PLANT REQUIREMENTS
FOR MANUFACTURE OF
CHALK WHITING

TECHNICAL AIDS BRANCH
INTERNATIONAL COOPERATION
ADMINISTRATION
Washington, D.C.
FOREWORD

This brochure is one of a series of reports resulting from overseas technical inquiries on factory or commercial establishments, operation, management, and engineering. The report is designed to provide only a general picture of the factors that must be considered in establishing and operating a factory of this type. In most cases, plans for actual installations will require expert engineering and financial advice in order to meet specific local conditions.

Mention of the name of any firm, product, or process in this report is not to be considered a recommendation or an endorsement by the International Cooperation Administration, but merely a citation that is typical in its field.

The original report was prepared by Thompson and Williams, Pennsylvania Building, Washington 4, D. C.

Technical information, as well as review, was provided by R. Poliakoff, Industrial Consultant, 126 Eleventh Avenue, New York 11, New York.

* * * * * * * * * * * *

This report has been revised and rewritten by George H. Andrews Engineering Associates, Inc. 411 Southern Building, Washington 5, D. C.

* * * * * * *

For further information and assistance, contact should be made with the local Productivity Center, Industrial Institute, Servicio, or United States Operations Mission.

Code Number
PR-73

September 1961
# TABLE OF CONTENTS

<table>
<thead>
<tr>
<th>Topic</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Introduction</td>
<td>1</td>
</tr>
<tr>
<td>General Assumptions</td>
<td>1</td>
</tr>
<tr>
<td>Product Specifications</td>
<td>2</td>
</tr>
<tr>
<td>Production Capacity</td>
<td>2</td>
</tr>
<tr>
<td>Manufacturing Unit</td>
<td>2</td>
</tr>
<tr>
<td>General Information</td>
<td>3</td>
</tr>
<tr>
<td>Whiting Substitutes and Processes</td>
<td>4</td>
</tr>
<tr>
<td>Manufacturing Operations</td>
<td>8</td>
</tr>
<tr>
<td>Direct Materials</td>
<td>11</td>
</tr>
<tr>
<td>Supplies</td>
<td>11</td>
</tr>
<tr>
<td>Plant Layout</td>
<td>11</td>
</tr>
<tr>
<td>Plant Site</td>
<td>12</td>
</tr>
<tr>
<td>Building</td>
<td>12</td>
</tr>
<tr>
<td>Power</td>
<td>12</td>
</tr>
<tr>
<td>Water</td>
<td>12</td>
</tr>
<tr>
<td>Fuel</td>
<td>12</td>
</tr>
<tr>
<td>Production Tools and Equipment</td>
<td>13</td>
</tr>
<tr>
<td>Other Tools and Equipment</td>
<td>13</td>
</tr>
<tr>
<td>Furniture and Fixtures</td>
<td>13</td>
</tr>
<tr>
<td>Direct Labor</td>
<td>14</td>
</tr>
<tr>
<td>Indirect Labor</td>
<td>14</td>
</tr>
<tr>
<td>Depreciation</td>
<td>15</td>
</tr>
<tr>
<td>Manufacturing Overhead</td>
<td>15</td>
</tr>
<tr>
<td>Manufacturing Costs</td>
<td>16</td>
</tr>
<tr>
<td>Fixed Assets</td>
<td>16</td>
</tr>
</tbody>
</table>
Working Capital 17
Capital Requirements 17
Sales Revenue 18
Recapitulation of Costs, Sales and Profits 18
Budget Control 19
Budget Control Accounts 19
Purchase Requisition 20
Voucher Check 21
Engineers 22
Training 23
Safety 24
Other Considerations 25
Materials and Supplies 25
Market Factors 25
Export Markets 26
Marketing Problems 26
Economic Factors 27
Personnel 27
Laws and Regulations 27
Financial Factors 28
Financial Requirements of the Project 28
Short Term Bank Credits 28
Financial Plan 28
Bibliography 29
American Equipment Manufacturers 30
Consultants 31
Plant Layout 32
INTRODUCTION

The purpose of this report is to present basic information for establishing a plant in a foreign country to produce chalk whiting.

GENERAL ASSUMPTIONS

In order to make realistic estimates in this report, certain assumptions are made. These are:

1. The costs of the building and general facilities are based on United States prices.

2. Material costs are based on sizes and specifications of materials used in the United States.

3. Labor costs are based on the average for the industry as recently published by the United States Bureau of Labor Statistics.

4. Adequate power and water are available at the plant site.

5. Adequate transportation facilities are available at the plant site.

6. The plant operates eight hours a day, five days a week, fifty weeks a year.
7. No special provision is made for the training of new personnel. It is assumed that learner's rates are paid in such cases.

8. The following items cannot be estimated realistically:
   A. Land value.
   B. Distribution and selling costs.
   C. In-freight and out-freight.
   D. Administrative costs.
   E. Taxes.

   While general estimates will be made of each of these items, for the purpose of completing cost estimates, adjustment should be made in accordance with actual local costs.

   In fact, all cost estimates contained in this report should be adjusted to conform to local conditions.

9. Columns are provided in the tables included in this report to facilitate the conversion of cost figures to conform with local costs.

   PRODUCT SPECIFICATIONS

   All information and figures contained in this report are based on the production of chalk whiting by pulverizing, purifying, and carefully sizing the particles of high grade chalk.

   PRODUCTION CAPACITY

   The capacity of this plant is three tons of chalk whiting per hour, twenty-four tons per day, or 6,000 tons per year.

   MANUFACTURING UNIT

   The manufacturing unit for this plant is one ton of chalk whiting.
Chalk is a soft, fine-grained, white, friable limestone formed on the ocean floor during the Cretaceous Age from calcareous remains of microscopic marine organisms. Chalk whiting, sometimes called true whiting, is a powder, made by pulverizing chalk, purifying it, and carefully sizing the particles. Whiting substitutes are not made from chalk but from pulverized limestone or dolomite, marble, or white marl. Substitutes may also be made by chemical precipitation of calcium carbonate. The terms "precipitated," "artificial," and "by-product" whiting are often applied to CaCO₃ originating in chemical manufacture.

