charge of this function should be notified when the materials have arrived. He then passes on the quality and notifies the proper person as to the result of his tests.

(*c*) Stores System.

Store-keeping is essential in principle to banking, the only difference being that bulky materials are handled instead of money. It should no more be possible to obtain material from the store-room without a properly signed requisition than it is possible to obtain money from a bank without a signed check. Just as the bank is held responsible for all moneys received by it, and has to produce either the cash or the canceled checks upon demand, so should the store-room be required to produce either the material with which it is charged or the requisitions upon which it has issued the materials. If the above principles are kept in mind, and the similarity to banking remembered, it will be easy to follow the description of store-room systems for large concerns.

The efficiency of a store-room system may be considered under three principles:

1. All materials not in actual use should be in the store-room or place of storage. They should remain there until issued for actual use. Materials, the use of which is temporarily discontinued, should be returned to the store-room until again used, when they are re-issued.

2. A set of records must be kept which will show at any time the exact amount of any kind of material on hand, or which has been apportioned to a given job or set of jobs, the material ordered, and the quantity available for any purpose. The records should be in such a form that they can be checked at any time against the quantities in the store-room.

3. Any piece or lot of material received in the store-room must be acknowledged and receipted for, and the acknowledgment and receipt must pass through the hands of the clerk in charge of the records. No piece or lot should be issued from the store-room without an order or requisition signed by a proper authority.

Location of Store-rooms. The location of a store-room must be central to all departments to insure a minimum cost of delivery from the store to the work. It is equally as important that it be situated on a rail-road spur so that all shipments of supplies may be received directly from the cars and stored without extra haulage. For fire protection, the timber yards should be at some distance from the store, and the oil storage and powder magazine placed well away from the other buildings. All materials of an inflammable nature should be so stored that they will not only be protected from danger of ignition themselves, but must be so

located as not to add an additional risk to the other buildings.

Arrangement of Store-room. Store-houses must be so arranged that no losses due to the following causes will occur:

1. Bad storage, which causes actual deterioration of materials.
2. Storage which makes it possible for unauthorized persons to gain access to the store-room and steal or pilfer materials.
3. Losses through waste.

One of the best designs for a mine warehouse is one on the principle of a railroad freight shed, i.e., it should have platforms on all sides, and doors so spaced so that cars and trucks can be placed alongside any part of the building for unloading or for loading purposes. The size of the warehouse is controlled by the nature and the quantity of the materials to be stored. One must first consider all stores material. Certain materials, owing to their nature and bulk cannot be stored under cover, or in the warehouse proper. These are usually gathered together in stock piles.

Stock Piles. Materials usually stored in stock piles consist of lumber, ties, mine timber, heavy rails, rough castings, structural steel and iron, large pipes, bricks and stones, etc. The arrangement of each pile depends upon the nature of the material. High-priced lumber should be stored in racks slightly above the ground, so as to prevent rapid deterioration due to decay. The material once located should have a lot number which should appear on the pile or piece. The place once

allotted to a particular kind of material should never be allowed to have but that particular kind upon it. Should this material be replaced by another kind or done away with, then the location becomes available for a new item. The clearance between stocks used for aisles should be sufficiently wide for handling purposes. Material on the piles must be arranged in such a manner that it can be quickly counted or measured. Also, the facility with which the material can be handled must be kept in mind, for instance, big, heavy plates should be arranged in racks, vertically and on rollers. The physical arrangement should be such as to insure stability and self-protection against the elements.

Oils and Explosives. Explosives or easily inflammable materials should be stored in special buildings at a distance from the other buildings. There is generally a special oil storage house and a powder magazine. Oils and liquids are usually stored in tanks, barrels, or flasks, and these should be so arranged that they can be easily filled and the liquid drawn from them.

Powder Magazines. Some mining companies in this country build the walls of the magazines of masonry from the waste rock of the mine. These are tied together crosswise at the top with rods. A small ventilation hole is left in the end walls near the top. The roof is built of concrete with reinforcing rods, and is covered with a thin, smooth layer of cement.

Other companies build a number of small magazines and a shipment of powder is distributed among them. This avoids the storage of large quantities in one place.

In the Transvaal, certain laws which regard the con-

struction and management of powder magazines must be complied with. The following is a description of a magazine built to meet those requirements:

The magazine is erected on rocky ground at a point where there is sufficient depth of soil. Only the lightest kind of material is used for walls and roof. Solid arched roofs should not be used. The distance between the floor and ceiling is 6 ft. 6 in., in the clear. The magazine has two compartments. One is called the lobby, is accessible from the outside, and serves as a room for the reception and delivery of explosives. The other room is used for storage only, and is accessible only from the lobby. The outer door to the lobby opens outward, is faced with sheet iron about $\frac{1}{4}$ in. thick, and is supplied with a strong lock. The compartments of the magazine are ventilated by protected ventilating channels in the gables. The highest temperature allowed does not exceed 95 degrees F. The ceiling is of wood, and the inner sides are also wood lined. This lining is about three inches from the walls, and the intervening space is filled with some non-inflammable, non-heat-conducting material. The floor is of wood and well ventilated beneath. It is provided with a drain to insure the dryness of the magazine. The roof is of galvanized iron, and has a wood lining immediately against the iron. All nails, fastenings, locks, keys, and fittings are of wood, brass, or copper. The magazine is fitted with a reliable lightning conductor, supported on a vertical post which stands clear of the building, not more than 18 in. from one of the walls, and rises at least 6 ft. above the highest point of the magazine.

The magazine is surrounded by an outer earth wall, and the bottom of the inner slope of the same is about 3 ft. from the sides of the building. The earth has a natural slope on each side, is 3 ft. wide at the top, and as high as the highest point of the roof. The approach to the precincts of the magazine through the outer earth wall has a strongly built gate which is kept locked. The door is protected by an outer protecting earth wall which entirely shields the entrance. A self-registering thermometer is kept in the storage room. A pair of magazine shoes is kept in the lobby, and no person is allowed to enter the storage room of the magazine except when wearing such shoes, or when barefooted.

Interior Arrangement of the Warehouse. After one has determined what materials are to be stored under cover in the warehouse, then the size and arrangement can be considered. For a small warehouse, the problem of arrangement is simple, but for the large type, where many different kinds and types are to be stored, the problem becomes more complicated.

In some cases it becomes necessary to store large, bulky material, not easily handled, but which must be placed under cover because of its value, or its deterioration if placed subject to the elements. This material may have to be handled with cranes, or it might be advisable to run a spur of the railroad track into the warehouse, so that the material can be unloaded directly from the cars, under cover. All such material should be stored in the same part of the warehouse so as to eliminate as much handling and moving as possible. The floors or platforms of this part must be built in a much

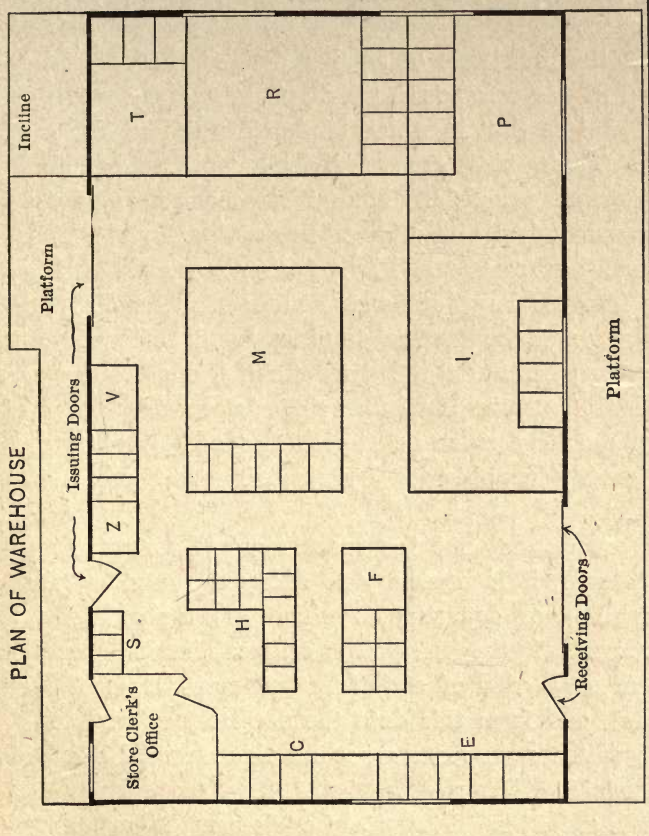
PLAN OF WAREHOUSE
Incline
Platform
Issuing Doors
Store Clerk's Office
T
R
P
V
Z
S
M
H
F
C
E
I
Receiving Doors
Platform
R.R.Tracks

FIG. 6a.

more substantial manner than the part for the lighter materials. The doors must be made of a special size and type. One of the best forms of large doors is the kind which is suspended from above, and which moves on rollers.

For the multitude of smaller articles that must be stored in the warehouse, the most satisfactory arrangement will be that in which bins of a standard size are used. These bins are subdivided and resubdivided on the unit principle. This arrangement permits the most economical utilization of space, since by it a large or small bin may be had by the simple process of slipping into the larger bin one or more smaller units, and then allowing the material to occupy only the space actually required. At the same time, if more space is required for some particular material because an unusual quantity must be stored, this additional space can readily be obtained by removing the unit subdivision.

In order to lay out the space required for any type of material, it is necessary to study the needs of the department or departments which use that material. Standards of the maximum and minimum quantities to be carried of each kind of material must be studied, and from this data the necessary cubical contents of the store-room space for this material can be determined.

Standard Bins. Store-room equipment, as manufactured and placed on the market by several concerns who make a specialty of this kind of work, is made of sheet steel. The three general types are:

1. Bins of the closed type.
2. Shelves or open type.
3. Racks.

For special requirements any design is made according to specifications. The equipment is built on the unit principle, and the standards of the unit size cover a wide range. The units are made flexible in size by means of dividers, so that space can be adjusted either horizontally or vertically. The material for this equipment is shipped "knocked-down" and can be easily erected by any workman. The important point of this steel equipment is that it is fire retardant. Where great permanency is desired, it might pay to investigate the products of several of these concerns.

Bins mostly used, however, are of wood, and can be easily made by the carpenters at the plant. In this manner, special features can be introduced and changes made with the least expense. The bin system used may be either the single or the double bin system. When the individual unit of the material is small in size, but carried in large quantities and used at a fairly uniform rate, the double bin system has its advantages. The issuing bin may be small and placed close at hand, while the remainder of the material is stored in a master bin which may be located in a less accessible place. The master bin tag, which shows the total amount in the small issuing bin and in the master bin, is suspended from the issuing bin. Also the location of the master bin is shown on this tag.

Pipe Racks. A special type of rack is usually desirable for pipes and long rods. The best racks are those

which permit the removal of the pieces either lengthwise or sidewise. When long pieces are handled, it is evident that removing them sidewise is the most desirable.

Additional Space. Space must be provided near the entrance of the store-room so that when goods are received there will be ample space for counting and checking these goods, and moving them to the racks or bins. Similarly, space must be left at the issuing end, so that the store-keeper can gather materials called for on a requisition in this space. These spaces should be at some distance apart, so that no errors are made in the exchange of received and issued materials stored there.

If the store-room is in a building also used for other purposes, the stores proper should be partitioned off either with a substantial wall or with wire mesh. The doors should be of the self-closing and self-locking type, so that no one can enter the store-room without the knowledge of the store-keeper. A call bell, which is operated from the outside, should be installed so that the store-keeper can be called to the issuing door or window.

Arrangement of Bins. For small warehouses, or where the variety of materials is not great, the bins or racks may be arranged in alphabetical order. This method, however, has serious disadvantages, and would result in confusion for large store-rooms, since it would not bring like materials together. For example, brooms might be stored next to bolts. If arranged in alphabetical sections, a uniform design for bins or racks would be impossible because of the great physical difference of the materials stored in each section.

If the amount of material is large or the variety extensive, and there is a constant call for some while others are but rarely used, those of the former type should be stored close at hand so as to be quickly and easily accessible, while those used less may be stored in more remote places. In order to locate materials when stored in this way, a card index system is used. The bins or store places are numbered in some well recognizable order. An index book or file is made which lists all materials according to name, size, quality, and other properties, and states the number of the bin or section in which the material is to be found. In this manner, storage space can be well utilized, and by reference to the alphabetically arranged index, it does not take much time to locate the goods. Also, like materials may or may not be stored together in the same section. It allows a great fluctuation in the manner in which goods are to be stored.

Another method of arrangement is according to a Mnemonic Classification. When all materials are classified mnemonically and given a symbol, they are arranged in bins or sections in alphabetical order according to the classification. Like kinds of materials will be placed together. The mnemonic symbol is an aid to the memory in recalling the name of the material. Likewise, given the name of the material, its mnemonic symbol is easy to determine, and hence the piece can be rapidly located. The system is easy to learn and a stranger in a short time can master it and locate materials in the store-room. The complete classification is always kept on hand, but in a very short time a per-

son has mastered the symbols and seldom refers to the classification. It does away with the necessity of a card index as described in the previous case.

Mnemonic Classification of Mine Materials. The following is a skeleton classification of materials used in and about mines. Because of the fact that the kind and amount of materials vary greatly at different properties, we have not endeavored to make this in any way complete, but have merely indicated the general method.

The first consideration to be given is to divide all materials into some large, fundamental groups. One must consider how the materials are most logically grouped with respect to their size and purpose. The general groups given may be applied to some properties, but it might be advantageous to make an entire different grouping for other cases.

It will be noticed that the letters " Q " and " U " are not used. In the writing of these letters, the " Q " is somewhat similar to " O " and the " U " to " V," hence this was done to avoid any possible errors in interpreting the symbols when in writing. When the first letter of the word is no longer available, the next following consonant is used, as, for example, under **Hardware,** " staple " is designated by " SHT " as the " S " was used to designate " screws " " SHS."

After sufficient letters are used to designate the article, the size or make follows, as, for example, 40% dynamite is designated as " SXD — 40%," or a hammer for a Waugh No. 17 drill is designated by " SMDH — W17," while the machine itself is designated by " SMD — W17." When sufficient symbols are used, and there

is still a variety to designate, serial numbers may be used, as, for example, blank forms may be numbered serially, and the numbers preceded by the symbol for stationery and office supplies. This allows an extension without getting into a complicated series of letters.

Persons soon become familiar with the symbol of the materials which they often use, and hence, if this symbol is written on the requisition, it saves time in writing.

"S" STORES.

SA	
B	
C	Chemicals for Assaying — Supplies.
D	
E	Electrical Supplies and Accessories to Electrical Machines.
F	Fire Accessories.
G	
H	Hardware.
I	Iron, Steel, and Castings.
J	
K	
L	Lumber.
M	Machines and Accessories other than Electrical.
N	
O	Oils, Greases, etc.
P	Pipes or Fittings.
R	Ropes, Cables, or Belts.
S	Stationery and Office Supplies.
T	Tools.
V	Vehicles and Accessories.
W	
X	Explosives.
Y	
Z	Miscellaneous.

"SC" CHEMICALS FOR ASSAYING — SUPPLIES.

SCA	Acids.
B	Bone Ash.
C	Crucibles.
D	
E	
F	Fluxes.
G	
H	
I	
J	
K	
L	
M	Metallic Substances.
N	
O	
P	
R	
S	Scorifiers.
T	Tools.
V	
W	Weights.
X	
Y	
Z	Miscellaneous.

"SCA" ACIDS.

SCAA	Acetic.
B	
C	
D	
E	
F	
G	
H	Hydrochloric.
I	
J	
K	
L	
M	
N	Nitric.
O	
P	
R	
S	Sulphuric.
T	
V	
W	
X	
Y	
Z	

"SCF" FLUXES.

SCFA	Argols.
B	Borax.
C	Cyanide of Potash.
D	
E	
F	Flour.
G	
H	
I	
J	
K	
L	Litharge.
M	
N	
O	
P	Potash.
R	
S	Soda.
T	Salt.
V	
W	
X	
Y	
Z	

"SE" ELECTRICAL SUPPLIES AND ACCESSORIES.

SEA	
B	Bells.
C	Cells.
D	
E	Electric Blasting Machines.
F	Fuses.
G	
H	Hangers.
I	Insulation.
J	
K	
L	Lights and Accessories other than Fuses or Switches.
M	Motor or Generator Accessories.
N	
O	
P	Phones.
R	
S	Switches.
T	Transformers.
V	
W	Wires.
X	
Y	
Z	

"SEL" LIGHTS AND ACCESSORIES OTHER THAN FUSES OR SWITCHES.

SELA	
B	Buttons.
C	Carbons.
D	
E	
F	
G	Globes.
H	
I	
J	
K	
L	
M	
N	
O	
P	Portable Lamps.
R	
S	Sockets.
T	
V	
W	
X	
Y	
Z	

"SH" HARDWARE.

SHA	
B	Bolts and Nuts.
C	
D	
E	
F	
G	
H	Hinges.
I	
J	
K	Keys and Cotters.
L	Locks.
M	
N	Nails.
O	
P	
R	Rivets.
S	Screws.
T	Staples.
V	
W	Washers.
X	
Y	
Z	

"SI" IRON, STEEL, AND CASTINGS.

SIA	
B	Beams.
C	Castings.
D	
E	
F	
G	
H	
I	
J	
K	
L	
M	
N	
O	
P	Plates.
R	Rods.
S	Steels for Drills.
T	Track Accessories.
V	
W	
X	
Y	
Z	

"SIT" TRACK ACCESSORIES.

SITA	
B	Bonds.
C	
D	
E	
F	Fishplates.
G	
H	
I	
J	
K	
L	
M	
N	
O	
P	
R	
S	Spikes.
T	Turnouts.
V	
W	
X	
Y	
Z	

"SM" MACHINES AND ACCESSORIES OTHER THAN ELECTRICAL.

SMA	
B	Breaker Parts.
C	Compressor Parts.
D	Drills and Drill Parts.
E	Engine Parts.
F	
G	
H	Hoist Parts.
I	
J	
K	
L	Lubricators.
M	Machine Tool Parts.
N	
O	
P	Pump Parts.
R	
S	
T	
V	
W	
X	
Y	
Z	

"SMD" DRILLS OR DRILL PARTS.