Although the distinguishing physical characteristics of true chalk have never been fully defined, its noncrystalline and colloidal properties are probably most important. Chalk consists largely of minute grains of calcium carbonate. Calcium carbonate (CaCO₃) may be produced chemically by combining carbonate ions with calcium ions.

Natural chalk deposits are found throughout Western Europe. In the United States, some grade of limestone is found in every state, but true chalk is found in only three large areas in the central and southern states. A large deposit of relatively pure limestone containing about 97 percent CaCO₃ has recently been found near Edna Bay, Alaska. Although limestones are found throughout the world, only highly industrialized countries have explored their limestone resources for other than building purposes. In general, most localities can supply their own raw materials for the manufacture of whiting or whiting substitutes, usually from limestone deposits, but occasionally from oyster shells.

Commercial Uses

Chalk whiting has many commercial uses depending upon color, texture, plasticity, and purity. True whiting is preferred for a filler extender in calcimine and as pigment in cold-water paints and putty. Both true whiting and whiting substitutes are used as ceramic raw materials, as fillers in paint and rubber, and as a coating material for paper. Whiting is used as a rubber reinforcing pigment and as a basic ingredient in metal polishes, tooth paste, white shoe dressing, and white ink. It is also used in the manufacture of pastes, paper, oilcloth, linoleum, window shades, caulking compounds, fireworks, explosives, mouldings, mineral foods, dolls, cigarette papers, wire insulation, crayons, phonograph records, plastics, baking powder, leather goods, glass, roofing materials, and dyes.

* See Bibliography, No. 12
** See Bibliography, No. 3
This report is primarily concerned with the absolute minimum operation for manufacture of true chalk whiting and, therefore, discusses the simplest manufacturing processes utilizing the crushing, grinding, and screening of high purity chalk. However, sources of raw material for the manufacture of true whiting are limited. This, and many other factors have led to the development of whiting substitutes with their alternate methods of manufacture and production. The CaCO₃ chemical industry that has grown up in the United States in recent years is an outstanding example of such a development.

Before presenting the detailed description of the manufacture of true chalk whiting, sufficient information on whiting substitutes is included to present a basic concept of methods for their production and to offer sources of information for further study of operations that may be adaptable to any locale and its available raw materials.

### Whiting Substitutes

There are two classes of whiting substitutes: chemically precipitated whiting (CaCO₃) and natural rock whiting.

**Precipitated whiting** is described as chemically precipitated calcium carbonate of good white color, prepared by the reaction of milk of lime with carbon dioxide or by some similar chemical reaction.

Other whiting substitutes are identified as limestone whiting, prepared from limestone; marble whiting, prepared from marble (marble flour); and dolomite whiting, prepared from dolomite (calcium magnesium carbonate). A discussion of the manufacturing processes involved in the preparation of these whiting substitutes is included in the section entitled Natural Rock Whiting.

Precipitated whiting may be produced chemically by any of the following four principal methods:

1. **Metathesis (chemical interchange)** of calcium chloride and soda ash (100 percent pure)

   \[ \text{CaCl}_2 + \text{Na}_2\text{CO}_3 \rightarrow \text{CaCO}_3 + 2\text{NaCl} \]

2. **Treatment of lime slurry with soda ash**

   \[ \text{CaO} + \text{H}_2\text{O} + \text{Na}_2\text{CO}_3 \rightarrow \text{CaCO}_3 + 2\text{NaOH} \]
3. Carbonation of milk of lime

\[ \text{Ca(OH)}_2 + \text{CO}_2 \rightarrow \text{CaCO}_3 + \text{H}_2\text{O} \]

4. Solvay-type method

\[ \text{CaCl}_2 + 2\text{NH}_4\text{OH} + \text{CO}_2 \rightarrow \text{CaCO}_3 + 2\text{NH}_4\text{Cl} + \text{H}_2\text{O} \]

The present trend is toward use of the first method.

Steps in the chemical processing are as follows:

1. Accurately measured batches of soda ash and calcium chloride are dropped from their respective weigh tanks into the reaction tank. (106 pounds of soda ash and 111 pounds of calcium chloride are mixed to produce 100 pounds of calcium carbonate.)

2. The mixture is agitated by a paddle stirrer in the closed reaction tank until precipitation of the calcium carbonate is completed, after which the contents are dropped into a large surge tank.

3. The batches weighed and dropped automatically one by one into the surge tank are again agitated and final blending yields the proper particle size distribution. A battery of regulators operates from controls at the weigh tanks to produce a given quantity of a precipitate of a given particle size and to set flow controls for the rest of the process which is continuous from the surge tank on.

4. From the surge tank, the slurry is pumped continuously over a weir to a settler from which excess fluid overflows to a sewer. Meanwhile, new batches are being made in the reaction tank and dropped to the surge tank to combine with the remaining material in the reaction tank.

5. From the settler, slurry is pumped to a rotary vacuum filter. Here it is washed free of sodium and calcium chlorides. The remaining product is left in the form of cake containing about 50 percent water, which, throughout the remainder of the process, moves by gravity.

6. The filter cake drops between a fin drum and a roll which ejects it as pellets.

* See Bibliography, No. 10
7. The pellets drop into a tunnel dryer where controlled
temperature to prevent agglomeration is of prime im-
portance.