SMDA	
B	
C	Chucks.
D	
E	
F	Feedscrews.
G	
H	Hammers.
I	
J	Jackscrews.
K	
L	
M	
N	
O	
P	Pistons.
R	
S	Springs.
T	Tappets.
V	Valves.
W	
X	
Y	
Z	

"SO" OILS, GREASES, ETC.

SOA	Axle Grease.
B	
C	Candles.
D	
E	Engine Oil.
F	
G	Gasoline.
H	
I	
J	
K	Kerosene.
L	Linseed Oil.
M	Machine Oil.
N	
O	
P	
R	Graphite.
S	
T	Transformer Oil.
V	
W	
X	
Y	
Z	

"SP" PIPES OR FITTINGS.

SPA	
B	Bushings.
C	Couplings.
D	
E	Ells.
F	Flanges.
G	
H	
I	
J	
K	
L	
M	
N	Nipples.
O	
P	Packing.
R	Reducers.
S	
T	Tees.
V	Valves.
W	
X	
Y	
Z	

"SX" EXPLOSIVES.

SXA	
B	Black Powder.
C	Caps.
D	Dynamite.
E	
F	Fuse.
G	Gelatine.
H	
I	
J	
K	
L	
M	
N	Nitro.
O	
P	
R	
S	
T	
V	
W	
X	
Y	
Z	

Stores Records. A stores record, in its simplest form, is a record which shows receipts and deliveries of materials. The debits and credits are expressed in items of materials instead of values, as in a ledger. That items of materials are used in place of dollars and cents, does not lessen the importance of this work. Materials on hand represent money. Often materials are purchased with borrowed money, so that over-stocking becomes as serious as a bad investment. "Out of stock" of an article, that takes days and perhaps weeks to procure, entails expensive and annoying delays. Ordering based on guesswork rather than on actual records of consumption can but result in excess materials in one direction, and inadequate provision in the other. In the case of perpetual inventory methods, one need only add the balances of each record to determine the stock on hand, and a physical inventory is not absolutely necessary. In case of fire, the records can be shown for insurance claims, and they will be of great benefit for re-ordering. Hence it is important that accurate records of materials be kept. The following will be a general description of methods now in use that have proved successful for each individual case.

The following method is adequate for small concerns, where the materials carried are small in number and variety. A form is filled out, either on loose-leaf paper or on a card, which gives the name of the article, the price per unit, the date of receiving or issuing, and the balance on hand. A leaf or card is made out for each different item of material and arranged alphabetically. See Fig. 7.

A card or leaf should be made out not only for each different kind of material, but for each size of this material. For example, metal plates or sheets should be listed as different-size plate or sheet, and each size have a record for itself. Three-inch pipe would be listed according to length. If four feet are cut from a ten-foot pipe and the six-foot piece returned to stores,

THE ACME M. & M. CO.

STORES RECORD

Article	*Unit Price*	*Date*	*Rec'd*	*Issued*	*On Hand*

FIG. 7.

the record for the ten-foot pipes is credited with one pipe, and the record for the six-foot pipes is charged with one pipe.

A method similar to the above, but which shows more items, is handled in the same manner either in a book or on cards. In this case, it shows the date received, the consignor, the quantity, cost, and the additional costs of handling and freight, the issuing date, name of the account to which it is to be charged, and the price.

The cards are balanced at the end of each month, hence do not give a perpetual inventory. This method may be sufficient for some cases, but it is better to have the cards show the balance on hand at all times, so that if kept reasonably accurate, one can easily determine how much there is on hand of each material without the necessity of a physical inventory. See Fig. 8.

In addition to the above features and a perpetual balance, all records should show the maximum quantity of each item which should be kept in stores, and the minimum amount to which each item can be safely allowed to fall. In determining these base figures for maximum and minimum, the following points must be considered:

1. Past records of consumption.
2. Time of consumption per unit.
3. Storage space occupied.
4. Economic amount to purchase at one time.
5. Time of delivery.
6. Terms of purchase.
7. Depreciation.
8. Interest on capital invested.
9. Insurance.

The average weekly consumption is the amount used per week on the average, and is determined from past records or by special investigations. These figures should be revised occasionally, since the rates of consumption will vary. There may be cases where periodic changes occur, and in such cases the figures should be determined for each period. The minimum should be

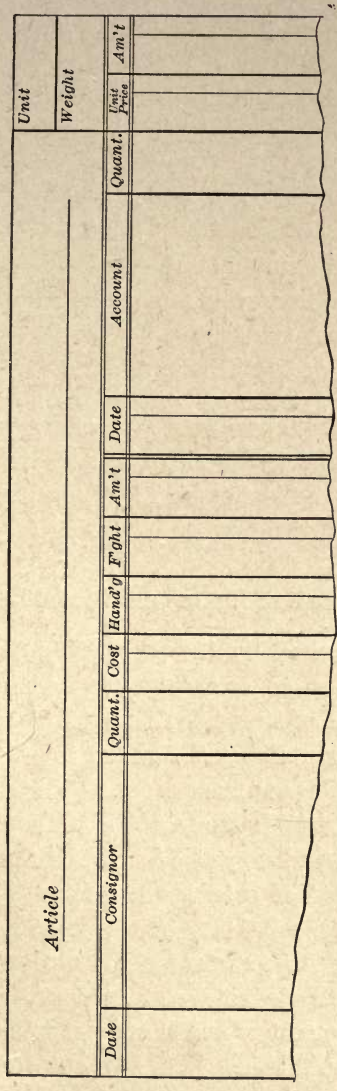
Article
Unit
Weight
Date
Consignor
Quant.
Cost
Hand'g
F'ght
Am't
Date
Account
Quant.
Unit Price
Am't

FIG. 8.

so set that the fresh supply comes in just before the old stock is exhausted.

The minimum amount to which an item of material may be allowed to fall may be determined by the following formula:

$$M = T \times Q,$$

where M = minimum amount.
T = time in weeks required to obtain material from the source.
Q = the weekly consumption.

The above formula may be further extended by considering the factors which make up each term.

The unit of time is the week. The unit of quantity is that one decided on as the standard for the balance of stores record.

The most important factors are the following:

(*a*) Time required by the purchasing department to place an order after receiving a purchase requisition from the balance of stores clerk.

(*b*) Time required by the seller to ship the goods after receipt of the purchase order.

(*c*) Time required in transit.

(*d*) Time required to unload and test the material.

(*e*) Time added as a factor of safety. (This usually depends upon the reliability of the shipping concern as to their keeping the promised delivery dates, and upon the unaccountable variables of transportation.)

(*f*) Average quantity consumed per week.

(*g*) Balance available.

(h) Maximum quantity that a single requisition on stores might require.

(M) Allowable minimum quantity.

Using the letters indicated above, the sum $(a + b + c + d + e)$ = time in weeks required to secure the material from the source = T of the preceding formula.

This sum multiplied by (f) gives the quantity used during the time required to replenish the stock. It might, therefore, be expected that if the balance of stores clerk made out a requisition on the purchasing department for material when this quantity was left on hand, the new lot would be ready just as the old lot was used up. There must, however, always be enough on hand to fill the maximum order that might be expected, so the factor (h) is added. The complete formula then becomes:

$$M = (a + b + c + d + e)f + h.$$

A requisition should be put through as soon as (g) becomes equal to (M).

In many cases some of these terms become so small that they need not be considered. By the intelligent use of this formula it is possible to keep but a relatively small amount of materials on hand and at the same time always be sure of an adequate supply.

The maximum quantity is the sum of the minimum quantity and the economic amount to purchase, or

$$X = M + P.$$

This economic quantity to purchase (P) has been previously discussed.

Article		Size		Max.	Account		
				Min.	Location		
		When Min. is reached notify Mr._____		Unit			
	Date 191__	Order No. In or Out	From Whom Ordered or Where Delivered	Am't-In	Am't-Out	Balance	Unit Price	Balance Value

FIG. 9.

A standing order should be made for the stores clerk to the effect that when stores on hand reach the minimum, he must issue a requisition to the purchasing agent for an amount to bring the item up to the maximum. These requisitions should be checked by some person who is thoroughly familiar with the needs of the

STORES CARD *Article*								*Order in Lots* / *Danger Limit*
Symbol		*Section* *Space*		*Unit*	*Remarks*			*Min.*
Date 191	*Quant. Order'd*	*Ord. No. or Job No.*	*Quant. Rec.*	*Quant. Issued*	*Quant. Bal.*	*Price*	*Am't*	*Cash Bal.*

FIG. 10.

concern, since it often happens that some of the items will go out of use. The including of these figures on the stores record card safeguards both the stores clerk and the purchasing agent, since it automatically reminds the clerk when he must order and it gives the purchasing agent ample time to order and receive the goods. This form of record is also kept on cards or loose-leaf books. See Figs. 9 and 10.

In some cases, a bin-ticket record system is used in connection with the card records. This facilitates the keeping of an accurate record in the warehouse itself. Another reason for using a bin ticket is that each stores man can be required to enter his initials on the bin card every time he withdraws materials. In this way he can be held to accuracy and prevented from taking an excess of small parts and let the surplus lie around the issuing space. The bin ticket cannot usually be made to serve as a record of materials on hand, such as is kept by a regular stores record clerk, because the records for quick reference and entering must be in a compact form. However, the bin ticket has a salutary disciplinary effect, besides it is useful to inform new stores men as to the correct names of the materials. See Fig. 11. When the quantities fall to the minimum, the ticket is sent to the stores record clerk, and a new ticket made out. Sometimes a temporary bin ticket is used when an item has fallen below the minimum. This ticket is of a different color, so that if a person passes through the warehouse, he can see at a glance what items are low.

The Scientific Management method of keeping stores records includes the best of the previously described methods with some additional features. The record is known as the " balance of stores " record, and is in charge of a " balance of stores " clerk, which is a special function. All stores are classified and given a mnemonic symbol. The bin tag method is also used in connection with the book records. It is assumed that work is planned ahead and lists of materials made out to be

Name of Arcticle _____ *Unit* _____

Symbol _____ *Max.* _____

_____ *Min.* _____

Date Rec.	*Date Issued*	*Quant.*	*Charge to Order No.*

Note: When Minimum is reached Send this Tag to Store Clerk.

FIG. 11.

used for this future work. This material is known as material apportioned to a job and, although still in the store-room, is not any longer available for other jobs. This method of planning ahead and apportioning materials for future work necessitates the introduction of another column in the stores record sheets. Such a Balance of Classified Stores Record Sheet is illustrated in Fig. 12. It consists of four main divisions, or columns, numbered consecutively 1, 2, 3, and 4. These columns are used for the following:

1. Stores ordered but not yet received.
2. Stores on hand in the store-room.
3. Stores apportioned to a job but not yet issued from the store-room.
4. Stores available.

It is assumed that the time necessary to replenish materials is known and that the minimum amount has not been exhausted before the new supply arrives, hence when stores are ordered, the quantity is added to columns 1 and 4. When the materials arrive, the quantity received is subtracted from column 1 and added to column 2. When materials are apportioned, the amount is added to column 3 and subtracted from column 4. When stores are issued, the quantity is subtracted from columns 2 and 3. The balance is brought down at once in each column affected. This method is of utmost value where all work is planned out in advance. The various balance sheets are kept in loose-leaf binders in alphabetical order, in accordance with their symbols.

In addition to the classified stores, usually some small

BALANCE OF CLASSIFIED STORES

Article _____

When quantity available fails to _____ issue requisition for _____

STORES ORDERED 1 But not yet Received					STORES ON HAND 2 In the Store Room					STORES APP. 3 But not yet Issued				STORES AVAILABLE 4		
Date Ordered	Quantity	Date Rec'd	Purchase Order No.	Date to be Del'd	Date Rec'd	Quantity	Date Issued	Issued for Order No.	Purchase Order No.	Date App.	Quantity	Date Issued	Order No.	Date	Quantity	Remarks

FIG. 12.

quantities are purchased at irregular intervals, and not usually kept in stores. These are known as unclassified or miscellaneous stores, are given consecutive numbers and filed accordingly.

The general procedure under this method is as follows:

All duties and work to be done is described in detail on written instruction cards to each person concerned. Standing orders are made out in writing which cover these instructions and regulations which regard the management and operation of the store-room.

The Planning Department plans the work ahead, and lists the material in advance for the jobs. The lists of this apportioned material are given to the balance of stores clerk for proper entry.

In order that the balance of stores clerk can keep his records in proper shape he must, in each case, be furnished with:

(*a*) The Purchase Order, or copy, so that he can enter the materials ordered but not yet received.

(*b*) The Materials Received Report, or copy, so that he can enter the materials as on hand in the store-room.

(*c*) The Issue Slip, or copy.

(*d*) Stores Credit Slip, or copy.

(*e*) Apportioned Slip, or copy.

(*f*) Price of materials.

Where the originals are used, they are stamped after entry and returned to the proper officials. Where copies are used, they are stamped after entry, and kept on file by the balance of stores clerk. Where the balance of stores clerk is furnished with a copy of the

Purchase Order, it is filed serially, and the purchasing agent's copy filed alphabetically, so as to form a cross-index.

The Materials Received Report is filed chronologically, because a freight bill, or other record, may give only a date on which an item of material was received and this system of filing makes it easier to locate reports.

After an invoice for materials purchased has been paid, it should go to the balance of stores clerk, so that he may enter the price. This should be done from the paid invoice in order to include any price adjustments. The price should invariably be reduced to the same unit as that in which the material is recorded on the record sheet.

Checks. Where no perpetual inventory is kept, it is necessary to go to each bin, rack, or stock pile and count the material, in order to determine how much there is on hand. Where a perpetual inventory is kept, this must be checked occasionally by a physical inventory. A certain amount of this checking should be done daily, so as to avoid an accumulation of this work. A good method of checking the store-keeper is one where the stores record clerk, daily, takes a number of the bin tickets to his desk and compares them with the balance on his record. At the same time, he orders a count made of the materials in these bins. The count is forwarded to him, and the count, ticket, and balance record should agree. The store-keeper does not know in advance what bins are to be counted, and does not know what the quantities are in the bins, as the bin tickets are removed

before the order to count is issued. The order of count should be so arranged that each bin is counted at least twice a year. Where more time is available, this schedule should be made even shorter. If errors are found, they are brought to the attention of the store-keeper so that immediate correction can be made, and a report is sent to a proper official.

Another method of inspection is conducted according to the Exception Principle. Someone delegated for the purpose inspects at random a certain number of bins each day, and checks the quantity found with the ticket and the record sheets. If an error is found, additional bins are counted. Exception inspections carried on in this manner, keep not only the store-keeper but also the record clerk on their mettle, and tend to find any errors that might have slipped by them. The amount of inspecting done under this method depends entirely upon the condition found when checking.

(*d*) Issuing Systems.

The management should have constantly in mind the cash-control idea with regard to stores. It is helpful to get the workmen imbued with the same spirit. The fact that the stores are kept under lock and key and that they can only be obtained through a requisition signed by a foreman or a proper official, exerts a strong influence in this direction. It is a psychologic fact that the sense of value is inversely proportional to the ease of obtainment. This does not mean that issuance should be so surrounded with safeguards and restrictions as to put the workmen to inconvenience in

order to secure necessary supplies; on the contrary, the methods should be such that needed materials can be obtained without unnecessary formality or delay. Any wasteful use must be discouraged. If the workmen know that the company does not keep track of its materials, it will create a bad influence among them. The workmen are not paid for keeping track of the company's materials, and they do not feel that they should be thanked for economizing. As a matter of fact, where no records are kept, it would not be known that a workman was economizing.

It is a common criticism that it is nothing more or less than "red tape" to require a written and signed requisition when an employee wants a pencil or a bolt, worth perhaps but a fraction of a cent. On the face of it, this appears to be true and it would seem to cost more, as some claim, to make out a requisition for a pencil or a bolt than either of them is worth. When one considers, however, that these are extreme cases, picked out to exaggerate or perhaps to condemn a method, and remembers, too, that these seemingly foolish requirements affect only a small percentage of the total values which the methods are to govern and control, the matter then assumes an entirely different aspect. A good manager knows how to transgress from a standard method in order to facilitate the operations for certain, irregular needs. As for example, consider office supplies. These should be drawn periodically in reasonably large quantities on a requisition signed by the head of the department. He must know his wants, so that perhaps once a week he can make his order on

stores for the supplies which he will need for a week. From this point on, he can keep his own records as to the consumption of the individuals under him. This method does away with the continual annoyance caused by the necessity to frequently make out a requisition for a small issue of stores, and at the same time, makes it easy and feasible to handle all kinds of material through the same routine as required for valuable material.

THE REX MINING CO. Date _____

SUPPLY ORDER

SUPPLY CLERK:-

Deliver the following to _____

Am't Ordered	Name	Value	Chargeable to

Foreman _____

NOTE:-No Material will be issued without this ticket. This Requisition properly signed must be filed in Store Clerk's Office.

FIG. 13.

Figs. 13 and 14 show forms of requisition slips much in use. The Credit Slip, Fig. 15, is used when supplies have been charged out and returned to be used for some other purpose. Credit should be given the job it was charged to, and the material charged back into the supply account.

In mines where men are working under contract and where the supplies which they draw from the store-

Charge to Order
*No.*_____

S C

ISSUED FOR

Quantity	*Unit*	*No. Piece*	
Total Wgt.	*Unit Price* / *Total Value*	*Drawing No.*	
		Job No.	
		Issue / *Written*	*Month* / *Day* / *Year*
STORES ISSUE		*Stores Delivered*	

Storekeeper:- *Please issue above*
*to*_____

*Signed*_____

App.	*ENTERED*				*Stores described above have been issued,*
	Tag	*Stores Acc't*	*Balance Acc't*	*Cost Acc't*	
					Storekeeper

FIG. 14.

room are deducted from the contract price, a special issuing record should be kept for these men. A separate record should be kept for such material, and Fig. 16 shows a form of such a record. They are made out for each man, or group of contractors, and are filed alphabetically according to the name.

THE REX MINING CO. *No.*_____

CREDIT SLIP

Deliver to Supply Clerk: *Date*_____

Amount	*Name*	*Value*	*Credit*

*Credit to*_____

Foreman _____

This slip must be kept on file in Store Clerk's Office.

FIG. 15.