8. The dried pellets are put through a ball mill for grinding
to the required size.

9. Finally the finished CaCO₃ is transported by a conveyor
to storage bins or is packaged in 50 or 75 pound paper
bags.

Natural rock whiting is produced by two processes: the wet method and
the dry method.* A typical wet process for manufacturing marble whit-
ing begins by the grinding of marble chips in a pebble mill. Enough
water is introduced into the mill along with the chips so that the mill
discharge may be pumped to settling cones. The settled product is then
returned in closed circuit to the pebble mill and the overflow is con-
ducted to settling tanks. From the settling tanks, the sediment con-
taining about 50 percent moisture is conveyed to a drum type dryer.
This drum, four by ten feet in size, rotates at 2½ revolutions per
minute about a hollow shaft. Steam is forced through the shaft and to
the inside of the drum at 75 pounds per square inch. The drum rotates in a
trough which holds the slurry mixture. A shaft with 3/8-inch iron pegs
rotates in the trough and just beneath the drum to splash the slurry
against the heated drum for partial drying. A series of spring-loaded
scrapers, each about one foot in length, removes the dried material
from the drum and drops it into the screw conveyor. Lumps are then
broken by an impact pulverizer. In such a plant, 1/3 to 1/2 tons per
dryer per hour may be processed.

For dry-processing of natural rock whiting, the crushed stone is first
passed through a rotary dryer. It is then ground by rolls or crushed
by impact mills of the swinging-hammer type. After the first, or coarse
grinding, the material is passed through impact pulverizers or pebble
mills for final grinding. Since the uses of whiting are determined by
its size or grading, among other qualities, various steps are required
depending upon the specific use for which the whiting is being manu-
factured. For some grades, sizing is accomplished with air separators
supplemented by vibrating screens. Air-floated material is satisfactory
for many uses.

Chalk Whiting

Whiting is produced from chalk by both the wet and dry processes. Of
the two, the wet process is the older method. Some of the advantages
of the wet process arc lower power costs, better quality control

* See Bibliography, No. 2
through use of wet screening, lack of dust, simpler handling methods using pipes and pumps. On the other hand, the dry process has been found advantageous where labor is expensive and capital investment is high. The principal advantages of dry grinding are the higher percent of fines producible and the longer life for mill liners and grinding media.*

Wet processing employs hand separation to remove flint, water grinding in edge-runners or stone-drag mills, washing, de-sanding, settling, de-watering, filtering, drying, pulverizing, sieving, and packaging. More modern wet process equipment includes roll and pebble mills for grinding; bowl and cone classifiers and hydroseparators for classification; and thickeners, continuous filters, and rotary or car dryers for de-watering.

Dry processing includes crushing; drying if necessary; coarse grinding in rolls or swing-hammer mills; and fine grinding in impact pulverizers, roller mills, ball mills, or air-swept tube mills. Tube mills are sometimes operated in closed circuit with pneumatic separators to make different grades of whiting. Micronizers have also been used to produce fine grades of whiting.

Wet processing in a typical mill of the older type begins with the chalk being dumped into a stone-washing tank 15 feet in diameter.** A stream of water, the overflow from the settling pits, continually flows into the tank. A rotating vertical shaft in the center of this tank, from which four rail sections are swung by chains, agitates the slurry and breaks up the lumps. At one side of this tank, an opening covered with 1/8-inch screen allows the slurry to flow to another tank or launderer. The launderer has eight gates through which the slurry flows to eight open trommels, each fitted with 180-mesh screens. These receptacles are tilted to allow streams of water from a perforated pipe to wash the slurry through the screen and to a collecting pit. The coarse chalk and sand remaining may then be directed to a sump and dried as a by-product for use in asphalt surfacing. From the collecting pit, the slurry is again washed alternately to four sets of settling pits. Each set consists of eight pits. The pits are 10' x 6' x 8' deep and are connected in series. As the slurry passes through each pit, the coarser whiting settles out and the overflow is conducted to the next and finally returned to the stone-washing tank for recirculation. Whiting in the last four pits is of finer grade than in the first four, and if handled separately commands a higher price. When the pits in one set are filled, the slurry is directed to another set of pits. The settled whiting is then removed to a drying floor while the next set of settling pits is being filled.

* See Bibliography, No. 4
** See Bibliography, No. 9
A roof covers the drying floor, but this structure has no sidewalls. The floor itself is 20' x 30' in area and is constructed of light gauge metal plate or ceramic slabs. Furnace-heated flues conduct the necessary heat under the floor to dry the whiting. Whiting spread 10 inches deep usually requires 36 hours drying time. From the floors, the whiting is cut into 4" x 8" cakes and is shoveled into screw conveyors which serve the dual purpose of breaking up the cake and discharging the whiting into a swing-hammer mill. From this pulverizer, the whiting is moved through a bolting machine. "Overs" are returned to the mill and the "throughs" may either go through another bolting process or be bagged. If double bolted, the product demands a higher price.

A more modern type of wet processing employs fewer persons, uses more expensive machinery, and requires greater capital investment. For example, a plant of this type capable of processing five tons of raw material per hour can be operated by nine men; a plant of the older type with this capacity requires thirty-eight men.* (One ton of chalk produces about .72 tons of whiting, assuming 20 percent moisture and eight percent sand.) Four men unloading from barges and transporting to storage with power grab buckets and a conveyor system can replace 10 men employing hand methods. An automatic cracking machine takes the place of three men with pick axes in the coarse crushing operation. Three men operating conveyor systems can move the raw materials that would require seven men with shovels and cable cars. No change is made in grinding methods, but three men required to handle the desanding and settling operation by shoveling can be replaced by automatically operated classifiers, hydroseparators, and thickeners. One person operating a modern filter can replace eight persons using plate filters, and one automatic dryer operator does the work of five men formerly required to haul filter cakes to and from steam racks. In this type plant, work normally done by two laborers could be done by a conveyor system which removes the finished product to storage bins. Of course, this is one crew only. If wet process plants are to be successful, continuous operation is vital and at least three shifts are necessary.

MANUFACTURING OPERATIONS

Dry processing is the preferred method in most modern plants. Where natural resources provide a good grade of chalk which can be quarried locally or arrangements can be made to import the required raw material, this type of processing plant can be operated with fewer people and less capital investment than can any of the plants mentioned in connection with other processing methods. A typical plant with a capacity of three

* See Bibliography, No. 7
tons per hour can be operated by five men and a foreman. One man operates the ring-roll mill.