For the absolute success of the Requisition System, close supervision is necessary. This means that the foreman in charge of the men must have sufficient time to investigate the reason why supplies are needed, before placing his signature on a requisition. If this is the case, then the men will not call for material which they do not need, since the foreman, who is held responsible for all supplies issued under his signature, will not likely authorize the order without good reason. When, however, a foreman has a large number of men under him and considerable work to do, the Requisition System will soon show defects. The men will soon

learn that they can get the material by going through a mere formality. The foreman has other important duties, and one can hardly expect him to look after these leaks. The store-keeper cannot object to deliver the goods when a properly signed requisition is tendered. In case he should investigate the reasons why each requisition is made out, it would entail endless friction and needless waste of time, and it would cost more than the saving would be worth. In such a case, the fault is not with the men, but with the system.

*Name*_____

*Level*_____ *Location*_____

*Month of*_____ *191*____

Date	*Candles*	*Powder*	*Fuse*	*Caps*	*Steels*	*Oils*	

FIG. 16.

Since the previously described case occurs, at times, some other schemes have been planned out and put into use. A type of these, for special cases, is the Budget,

or Bill of Material, System. This method is based on the principle that the store-keeper can be held responsible for over-issues of materials for a job, when he has a complete list of materials necessary for that job.

This system can only be used where the work is such that it can be planned out in advance, specifications made for the materials necessary, and these materials entered in detail on a Bill of Material form. Then a copy of this Bill of Material is sent to the store-keeper with instructions somewhat like the following: "Issue material to any responsible workman who calls for it, provided the materials are listed on this sheet, but take precautions to get the workman's number or name against every amount of goods which he takes out. When the list has all the items checked off, issue no more goods, unless spoiled material is returned, or some satisfactory explanation comes from the foreman, under his signature, as to why the additional material is needed."

This system has the following advantages:

1. It prevents theft, since no one can obtain materials unless he is responsible for them.

2. Wastes are lessened, since additional material called for is noted and the cause investigated.

3. It notifies the store-keeper in advance what materials will be needed.

4. It lessens the accounting, since it eliminates the handling of individual requisitions.

5. It enables the men in charge to keep close watch on all material.

A modification of the above plan is one where materials such as oil or waste are issued, which cannot be allotted to any particular job. A certain amount of such material is issued to each man every week and no more given to him, without explanation, until the next distributing day. The needs of each particular case must be studied and the amount to be issued set accordingly.

Another modification of the Budget Method is used by large mining companies for Extraordinary Expenses. Extraordinary Expenses are those which exceed a minimum amount fixed by the officers of the company. If it is estimated that the cost of a new job, repair, improvement, construction, or additional equipment, amounts to more than this fixed minimum, the approval of the general manager and the general superintendent is required. The method of handling these items is to make out at the mine, an estimate, which gives details, and forward copies of this to the officers concerned for their investigation and approval.

(*e*) Reports of Consumption of Supplies.

In order to know where and when to place restrictions on the issuance and consumption of materials, and in order to obtain data from which to study material consumption of the different jobs or workmen, the management must determine standards of consumption for different kinds of work.

Daily reports are usually required from the timbermen, drillers, enginemen, etc., as to how much timber, powder, oil, etc., they used that day. Fig. 17 shows a form of report for timbermen. Other reports are made out

in a similar manner. One of the office men compiles these reports on forms for the month's supply. At the end of the month, these are totaled and the cost

THE REX MINING CO.
Timberman's Report

Date _____ _____ *O'Clock Shift*

Level _____ *Stope or Drift* _____

Caps	
Sills	
Posts	
Stulls	
Butt Caps	
Ties	
Lagging	
Sprags	
Ladders	
Planks, ft.	
Cribbing	
Remarks	

Timberman

FIG. 17.

entered. Figs. 18 and 19 show forms for the monthly compilation of such reports, for timber and powder. Figs. 20 and 21 show forms for noting the supplies used on engines and a record of coals consumed. The amounts are entered daily from the individual reports. The

card, or page, is usually made large enough to show a month's consumption.

THE REX MINING CO.

Timber Report.

Month of _____ 191____

Day	Caps	Sills	Posts	Stulls	Butt Caps	Ties	Lagging	Sprags	Planks-Ft.	Cribbing		Remarks
1												
2												
3												
4												

FIG. 18.

THE REX MINING CO.

Powder Report

Level _____

Place _____ Month of _____ 191____

Day	1 1/8" Powder lbs.	7/8" Powder lbs.	Powder 100% lbs.	Fuse, Ft.	Water Fuse, Ft.	Caps				Remarks
1										
2										
3										

FIG. 19.

Timber Records. In mines where considerable timber is used, special methods of keeping track of this have been adopted. For a large mine, this problem is

CONSUMPTION OF MATERIALS

Month of _____ *191*____

Where Used	*Oils—Gals.*					*Greases*	*Waste*	*Packing*	*Belt Dressing*	*Coal*	*Wood*
	Cylinder	*Engine*	*Machine*								
Compressors											
Hoists											
Pumps											
Engines											
Machine Shop											
Drills											
Cars											
Boilers											
Blacksmith Shop											
Assaying											
Heating											

FIG. 20.

a difficult one. Timber is usually placed as the work progresses, re-timbering is a frequent occurrence, and the age of any particular set of timber, the cause of its failure, and many other items that are of value to the manager, soon become hopelessly confused. Where timbering or re-timbering is done on contract and payment made every two weeks, it is imperative that some method of recording and posting timber sets be adopted. The

THE REX MINING CO. *Coal Record*	*Jan.*	*Feb.*	*Mar.*	*Apr.*	*May*	*June*	*July*	*Aug.*	*Sept.*	*Oct.*	*Nov.*	*Dec.*
On Hand at First of Month	125	45	274									
Amount Received During Mo.	200	500										
Total, tons	325	545										
Amount Consumed During Mo.	280	271										
Balance, tons	45	274										

FIG. 21.

following is a description of a method used especially for drifts, but it can easily be extended to embrace all timbering:

Every stick of timber, after being set in the mine, is blazed with a carpenter's hatchet, and the date of setting punched thereon with a set of steel figures and then painted over with a coat of wood preservative paint. The head timberman on his final round, just before the end of the shift, does this marking, and at the same time fills out a blank form as shown by Fig. 22. The sheets are kept on file by levels, and the totals brought down and posted by the book-keeper. Old timbers re-

Date_____

Shift_____

Level_____

THE REX MINING CO,

Timber Sheet

Location	CAPS		SILLS		POSTS		STULLS .		LAGGING		PLANKS		LADDERS	
	No.	Dimension	No.	Dimension	No.	Dimension	No.	Dimension	No.	Dimension	No.	Dimension	No.	Dimension

THE REX MINING CO.

Timber Sheet

(Book-keeper's Extension)

Cost of Timber	Labor Cost			Total Cost	Remarks
	No.	Rate	Cost		

FIG. 22.

set are marked a second time. The original date is left intact, so that when a set of timber is finally removed, the individual timbers which compose the set practically tell their own history and age.

" Lost " Material. A careful inspection of some of our mines will show that large amounts of old but perhaps re-usable timber, tracks, switches, pipes, wires, etc., are apparently " lost " in the old workings or abandoned parts of the mine. In some cases this amounts to a serious figure, but apparently the management is not aware of this. It certainly would be time well spent to keep a closer account of this material. Practically a debit and credit ledger system could be used for this. The mine could be divided into different parts, and a regular charge account kept for each part. When any material is moved to this part, the part should be charged with it. When material is removed, the part should be credited. In this manner one could keep a careful record of materials underground, and the time consumed to keep such a record would certainly be well spent, since it would be of considerable aid to prevent materials from getting " lost."

Graphic Charts. Some concerns make elaborate graphic charts which show the consumption of supplies. Material costs are usually computed per ton of ore mined or treated, and these material costs per ton plotted, together with the date of consumption. In some places, charts which show the total consumption of materials are in vogue, while in other cases a chart is made for each important item. The chart method is merely an easy method of showing consumption

records at a glance without the need of going through a mass of statistical figures. Some concerns gather elaborate statistics, but seldom put these to actual use. A manager is more likely to make a study of a good chart than of a mass of figures. In a chart, one can see abnormal conditions of consumption at a glance, and center the analysis on these, rather than analyzing long lists of figures where the maximum of these show normal consumption, and only once in a while an abnormal figure is indicated which may pass the eye without notice. Abnormal points on a chart, whether they indicate an unusual excess or unusual minimum of consumption, should be noted, and an investigation made as to the reason why they diverge from the normal. Such an investigation will often result in a general reduction of consumption. Graphic charts are also of use in the Reports to the Board of Directors or to the Stockholders, since they are a condensation of statistical figures. The evil of too many reports and statistics is also recognized. Some superintendents or managers spend considerable time each day reading reports of labor and material consumption, when their time might well be occupied with other work. The following is a fundamental law of management: "Arrange the work in such a manner that no high priced man does work which a lower priced man can do." In order to comply with this law, the Exception Principle can well be put into use in the study of reports and charts. This principle is based on the fact that high officials need only investigate exceptional cases. A manager need not feel worried when he knows that everything is working under

normal conditions. Only in cases when conditions become abnormally high or low should he need to investigate. Charts according to the Exception Principle are made in the following manner:

A chart is plotted which shows times and units of consumption or output. By a study of the past records, one determines the normal figures, and draws a heavy line across the chart to represent this normal. This is the base line from which the abnormals diverge. The foreman's zone is indicated by a line above and below this base line, and parallel to it. As long as the consumption or output curve remains in the foreman's zone, the report need go no further. The next zone would be that of the superintendent; then a zone for the manager, and perhaps one for the president. If the curve enters the superintendent's zone, the report is shown to him; when in the manager's zone, it is also forwarded to him. The limits of these zones are arbitrary and depend upon the value of the consumption or output plotted, and the need of investigation by higher officials when abnormals show. Fig. 23 shows a chart made on this principle for powder consumption per foot of drift, and it will probably make the method clear. One can readily see that this method has many uses.