Chalk is received at the plant ready for processing. It is fed to a hammer mill for preliminary reduction. Oversize pieces are broken by hand with a sledge hammer. "Throughs" from the hammer mill have a maximum size of 1/2 inch.

The hammer mills break the chalk entirely by impact. The hammers are connected to a high speed shaft and they either break the lumps as they are hit or throw the larger pieces against a breaker plate or anvil. Particles are then rubbed against a screen or grate.

From the hammer mill, chalk is taken to a dryer. In the dryer, a rotating cylinder with internal baffles thoroughly agitates the chalk as it passes through while an exhaust fan draws hot gases through the chalk for drying. An oil burner provides the heat which exhausts at about 240 degrees Fahrenheit at the outlet end of the cylinder. Exhaust is passed through a cyclone collector and if dust presents a problem this may be eliminated by directing the final exhaust through a wet box about 4' x 6' x 10' equipped with a fine water spray.

Chalk from the quarry usually contains about 12 percent moisture, but if left exposed to rain, it may contain as much as 25 percent. For dry grinding, this moisture content must be reduced to .5 to 1.0 percent.

Raw materials are stored in a bunker of approximately 50-ton capacity. The bunker should be so constructed that it may be filled from the top, either from barges or rail cars, with a power shovel; or a ramp should be constructed to allow dump trucks to back in for unloading. An elevator or a conveyor can be substituted. The bottom of the bunker is built to form a "V" which allows the chalk to be removed with a belt conveyor. A simple conveyor running close to the bottom of the bunker can become an automatically controlled feed belt by placing a vertical weir at the bottom of the "V" inside the bunker. This weir may be adjusted with a rack-and-pinion gear to allow various pre-determined amounts of chalk to be fed to the mill. The amount of feed determines the output of the mill, and therefore, the grade of whiting produced. No adjustment of the feed belt is necessary until a change in the grade of whiting is desired.

The milling is accomplished with a ring-roll mill, of the three-roll type with two cone separators. The mill depends upon rolling compression for pulverization, its three rotation rings turning under pressure over the surface of an anvil ring, or bull ring. The free turning rings avoid overgrinding, save power, reduce wear, and avoid producing too many fines. The chalk is dropped into the hopper from the feeder belt and is conducted...
into the machine with a screw feeder. The lumps of chalk are broken up when they fall on the rotating size reduction element and are blown upward by high speed air from the bottom of the shaft. When the pulverized chalk rises to the classifier, it is rotated at high speed and centrifugal force throws coarse particles against the walls of the chamber. Those particles continually return to size reduction and the fine particles pass between the radial blades of the classifier. They are then carried by air through the fan and discharge port to a cyclone collector. Here, the whiting is separated from the air stream. Air may be returned to the pulverizer or exhausted through a bag collector. Machines of this type will produce whiting as fine as 99 percent through 200 mesh. The ground whiting from the cyclone is transferred to a single sack automatic weighing and bagging machine. It is commonly packed in 50-pound bags.

Bagged whiting is then removed by hand, conveyor, or trucks to shipping or storage. For a plant of the size described, space for approximately 200 tons of bagged whiting should be provided.

All cost figures contained in this report are based on the dry processing of a good grade of chalk as shown under the above heading, Manufacturing Operations.

The raw material chalk is purchased from a quarry delivered at the plant.
### DIRECT MATERIALS

<table>
<thead>
<tr>
<th>Item</th>
<th>Annual Requirements</th>
<th>Unit Cost</th>
<th>Annual Cost</th>
<th>Estimated</th>
<th>Actual</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chalk</td>
<td>8,350 tons</td>
<td>$4.00 per ton</td>
<td>$33,400</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bags</td>
<td>240,000 bags</td>
<td>$3.00 per 1000</td>
<td>8,400</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Thread</td>
<td>1,330 pounds</td>
<td>$.90</td>
<td>1,200</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td></td>
<td><strong>$43,000</strong></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### SUPPLIES

<table>
<thead>
<tr>
<th>Item</th>
<th>Annual Cost</th>
<th>Estimated</th>
<th>Actual</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lubricants and hand tools</td>
<td>$300</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Maintenance and repair parts</td>
<td>1,000</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Office supplies</td>
<td>200</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>$1,500</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### PLANT LAYOUT

A plant layout and work flow sheet, showing the location of equipment and the sequence of operations is shown on the last page of this report.
PLANT SITE

About 20,000 square feet will be required. The plant site should be located as advantageously as possible with respect to transportation, power, water, fuel, sources of labor and markets. The plant should be located near a source of high grade chalk.

The estimated cost of the plant site is $500.

BUILDING

A one-story building having about 2,400 square feet of floor space is required for the manufacture of chalk whiting. Any suitable local material may be used.

The cost of this building is estimated at $9,600.

POWER

The connected load requirements for this plant amount to about sixty horsepower.

The estimated annual cost of power amounts to about $1,200.

WATER

The annual cost of water for production, sanitary purposes, and fire protection is estimated at $300.

FUEL

About 21,500 gallons of oil are needed annually for production, heating, and sanitary purposes.

The estimated cost of oil will amount to about $2,000 per year.
## PRODUCTION TOOLS AND EQUIPMENT

<table>
<thead>
<tr>
<th>Description</th>
<th>Number Required</th>
<th>Unit Cost</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hammer mill</td>
<td>1</td>
<td>$ 5,000</td>
<td>$ 5,000</td>
</tr>
<tr>
<td>Conveyors</td>
<td>2</td>
<td>2,000</td>
<td>4,000</td>
</tr>
<tr>
<td>Dryer</td>
<td>1</td>
<td>10,000</td>
<td>10,000</td>
</tr>
<tr>
<td>Ring-roll mill</td>
<td>1</td>
<td>30,000</td>
<td>30,000</td>
</tr>
<tr>
<td>Weighing and packaging equipment</td>
<td></td>
<td></td>
<td>1,000</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td></td>
<td>$ 50,000</td>
</tr>
</tbody>
</table>

## OTHER TOOLS AND EQUIPMENT

<table>
<thead>
<tr>
<th>Description</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hand trucks - 4 (½-ton each)</td>
<td>$ 400</td>
</tr>
<tr>
<td>Maintenance and spare parts</td>
<td>600</td>
</tr>
<tr>
<td>Total</td>
<td>$ 1,000</td>
</tr>
</tbody>
</table>

## FURNITURE AND FIXTURES

<table>
<thead>
<tr>
<th>Item</th>
<th>Number Required</th>
<th>Unit Cost</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Desk and chairs</td>
<td>3</td>
<td>$150</td>
<td>$ 450</td>
</tr>
<tr>
<td>File cabinets</td>
<td>3</td>
<td>75</td>
<td>225</td>
</tr>
<tr>
<td>Typewriter</td>
<td>1</td>
<td>175</td>
<td>175</td>
</tr>
<tr>
<td>Adding machine</td>
<td>1</td>
<td>150</td>
<td>150</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td></td>
<td>$ 1,000</td>
</tr>
</tbody>
</table>
### DIRECT LABOR

<table>
<thead>
<tr>
<th>Occupation</th>
<th>Number Required</th>
<th>Hourly Rate</th>
<th>Annual Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Crusher</td>
<td>1</td>
<td>$2.00</td>
<td>$4,000</td>
</tr>
<tr>
<td>Ring-roll mill operator</td>
<td>1</td>
<td>2.00</td>
<td>4,000</td>
</tr>
<tr>
<td>Baggers</td>
<td>2</td>
<td>1.50</td>
<td>6,000</td>
</tr>
<tr>
<td>Laborer</td>
<td>1</td>
<td>1.50</td>
<td>3,000</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>5</strong></td>
<td></td>
<td><strong>$17,000</strong></td>
</tr>
</tbody>
</table>

### INDIRECT LABOR

<table>
<thead>
<tr>
<th>Occupation</th>
<th>Number Required</th>
<th>Annual Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Manager</td>
<td>1</td>
<td>$10,000</td>
</tr>
<tr>
<td>Foreman and maintenance</td>
<td>1</td>
<td>7,000</td>
</tr>
<tr>
<td>Office</td>
<td>2</td>
<td>8,000</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>4</strong></td>
<td><strong>$25,000</strong></td>
</tr>
</tbody>
</table>
### DEPRECIATION

<table>
<thead>
<tr>
<th>Item</th>
<th>Estimated Cost</th>
<th>Years Life</th>
<th>Annual Cost Estimated</th>
<th>Actual</th>
</tr>
</thead>
<tbody>
<tr>
<td>Building</td>
<td>$ 9,600</td>
<td>20</td>
<td>$ 480</td>
<td></td>
</tr>
<tr>
<td>Production tools and equipment</td>
<td>50,000</td>
<td>10</td>
<td>5,000</td>
<td></td>
</tr>
<tr>
<td>Other tools and equipment</td>
<td>1,000</td>
<td>10</td>
<td>100</td>
<td></td>
</tr>
<tr>
<td>Furniture and fixtures</td>
<td>1,000</td>
<td>10</td>
<td></td>
<td>100</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>$ 5,680</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### MANUFACTURING OVERHEAD

<table>
<thead>
<tr>
<th>Item</th>
<th>Annual Cost Estimated</th>
<th>Actual</th>
</tr>
</thead>
<tbody>
<tr>
<td>Depreciation</td>
<td>$ 5,680</td>
<td></td>
</tr>
<tr>
<td>Indirect labor</td>
<td>25,000</td>
<td></td>
</tr>
<tr>
<td>Power</td>
<td>1,200</td>
<td></td>
</tr>
<tr>
<td>Water</td>
<td>300</td>
<td></td>
</tr>
<tr>
<td>Fuel</td>
<td>2,000</td>
<td></td>
</tr>
<tr>
<td>Supplies</td>
<td>1,500</td>
<td></td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>$ 35,680</strong></td>
<td></td>
</tr>
</tbody>
</table>
## MANUFACTURING COSTS

<table>
<thead>
<tr>
<th>Item</th>
<th>Annual Cost</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Estimated</td>
<td>Actual</td>
</tr>
<tr>
<td>Direct materials</td>
<td>$43,000</td>
<td></td>
</tr>
<tr>
<td>Direct labor</td>
<td>17,000</td>
<td></td>
</tr>
<tr>
<td>Manufacturing overhead</td>
<td>35,680</td>
<td></td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>$95,680</strong></td>
<td></td>
</tr>
</tbody>
</table>

## FIXED ASSETS

<table>
<thead>
<tr>
<th>Item</th>
<th>Cost</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Estimated</td>
<td>Actual</td>
</tr>
<tr>
<td>Land</td>
<td>$500</td>
<td></td>
</tr>
<tr>
<td>Building</td>
<td>9,600</td>
<td></td>
</tr>
<tr>
<td>Production tools and equipment</td>
<td>50,000</td>
<td></td>
</tr>
<tr>
<td>Other tools and equipment</td>
<td>1,000</td>
<td></td>
</tr>
<tr>
<td>Furniture and fixtures</td>
<td>1,000</td>
<td></td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>$62,100</strong></td>
<td></td>
</tr>
</tbody>
</table>
### WORKING CAPITAL

<table>
<thead>
<tr>
<th>Item</th>
<th>30 days</th>
<th>Cost</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Direct materials</td>
<td></td>
<td>$3,600</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Direct labor</td>
<td></td>
<td>$1,400</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Manufacturing overhead</td>
<td></td>
<td>$3,000</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reserve for sales collections</td>
<td></td>
<td>$17,000</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td><strong>$25,000</strong></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### CAPITAL REQUIREMENTS

<table>
<thead>
<tr>
<th>Item</th>
<th></th>
<th>Cost</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Fixed assets</td>
<td></td>
<td>$62,100</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Working capital</td>
<td></td>
<td>$25,000</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td><strong>$87,100</strong></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
SALES REVENUE

The capacity of this plant is 24 tons of chalk whiting per day, or 6,000 tons per year. The average price for chalk whiting of the type produced in this plant is $34.00 per ton.