(*f*) Methods of Preventing Waste.

Records of Equipment. It is to be recommended that all companies keep a complete record of their machines and equipment. A good method is one where each machine and piece of equipment is given an inventory number, and a full record is kept which gives the entire

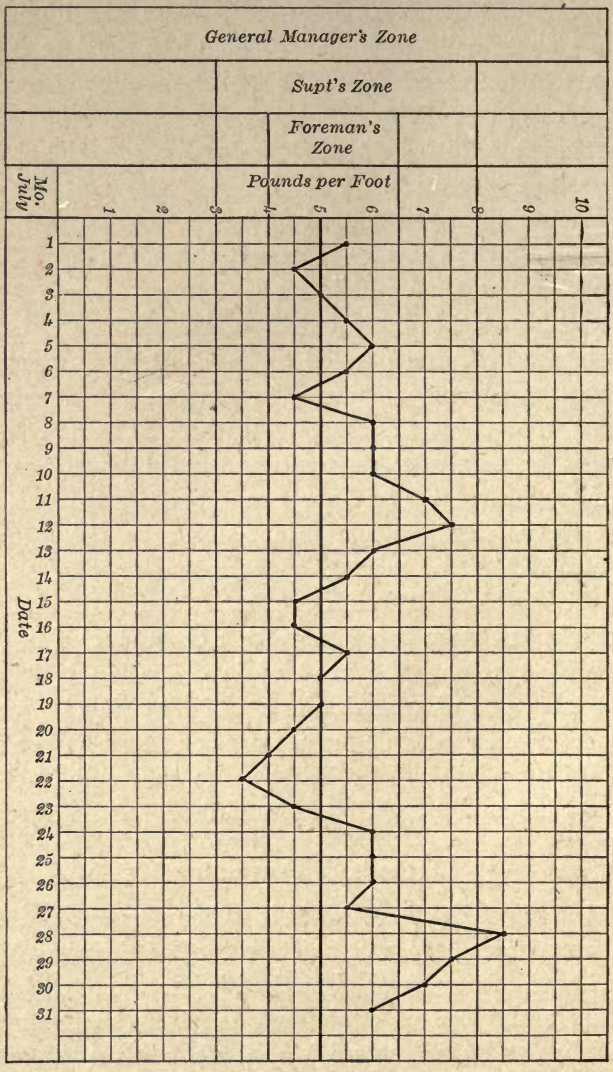
General Manager's Zone
Supt's Zone
Foreman's Zone
Mo. July
Pounds per Foot
1
2
3
4
5
6
7
8
9
10
Date
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31

FIG. 23.

history of the piece. A simple card record may be used. A card is made out for each piece of equipment. This card has the same number as the one affixed to the represented item. Such a card should show from whom the item was purchased, the date of installation, the original cost, the cost of

Machine No.			*Dept.*					
Description							*Total*	
Bought of		*P.O.*	*Date*		*Cost*			
Installed No.		*Cost*	*F'ght*		"			
Remarks								
				Year	*Dep.*			
Additions and Improvements		*Nature of Improvements*						
Date	*Order No.*							

FIG. 24.

improvements or betterments, and the depreciation as inventoried each year. The rear of the card may show repair and maintenance charges, so that the comparative efficiency of each machine may be shown. Fig. 24 illustrates such a card.

Another plan is one where a drawing is made of all power houses, shops, etc., which show the exact location of each machine or piece of equipment. The items are numbered, and the number placed on the article itself and on the drawing. A key to the numbers is placed on the drawing. In addition to this, the card record

is also used for detailed informations. Such a drawing alone presents considerable information.

These inventory records have many advantages. In case of fire, they are of great use in making insurance adjustments. In case of breakdown, there need be no search through old catalogues to get information as to where and from whom new parts are to be ordered. They keep the management informed as to the exact status of the plant. The true value of the equipment, both in total and individual items, may be easily ascertained, and the physical assets of the company determined at any time with very little work.

Tools. The variety of tools used in and about mines, unless there is a large machine shop in connection, is not very great, but the number of tools is at times very large. One seldom finds an accurate tool record system in use about mines. Tools, like materials, represent money, and the same laws which apply to materials, also apply to tools. A general law is, that when a tool is not in use, it should be kept in some proper place. The place for tools not in use is the tool-room. Tools that are used constantly must be kept in a place convenient for the workmen. The location of these places depends entirely upon the working conditions of each individual case. A large bulk of the tools can be kept in a central tool-room. The tools should be so arranged in this room that anyone can find them, even if he is a comparative stranger in the room. The records must be so arranged that the man in charge knows at all times when tools are out, and in whose possession they are to be found. Since the variety of tools used in mining work is not

great, it is not difficult to arrange such a room. However, when a large machine shop is run in connection, the problem becomes more complicated.

Tools in the tool-room should be kept in good condition. The workmen should be relieved of the responsibility of caring for their own tools. This should be a separate function. A workman cannot do efficient work unless his tools are in first-class condition, and the management should take this responsibility upon their shoulders. There should always be a plentiful supply of tools, so that a workman should at no time fail to obtain one when needed. The workman should be responsible for the tool after he has received it, but there should be no unnecessary trouble to get it.

For the average mine tool-room, a simple method of arrangement as to classes and groups will be sufficient. Proper racks or boxes should be made for each kind of tool. Equally as important as to be able to find a tool in the tool-room is the ability to tell where the issued tools are. A simple but efficient method is one where a workman is provided with a set of brass checks stamped with his number. When a tool is issued to the worker, this brass check is put in place of the tool. This check acts as a receipt for the tool, and is not given back to the workman unless he returns the tool. When a workman calls for a tool which is not on hand, one can soon tell who is using this tool. By this simple scheme, one can keep track of all tools out of the tool-room. When a workman leaves the employ of the company, he must return all checks to the tool-room before he is given a clearance paper.

Besides keeping track of the tools, a system should be in use whereby one can report to the management the kinds and makes of the most serviceable and profitable tools. A good method is one where the date of purchase and the name of the firm which made it, if not already there, is stamped on the tool. Then the tools may be issued under comparison a number of times, and the management can soon tell which makes prove the most efficient and economical. One can also determine the expenses connected with tools, and what workmen are the most economic users of tools.

Oils and Lubricants. Some concerns use large amounts of oil and lubricants, and this factor assumes considerable importance at times. Large quantities of oils are wasted by spillage and evaporation. High-grade oils are used where low grades would do as well. Considerable savings in lubricant costs might result where some definite oil system is in use.

The floor of the special oil house should be built with a sloping floor, of concrete or cement, with a drain at one end. Any waste oil will then drain to one end where it may be collected in a tank set under the floor. This oil is easily cleaned for re-use by passing it through an oil filter. Drip-pans should be placed wherever practical, and the drip oil cleaned by passing it through this filter. Large concerns find it convenient to make oiling the function of one man or group of men. Enough oil for a shift is distributed to the individual lockers of each oiler. The cans in these lockers are filled by certain men, so that the individual oilers need not go to the oil house for their supply. Time is saved by this method.

It also fixes the responsibility on each oiler for the oil allotted to him. The man in charge of the oil house has absolute control of the oil issued, so that he can keep accurate records of oil distribution. Any unused oil is emptied into a surplus can, and when enough has accumulated for a shift's work, it is used. The daily issuing record is kept in the form of a balance record, and may be checked at the end of each month by a physical inventory, since errors in measurement arise by measuring out numerous small quantities each day.

Timber. The results obtained by the telegraph, telephone, and railroad companies in the preservation of poles, ties, and piles, has caused the preservation of timber to become more and more common in recent years. However, little has been done as regards mine timber. Enormous amounts of timber are used in and about mines and the study of preservation of such timber should be made an important subject. The U. S. Department of Agriculture and the Forest Service have conducted some experiments and gathered statistics on timber preservation. Several bulletins and circulars have been issued. By far, the greater amount of experimenting and application has been done in Germany and many articles have been published on that subject.

Because of the rapid decay of timber, especially in coal mines, the artificial preservation is of great importance, and as the price of wood is increasing day by day, it will soon become necessary to take rigorous steps in that direction. Conditions in most coal mines are such

as to favor the growth of wood-destroying fungi. If the bark is peeled from the timbers, protection is offered against damages caused by insects, but the only remedy for decay is the impregnation of some liquid which is poisonous for the fungi. The following is a brief résumé of the general methods. Only, to date, satisfactory preservatives for mine timber are discussed.

The three general methods of applying the preservative are:

1. *Brush Treatment.* This method has several disadvantages.

(*a*) It is difficult to cover completely all of the timber and to fill all checks and cracks.