Based on these figures the annual sales revenue would be $204,000.

RECAPITULATION OF COSTS, SALES AND PROFITS

<table>
<thead>
<tr>
<th>Item</th>
<th>Estimated Cost</th>
<th>Actual Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Direct materials</td>
<td>$ 43,000</td>
<td></td>
</tr>
<tr>
<td>Direct labor</td>
<td>17,000</td>
<td></td>
</tr>
<tr>
<td>Manufacturing overhead</td>
<td>35,680</td>
<td></td>
</tr>
<tr>
<td><strong>Total manufacturing cost</strong></td>
<td><strong>$ 95,680</strong></td>
<td></td>
</tr>
<tr>
<td>Interest on loans</td>
<td>$ 2,600</td>
<td></td>
</tr>
<tr>
<td>Insurance</td>
<td>300</td>
<td></td>
</tr>
<tr>
<td>Legal</td>
<td>1,000</td>
<td></td>
</tr>
<tr>
<td>Auditing</td>
<td>2,000</td>
<td></td>
</tr>
<tr>
<td>Unforeseen expense</td>
<td>28,420</td>
<td></td>
</tr>
<tr>
<td><strong>Total administrative costs</strong></td>
<td><strong>$ 34,320</strong></td>
<td></td>
</tr>
<tr>
<td>Sales commissions</td>
<td>15,000</td>
<td></td>
</tr>
<tr>
<td>Travel, bad debts, discounts and</td>
<td>9,000</td>
<td></td>
</tr>
<tr>
<td>allowances, freight-out</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Profit before taxes</strong></td>
<td><strong>50,000</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Total annual gross sales</strong></td>
<td><strong>$204,000</strong></td>
<td></td>
</tr>
</tbody>
</table>
A requisition form designed to provide accurate records of procurement and indicate the purpose of procurement with the least amount of time and effort is shown on the following page.

This form has an account number for each type of the various expenditures which the manager will review in detail, monthly or oftener, in order to control his expenses. Some items, such as power and water, are usually under contract and are easily checked by reference to monthly bills. For simplification, items (marked with an asterisk below) are omitted from the purchase requisition. Variations in the labor costs are easily reviewed by examination of the payroll vouchers. The simplified type of control thus provided makes certain that the manager can control expenditures promptly.

Following the requisition form, a sample voucher check is shown. Voucher checks should be used for the payment of all expenditures and the appropriate book account number placed on each voucher.

At the end of each month the manager will receive a statement of all expenditures broken down by budget accounts. If the expenditures exceed the budgeted monthly allowances of any of the accounts, the bookkeeper will furnish the manager with a break-down of all expenditures relative to the budgeted accounts exceeded. All these supporting data can be secured by reference to the purchase requisitions and the check vouchers. This reference will enable the manager to determine what caused the over-expenditure and take corrective action.

If at any time during each month it becomes apparent that expenditures will exceed any of the budget accounts, the bookkeeper will bring this to the attention of the manager for his information and action.

### BUDGET CONTROL ACCOUNTS:

<table>
<thead>
<tr>
<th>Account Number</th>
<th>Monthly Expense</th>
<th>Monthly Budget</th>
<th>Annual Budget</th>
<th>Actual</th>
</tr>
</thead>
<tbody>
<tr>
<td>10 Administrative</td>
<td>$______</td>
<td>$ 491</td>
<td>$ 5,900</td>
<td>$______</td>
</tr>
<tr>
<td>20 Sales</td>
<td>$_____</td>
<td>2,000</td>
<td>24,000</td>
<td>$______</td>
</tr>
<tr>
<td>30 Direct Materials</td>
<td>$_____</td>
<td>3,583</td>
<td>43,000</td>
<td>$______</td>
</tr>
<tr>
<td>40 Supplies</td>
<td>$_____</td>
<td>125</td>
<td>1,500</td>
<td>$______</td>
</tr>
<tr>
<td>51 Power*</td>
<td>$_____</td>
<td>100</td>
<td>1,200</td>
<td>$______</td>
</tr>
<tr>
<td>52 Water*</td>
<td>$_____</td>
<td>25</td>
<td>300</td>
<td>$______</td>
</tr>
<tr>
<td>53 Fuel</td>
<td>$_____</td>
<td>166</td>
<td>2,000</td>
<td>$______</td>
</tr>
<tr>
<td>60 Unforeseen Expense</td>
<td>$_____</td>
<td>2,368</td>
<td>28,420</td>
<td>$______</td>
</tr>
<tr>
<td>(Reserve Account)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>71 Direct Labor*</td>
<td>$_____</td>
<td>1,416</td>
<td>17,000</td>
<td>$______</td>
</tr>
<tr>
<td>72 Indirect Labor*</td>
<td>$_____</td>
<td>2,083</td>
<td>25,000</td>
<td>$______</td>
</tr>
<tr>
<td>80 Depreciation</td>
<td>$_____</td>
<td>473</td>
<td>5,680</td>
<td>$______</td>
</tr>
<tr>
<td>(Reserve Account)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PURCHASE REQUISITION</td>
<td>COMPANY NAME</td>
<td>DATE</td>
<td></td>
<td></td>
</tr>
<tr>
<td>----------------------</td>
<td>--------------</td>
<td>------</td>
<td></td>
<td></td>
</tr>
<tr>
<td>□ 10 ADMINISTRATION</td>
<td>□ 40 SUPPLIES</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>□ 20 SALES</td>
<td>□ 50 UTILITIES</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>□ 30 MATERIALS</td>
<td>□ 60 UNFORESEEN EXPENSE</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

INDICATE BELOW THE USE OF MATERIALS

□ DIRECT MATERIALS  □ MAINTENANCE SERVICES
□ MAINTENANCE MATERIALS □ OPERATING SUPPLIES

<table>
<thead>
<tr>
<th>QUANTITY</th>
<th>DESCRIPTION</th>
<th>UNIT</th>
<th>TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>QUOTES FROM</th>
<th>REQUISITIONED BY</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>QUOTES FROM</th>
<th>APPROVED BY</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>QUOTES FROM</th>
<th>ORDER NO.</th>
<th>ORDER DATE</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
R. W. MITCHELL MANUFACTURING COMPANY
1422 BOSWORTH STREET, S. E.