(*b*) The preservative will not penetrate deeply. The cost of application by this method is cheap, but little or no advantage is gained. The cost of treatment is likely to be higher than the saving which results from a prolonged life.

2. *Open Tank Method.* The timber is immersed in the solution in large tanks, for a suitable length of time. Some remarkable results have been achieved in the tests. The economic success of the practical application will depend upon the cost of the preservative.

3. *Closed Tank Method.* The greatest impregnation is obtained by this method, and where large amounts of timber are to be treated, it is to be recommended. The wood is placed in a cylinder, and first subjected to a high vacuum. This rapidly seasons the wood. Then the solution is sucked into the cylinder, and when filled, a high pressure is applied by means of an air pump. The timber is removed, and the water of the solution

allowed to evaporate, which leaves the salts fixed to the fiber.

Creosote is commonly used to treat timber used for telegraph and telephone poles, piles, and railroad ties. For timber to be used underground in mines, it has some serious disadvantages. It has a bad effect on the eyes and skin of the miners, has a piercing and disagreeable odor, and many men decline to work in places where the timber has been so treated. It increases the fire risk. The timber is greatly increased in weight. As regards the prolongation of life, creosote is a good preservative, but because of the above disadvantages, it can hardly be considered in the treatment of timber for mining purposes.

The knowledge on the subject to date would seem to advocate but two kinds of preservatives, viz.: bichloride of mercury and sodium fluoride. The fluoride is not applied pure, but is mixed with other salts. Wolman's experiments have produced a suitable mixture. Both of these are strong and effective salts, and but small quantities need be injected into the wood. The Wolman mixture is economic as regards price and efficiency. It is applied hot, and when great quantities of timber are to be treated, the vacuum and pressure method should be used. The bichloride of mercury is usually used in the open tank method.

The practical applications of these methods show that it is possible to economically treat mine timber, and where the timber problem is an important one, they certainly should be investigated.

The following formula can be advantageously used

to compare the economic values of treated and untreated timber:

$$A = C - \frac{C}{(1-r)^n - 1},$$

where

C = initial cost of timber, per unit (treated or untreated).

r = rate of interest.

n = life of timber in years.

A = initial cost of timber plus a sum, which at the end of n years will accumulate enough interest so that a new unit of timber can be bought with this interest.

As an example, assume that untreated timber, now in use, cost 10 cents per cu. ft., and that its life is 2 years. How much can we afford to spend for treatment in order to double the life of the timber? Rate of interest 5 per cent.

Solution:

$$A = \$0.10 - \frac{\$0.10}{(1-0.05)^2 - 1} = \$1.125.$$

Hence, if C' is the total cost of treated timber per unit,

$$\$1.125 = C' - \frac{C'}{(1-0.05)^4 - 1},$$

from which $C' = \$0.176$.

Therefore, \$0.176 less \$0.10, the initial cost of timber, equals \$0.076, equals the amount we can afford to spend per cu. ft., for treatment.

Pipe Lines. In arid regions, the problem of pipe protection against alkaline soils becomes a serious one.

In some regions the percentage of chlorides and sulphates in the soil is quite high, and although the pipes are heavily coated with asphaltum paint, they corrode rapidly and pit-holes develop. It is obvious that a protective coating which will double or triple the life of a pipe is an important factor.

In the investigation of this problem, a number of coverings have been developed. Various kinds of asphaltum paints have been used without any very great success. Pipes covered with crude oil after being placed in a ditch immediately filled with earth were found to soon lose the oil covering by reason of its soaking into the sand or soil. The metal was left as badly exposed to the alkali as without a preservative. Quick setting, bituminous enamels, if heavily applied, give fair results. But these cannot be successfully applied to a moist pipe or when the temperature of the pipe is below 60 degrees F. The enamel, although applied heated, soon becomes chilled and is hard to apply.

The most successful method, and one extensively used for large pipe lines, consists in covering the pipe with especially prepared roofing paper. This paper is made by running the deadening felt through a mill and plunging it into a number of baths of hot asphaltum, so that the fibers are thoroughly impregnated with the asphaltum. In some cases, asbestos papers are similarly treated.

The paper is wrapped spirally about the pipe. It can be obtained in any desirable width from 3 to 12 inches, and from 50 to 100 feet in length. The pipe is coated with hot asphaltum and before it has had time

to set, the wider strips are wound spirally over the asphaltum. The crack which is left between each wrap of the wide strip is coated with hot asphaltum and a batten, or 3-in. strip, wound on to cover it. At the joints, 3-in. strips are stuck together with asphaltum and are wound around the pipe at either side of the collar, until a shoulder is built up flush with the outer circumference of the collar. The sleeve and shoulder thus built up are coated with hot asphaltum and the whole covered with a 12-in. strip of paper. The last strip is bound on with wire, as are the ends of the paper which are wrapped spirally.

The advantages of wood pipe for water transportation are somewhat offset by the liability to rapid decay. When a wood pipe is thoroughly saturated with water, and not exposed to the air, its life is lengthened. Pipes covered with clay help to bring about this condition. Clay holds moisture, and thus means continuous and thorough saturation of the wood at the surface of the pipe. Moist clay is not a good culture bed for the growth of fungi that cause decay.

Prevention of Corrosion of Iron and Steel. Steel is being used more and more every day for buildings, structures, and equipment. The decay of iron and steel by corrosion is more rapid than that of wood, if natural agencies are allowed to act on them. On the prevention of this decay, depends the permanency of the work. The size and consequent high cost of such structures make it a duty to preserve them from decay.

The technical preservation of iron and steel presents a great many separate problems, each one of which has

special considerations, and requires different treatment. The protection of the great bulk of finished iron and steel products, must inevitably remain a paint problem, and the discussion will be limited to this phase.

A general statement which regards corrosion is as follows: "Water is necessary before corrosion can take place, since this is the medium which contains or supplies the hydrogen ions which are necessary for the interchange with iron. In order to prevent rusting, you must either exclude water entirely, or have some substance present which will prevent the formation of hydrogen ions. The only way in which this problem can be solved is by the application of a paint which will protect the iron, by being absolutely impervious to water, or one which contains in itself some substance which can produce the passive state."

In the painting of iron or steel, the surface should be most carefully cleaned from all scale, rust, dirt, etc., and the paint should be applied in dry weather. No painting should be done in wet or freezing weather. When, for any reason, it is necessary to repaint, the repainting should be done on clean surfaces absolutely free from all rust, paint skins, dirt, etc. It is not sufficient to apply a new coat over an old paint surface under which traces of corrosion appear. The new paint may cover the old surface and adhere firmly thereto, but the corrosion goes on underneath just the same.

Any single variety of paint cannot fulfill all purposes for which protective paints are used. Inhibitors are substances which restrict or repress corrosion. An inhibitive priming coat should always be placed between

the steel surface and the rust-stimulating pigments. This inhibitive coating consists of compounds of the chromes, zinc oxide, white lead, red lead, willow charcoal, etc. Over this priming coat, the air and moisture excluding coats can be safely applied.

Large amounts of galvanized iron are used for siding and roofing purposes. In order to secure the proper adhesion of paint to this, several different methods of preliminary treatment are used by painters. Vinegar, acid salts, ammonia, sal soda are generally used. The object is to produce a slightly roughened surface to which the paint will adhere. As a matter of fact, this can be done away with by the use of a primary coat of a sharp-toothed, silicious pigment, ground in varnish. This should be well brushed onto the metal, and serves for the purpose of cementing the pigment to the zinc. Any subsequent coats of paint may be applied.

Bituminous coatings undergo certain changes under the action of sunlight and air, hence their successful application has been confined to cases in which sunlight is excluded. They are used for painting pipe lines, smoke stacks, tunnel work, and piping generally. By mixing lime with hot coal tar, a valuable mixture has been produced for pipe dipping. Baked japan coatings are much in use. They are compounds of high grade asphaltic gums, such as gilsonite and elaterite. The material to be coated is generally heated and then dipped into the hot mixture.

Properly refined coal tar makes a good covering, especially for metal surfaces which are subjected to the action of corroding gases. Crude coal tar should never be

used, since it contains elements which make it unsuitable for use as paint. A satisfactory paint is produced by cutting moderately hard pitch with about three-fourths of its volume of light oils. Such paint may be applied cold and will dry in a comparatively short time.

The protection of iron in underground workings is a difficult problem. Seepage drippings may be of an extremely corrosive nature. The moisture is apt to be rich in chloride and other corrosive electrolytes. These salts act to remove paint coverings. As previously stated, a properly refined coal tar, treated with lime, is well adapted for certain conditions.

Water tanks should be painted on both the inner and the outer surfaces. A good mixture for such a purpose consists of 25 lbs. dry red lead, 5 lbs. litharge, 5 lbs. iron oxide, one gallon boiled linseed oil, and one gallon of turpentine. Three coats are usually given.