ANYWHERE, U. S. A. 19 No. 10000

Pay

TO THE ORDER OF

DOLLARS $

TO FIRST NATIONAL BANK
ANYWHERE, U. S. A.

R. W. MITCHELL MANUFACTURING COMPANY

Account Number

Sample voucher check to be used for the payment of all expenditures in connection with Budget Control.
ENGINEERS:

The services of professional engineers are desirable in the design of this plant, even though the proposed plant is small.

A correct design is one which provides the greatest economy in the investment of funds and establishes the basis of operation that will be most profitable in the beginning and will also be capable of expansion without expensive alteration.

The addresses of professional engineers who specialize in industrial design, some of whom may be willing to undertake such work on low cost projects overseas, can be secured by reference to the published cards in various engineering magazines. They may also be reached through their national organizations, one of which is the

National Society of Professional Engineers
2029 K Street, Northwest,
Washington 6, D. C.

Manufacturers of industrial equipment employ engineers familiar with the design and installation of their specialized products. These manufacturers are usually willing to give prospective customers the benefit of technical advice by those engineers in determining the suitability of their equipment in any proposed project.

The equipment manufacturers also know, and can recommend, professional engineers in private practice, who are willing and able to provide appropriate consulting services.
TRAINING:

Manufacturing an inferior quality of product during the training period could create sales resistance that might be difficult to cope with later. To avoid such possibilities, the quality of the product should be maintained at all times, including the training period.

In some areas skilled operators may be available locally. In other areas all the operators may have to be trained.

If skilled operators are not available, adequate training would be assured by using one or more of the following methods:

A. If the plant is designed and installed by a competent engineering firm, the contract should be negotiated, if possible, on a turn-key basis. On this basis the contractor agrees to operate the plant and produce the quality and quantity of the product stated in the contract for an agreed period of time. Such a contract would assure adequate personnel training, since full quantity and quality could not be produced with an untrained organization.

B. The engineering firm that designs and installs the plant can usually make training arrangements to have key personnel placed, for training purposes, in a foreign industry that produces the same type of product. This would provide training for the key personnel while the plant is being installed.

C. If neither of the above methods is possible, then qualified and experienced individuals should be employed for the key positions, either permanently or temporarily, to perform the key operations and assist in training the organization, even if they must be secured outside the country.

D. The manager should have years of successful experience in this type of business and be fully qualified in all phases of management, including the training of employees.
SAFETY:

There is always danger of accident and injury in any industrial plant. Because of this, the manager should take specific action to bring to the attention of each employee the importance of safety precautions and intelligent first aid.

Practically all machines have safety appliances, and the manager should see that these are in good working condition and that the operators are making full use of them.

In addition to constant watchfulness to make sure that all practicable safety precautions are taken, first aid supplies should be readily available. One complete first aid kit should be maintained near the manager's office, and others at appropriate places throughout the plant. Some of the employees should be trained to provide first aid service.

The use of accident posters in the plant have proved to be of value in reducing accidents. It is recommended that such posters be used, and that some direct special action be taken by the manager, at least once each month, to bring to the attention of all personnel the importance of safety precautions.

A fire brigade should be established and each member trained as to his responsibility in case of fire. Fire drills should be conducted periodically.

It is recommended that the employees be encouraged to offer suggestions or recommendations relative to prevention of accidents, removal of fire hazards and maintaining general interest in all safety factors.
OTHER CONSIDERATIONS

There are other important subjects, shown below, that should be fully investigated and considered. Information on these subjects is usually available from such sources as banks, government agencies, exporters and importers, wholesalers, retailers, transportation companies and manufacturers.

MATERIALS AND SUPPLIES

1. Are all materials and supplies available locally?
2. Is the local material market competitive?
3. Is satisfactory delivery of local materials assured at reasonable prices?
4. What materials and supplies must be imported?
5. Are they available in world markets at competitive prices?
6. Would prompt delivery of imported materials and supplies be assured so that large inventories would not be required?

MARKET FACTORS

1. Is there already a demand for the product?
   A. Who are the principal consumers?
   B. Who are possible new consumers?

2. How is demand for the product now satisfied?
   A. By local production? If so, what is the volume of annual production?
   B. What percentage of consumption is filled by local production?
   C. By imports? If so, what is the volume of annual imports?
   D. What percentage of consumption is met by imports?
   E. From what areas are imports derived?

3. What is the estimated annual increase in local consumption over the next five years?
   A. How were such estimates made?
   B. By reference to official figures on population growth, family budgets, imports, etc.?
   C. By consultation with trade or industry, ministries, associations, bankers, commercial houses, wholesalers, retailers, industrial consumers, etc.?
4. If the product is already being manufactured, can the existing and estimated future local market absorb production of the new plant without price-cutting or other dislocations?

5. Would the estimated sales price and quality of the new product make it competitive with an imported equivalent?
   A. After adjusting cost to local conditions, is the estimated sales price of the product so high that tariff protection is necessary to protect it from imports?

**EXPORT MARKETS:**

1. Could the product compete in export markets on the basis of price, quality and dependability of supply?
2. Can export markets for the product be developed?
3. If so, in what areas and in what annual volume?
4. What procedures would be necessary to develop export markets?
5. What would it cost?

**MARKETING PROBLEMS:**

1. In calculating costs of the product, has adequate allowance been made for the expense of a sales department, advertising and promotion that might be required?

2. Do consumer prejudices against locally manufactured products exist?
   A. If so, why?
   B. Would they apply to the new product?
   C. If so, how could they be overcome and what would it cost to do so?

3. Do marketing and distribution facilities for the product exist?
   A. If not, can they be set up?
   B. What would it cost to do so?

4. Will the product be sold to:
   A. Wholesalers?
   B. Retailers?
   C. Direct to consumer?
   D. Other industries?
   E. Government?
ECONOMIC FACTORS:

1. How much foreign exchange (and in what currency) is required to import machinery, equipment and supplies:
   A. How much foreign exchange (and in what currency) is required for annual interest payments and amortization of any loans contracted to import machinery and equipment, or for payment of royalties and technical services?
   B. How much foreign exchange (and in what currency) is required for annual import of raw materials and supplies?
   C. What are estimated annual foreign exchange earnings and in what currencies?
   D. Has careful consideration been given to the possibility of depreciation in the foreign exchange value of the local currency?
   E. Has careful consideration been given to the possibility of import controls, or restrictions on availabilities of foreign exchange necessary to operate the business?
   F. What benefits would the new business bring to the economy in the use of local raw materials: in employment and in technology?
   G. Do dependable facilities exist for transportation, power, fuel, water and sewage?
      (1) If not, can existing deficiencies be eliminated satisfactorily?
      (2) What would be the cost to do so?

PERSONNEL:

1. Is there an adequate labor supply near the plant location?
   A. If not, how can the problem be solved?

2. Can the problem of training competent management and supervisory personnel be solved?
   A. Also, the training of skilled labor?
   B. Is technical advice available in the locality?
   C. If not, where can it be obtained and what will it cost?

LAWS AND REGULATIONS:

1. Do existing labor laws, government regulations, laws and taxes favor establishment of new business?
   A. If not, can existing obstacles be removed?
   B. If so, how and when?
FINANCIAL FACTORS:

1. Technical advice on selection of machinery and equipment.
   A. In selecting the machinery and equipment for the new plant, have reputable and competent engineers and technicians been consulted?
   B. Have they been asked for advice on the most suitable types of machinery and equipment for the process and locality?
   C. Have they carefully compared costs of various suppliers?
   D. Credit terms offered purchasers?

FINANCIAL REQUIREMENTS OF THE PROJECT:

1. In estimating the cost of the project, has careful consideration been given to:
   A. The effect on costs of delays in construction schedules?
   B. In delivery and installation of machinery and equipment?
   C. In import of essential raw materials and supplies?

2. In calculating cash flow and working capital requirements, has careful consideration been given to:
   A. Maintaining adequate inventories of raw materials?
   B. Supplies and spare parts?
   C. Seasonal fluctuations in the business?
   D. The time required to liquidate credit sales to customers and bad debts?
   E. The period necessary to get the plant into production?
   F. Cash required to amortize its principle loans?

3. If the economy is in a period of inflation, has full allowance been made for the influence of rising prices and wages on the cost of the project and on working capital requirements?

SHORT TERM BANK CREDITS:

1. Has it been possible to make arrangements with local banks to finance short-time working capital requirements of the business?

FINANCIAL PLAN:

1. Has a definite plan to finance the project been worked out?
   A. Is sufficient capital available locally?
   B. If not, what is the plan to obtain the required capital?
BIBLIOGRAPHY


5. Fraser and Chalmers Engineering Works, Erith, Kent, Chalk Crushing and Screening Plant; Engineering, Vol. 175, No. 4538, January 1953, p. 94-95.


The following is a representative list of companies selling to the processing industry. It is far from complete and is intended only to indicate the ready availability of firms willing to assist any prospective processor in securing more detailed equipment information. It is suggested that managers of new plants in foreign countries may obtain information concerning sources of supply in other countries through appropriate importers or consulates.

**Ring Roll Mills**

Babcock and Wilcox Co.  
85 Liberty Street  
New York 6, New York  

Williams Patent Crusher and Pulverizer Co.  
2701 North Broadway Street  
St. Louis 6, Missouri  

Sturtevant Mill Co.  
Harrison Square  
Boston, Massachusetts  

**Hammer Mills**

American Pulverizer Co.  
1139 Macklind Avenue  
St. Louis 10, Missouri  

Allis Chalmers Manufacturing Co.  
Milwaukee 1, Wisconsin  

Jeffrey Manufacturing Co.  
Columbus 16, Ohio  

**Materials Handling Equipment**

Arthur L. Chandler & Co.  
Mills Building  
Washington 6, D. C.  

Orangeville Manufacturing Co.  
Columbia County  
Orangeville, Pennsylvania  

Pennsylvania Crusher Co.  
Liberty Trust Building  
Philadelphia 7, Pennsylvania  

Raymond Pulverizer Division  
Combustion Engineering Co.  
1315 North Branch Street  
Chicago 22, Illinois  

Bradley Pulverizer Co.  
Allentown, Pennsylvania  

Buffalo Hammer Mill Corp.  
27 Washington Street  
Buffalo 3, New York  

Bauer Brothers Co.  
Springfield, Ohio  

Combustion Engineering, Inc.  
1315 North Branch Street  
Chicago 22, Illinois  

Sage Equipment Co., Inc.  
30 Essex Street  
Buffalo 13, New York
CONSULTANTS

Morse Laboratories
316 Sixteenth Street
Sacramento 14, California

Chester L. Knowles
19 Rector Street
New York 6, New York

Ebasco Services, Inc.
Two Rector Street
New York 6, New York

Booz, Allen and Hamilton International, Ltd.
1625 Eye Street, N. W.
Washington 6, D. C.

Dallas Laboratories
P. O. Box 9215
2121 South Central Expressway
Dallas 15, Texas
Plant Layout

Arrows indicate work flow

Bunker
Dry storage for 50 tons chalk

Furnace

Beltfeed conveyor

Processing

Automatic weighing and bagging

Storage 200 ton bagged whiting

Office

Women

Men