In recent years the substitution of metal supports for underground workings to replace timber has been much discussed, and in some cases put into effect. The application of economic principles to the use of such metal supports, demands that the length of life be as long as can possibly be obtained. True economy will require the painting of all steel for underground operations with one shop coat of good paint and with at least one field coat. Steel should not be painted with carbon paints in whose manufacture sulphuric acid has been used. The use of improperly refined and untreated coal tar products should, therefore, be avoided. Natural carbons, such as graphite, and the hydrocarbons, such as asphalt and gilsonite, may be recommended for second

coat work if properly ground and mixed with a good vehicle. Red lead, although not absolutely inhibitive, has been demonstrated in all kinds of exposures, to be a first-class pigment. The oil in which it is mixed should be pure, and the raw is better than the boiled. Steel mine supports should be painted at the shop with one coat of red lead and raw linseed oil, mixed in a proportion of 15 lbs. red lead and 2 lbs. of asbestine, to a gallon of pure, raw linseed oil, with sufficient japan drier to work well under the brush. A field coat of first-class graphite paint is then applied.

For a detailed discussion of this subject one should refer to the Transactions of the American Society for Testing Materials.

Fuel Consumption. At most of the metal mines, the fuel item is one of great importance. Because of the temporary character of most of the mining enterprises, the boiler and engine equipment is not, in all cases, of as high a type as in permanent industrial plants. Assuming, however, that all factors have been taken into consideration in the purchase and erection of this equipment, there still remains the great difference in fuel consumption when boilers are fired by unskilled and negligent firemen and when fired by trained, first-class firemen. This side of the problem only will be discussed.

Losses due directly to the improper firing of the boiler are:

1. Heat carried away by the stack gases.
2. Losses caused by incomplete combustion.
3. Loss of fuel through the grate.

4. Unburned fuel carried beyond the combustion chamber in the form of soot and smoke.

Coal may clinker and slag, which stops the admission of the right amount of air through the grate. This results in the formation of CO instead of CO_2, and only one-third of the heat generated by perfect combustion will be obtained. Some firemen use a heavy fire bed, so as to make the interval between firing quite long. This gives them longer periods of rest. Some firemen turn the fire upside down and mix much ash with the white hot coal, every time they use the slice bar. The ash melts, and by the time it has reached the grate, it has cooled and formed slag or clinker which increases the resistance of the fuel bed.

Every fireman should understand that just as much fuel can be wasted by an excess of air which comes through uneven and too thin fires, as through an open furnace door. For a given boiler, quality and size of fuel, and intensity of draft, a certain depth of fuel will give maximum efficiency. Too thin a fire results in an excess of air, and too thick a fire in a deficiency. The economy is lowered in either case. On account of the number of conditions upon which the proper thickness depends, it can only be determined for a particular case by actual test. In general, with natural draft, fine sizes of coal necessitate thin fires, since they pack so closely as to greatly restrict the draft. Thin fires require closer attention to prevent holes being burned in spots, and respond less readily for sudden demands for steam, but have the advantage of letting the air required pass through the grate; whereas thick fires often require air

to be supplied above the grate to insure complete combustion. Thick fires require less attention and hence are preferred by firemen. Where sufficient draft is available, thick fires are more efficient than thin ones, as the air excess is more readily controlled.

In order to secure good fuel economy, the following points should be adhered to:

1. Large lumps should be broken, as they do not ignite properly, and their presence causes holes to form in the fire which allow the passage of too much air.

2. Ash pits should be kept bright at all times. If they become dark, it is evident that the fire needs cleaning, which if not done will cause imperfect combustion and smoke. Ashes should not be allowed to accumulate in the ash pits, as they not only shut off the air supply, but may cause the grate to be burned.

3. In firing the coal should not be landed all in one heap, but it should be spread over as wide a space as possible as it leaves the shovel.

4. The fresh coal should be placed from the bridge wall forward to the dead plate, and not more than three or four shovels added at a charge. Where only a small capacity is required, firing by the coking method is the best. The fresh coal is placed at the front of the fire, and pushed back and leveled when it becomes coked.

5. One side of the boiler should be fired at a time, so that the other side, which contains the bright fire, will ignite the volatile gases from the fresh charge.

6. The fire should not be allowed to burn down dull before charging. If this is done, it will result in a smoky stack and an irregular steam pressure.

7. No holes should be allowed to form in the fire. If one forms, it should be filled by leveling, and not by a shovelful of fresh coal. The fire should be kept even and level at all times.

8. The fire should be carried as thick as the draft will allow. If the draft is poor, a thin fire will be in order; if strong, a thick fire should be carried.

9. The draft should be regulated by the bottom or ash pit doors, and not by the stack dampers. If the stack damper is used, it tends to produce a smoky stack. The closing of the ash pit door decreases the capacity to burn coal.

10. A good general rule is to fire little and often, rather than heavy and seldom. The former means economy in fuel and a clean stack, while the latter signifies extravagance in fuel, and a smoky stack.

General. In the preceding paragraphs, on methods of preventing waste, the most important items of a general nature were discussed. There are still other items of extreme importance about which no general statements as to application or consumption can be made, but each has its own peculiar characteristics and features which must be studied separately for each case. To discuss these in detail is beyond the scope of this article.

Among such items of importance are the explosives. The amount and quality of explosive to be used to obtain the most economic results varies with each instance. There is a best amount and a best quality for each case, but that can be determined only by actual tests. No specific rules will hold for all cases. Where no tests are

made, high-grade explosives may be in use where a lower grade would do just as well; also, a large quantity may be used where a small quantity might render good results. This, without a doubt, is an important subject, and the time consumed to make specific tests would be time well spent.

Another item which will bear investigation is that of illumination. At stations and main haulage ways, this problem has been satisfactorily solved by the use of electric lights. However, in stopes and other workings, where the miner carries his own light, one is confronted with the economic consumption of candles or carbide. Where the issuance of candles is not strictly regulated, there may be considerable waste because of the following:

1. Too many candles burned at once.
2. Unburned, or only partly burned, candles allowed to become covered with débris and thus become lost.
3. The hiding of candles for future use, which, however, may be forgotten and thus lost.
4. Actual theft of candles.

These leaks can be avoided by a study of the requirements for each case, and the issuance regulated accordingly.

Carbide lights are coming more and more into use, particularly since these lamps are now made with a hafted holder, which resembles that of the candlestick. Better light is given, and the light is thrown where it is wanted. Some companies, which have made tests and where the use of carbide lights has been made compulsory, claim that in the long run carbide is more economical than candles.

Still another economic consideration is the re-use of old materials, and the sale of unusable materials, either new or old. As examples which we have observed, we may cite the use of old rails for ties or reinforcements; the cleaning of soiled cotton waste and its re-use for purposes where an absolutely clean waste is not essential. Every mine has its quota of discarded material which might be put to some use or sold to an advantage.

Training and Loyalty of Workmen. Where no records of material consumption are kept, the management cannot determine whether or not a workman is an economical and efficient user of tools and materials. When the workman discovers that no records are kept by the management, he will become careless in the use of materials, since he knows that he can obtain additional amounts without trouble or quizzing. He will know that he will not be rewarded if he takes especial care to prevent waste of material, for the management will not know that he is endeavoring to economize.

The president, board of directors, and the manager are the brains of the industry. If they fulfill their proper functions, they will directly control the policies of the company in every important factor of its activity. The personal ideas of these men permeate throughout the entire works. If the care and consumption of materials are allowed to drift along in a haphazard, and often dangerous, manner, this state of affairs is directly chargeable to the management. They alone are responsible for the operations of the concern and it is entirely within their control to alter these conditions. Where the highest official of the company considers the material

factor an unimportant one, it will likewise be so considered by the manager, superintendent, foremen, shift-bosses, and workmen. This atmosphere of carelessness, often unconsciously created, will invariably lead to a condition of wastefulness and inefficiency throughout all the operations.

Operation deals entirely with the human element. The degree of efficiency betterment will depend almost entirely upon the training, intelligence, and loyalty of the workers. This point is being more and more considered every day. Where we have a group of loyal, first-class men, the material expense will be much lower than where we have a group of untrained, dissatisfied workers. A high state of efficiency will cause an economic use of materials.

There is less waste where the work is carefully planned out in advance by men who are especially trained to handle the function of planning. The materials and tools must be in the standard condition as prescribed by this planning, when they are delivered to the workers of the operating department. The method of applying the material and using the tools should be carefully specified, and, whenever possible, these instructions given in writing. The bosses should be relieved of many of their functions, and their main function should be that of teacher and helper to the workmen. A man cannot efficiently utilize materials unless he is trained in the best methods. The best methods should be determined by the management and these taught to the workers by the bosses. Unless the relationship between bosses and workers is changed to one of teacher and pupil, we

cannot reach the highest state of efficiency. We cannot obtain this relationship, nor can we get a worker to follow carefully a specified set of instructions, unless both he and the bosses in actual charge of the men are paid extra for the special effort. Men who continually work in a haphazard and careless manner soon become fixed with this habit, and unless some special inducements are offered to comply with a new method, they will not break themselves of the habit. Even where the "drive method" is used, the worker will only conform to the new instructions as long as he is under personal supervision and as soon as this is withdrawn, he will lapse into his old habits. In order to fix the habit of using less wasteful methods, and to obtain co-operation, we must give the worker an extra inducement.

To summarize: In order to reduce wastes of material due to the human factor, we must have:

1. All work carefully planned out in advance.
2. Specifications as to the best materials and tools to be used.
3. Carefully drawn instructions of how to use and apply the tools and materials.
4. Materials and tools must be delivered to the worker in the standard condition specified.
5. Competent instructors to teach and aid the worker to follow these instructions.
6. Individual records of each worker as to results.
7. Extra pay when work is carried out as per instructions.