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TECHNOLOGICAL CHANGES IN THE CEMENT MANUFACTURING INDUSTRY.

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THE PURPOSE OF THIS STUDY IS TO PRESENT A PRELIMINARY PICTURE OF OCCUPATIONAL CHANGES BROUGHT ABOUT IN THE MANUFACTURE OF CEMENT AS A RESULT OF INTRODUCING AUTOMATED EQUIPMENT. ONE AUTOMATED AND SEVERAL CONVENTIONAL TYPE CEMENT PLANTS WERE STUDIED. ANALYSIS OF DATA OBTAINED THROUGH RESEARCH AND DATA COLLECTED DURING THE STUDY REVEALED THAT MANUFACTURERS OF CEMENT, LIKE THOSE IN SO MANY OTHER INDUSTRIES, ARE AUTOMATING THEIR MANUFACTURING PROCESSES. THE CEMENT INDUSTRY IS GOING THROUGH ONE OF THE GREATEST REMODERNIZATION ERAS THAT COULD BE EXPERIENCED BY ANY INDUSTRY. INFORMATION IS PROVIDED ON THE OCCUPATIONAL STRUCTURE OF THE CEMENT PLANT BEFORE AND AFTER INTRODUCTION OF A COMPUTER CONTROL SYSTEM, THE JOBS ELIMINATED AND NEW JOBS CREATED, THE KIND OF WORK THE NEW JOBS ENTAIL, THE KINDS OF KNOWLEDGE AND SKILLS THE NEW JOBS DEMAND, AND THE SOURCE OF WORKERS FOR FILLING THE NEW JOBS. HISTORICAL MATERIALS, PROCESS FLOW CHARTS, AND OTHER PERTINENT INFORMATION ARE PRESENTED FOR EACH PROCESS IN THE AUTOMATED PLANT DESCRIBED. CHANGEOVER TO AN AUTOMATED SYSTEM IN THE ABC CEMENT COMPANY INDICATED A DECREASE IN EMPLOYMENT OF ABOUT 13 PERCENT. AVERAGE PRODUCTION WAS INCREASED. (FS)

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Employment Service

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Technological Changes in the Cement Manufacturing Industry

Department of Employment
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TECHNOLOGICAL CHANGES IN THE CEMENT MANUFACTURING INDUSTRY

Date____________

CALIFORNIA STATE EMPLOYMENT SERVICE
DEPARTMENT OF EMPLOYMENT
ALBERT B. TIEBURG, *Director*

TABLE OF CONTENTS

FOREWORD

The purpose of this study is to present a preliminary picture of occupational changes brought about in the manufacture of cement as a result of introduction of automated equipment.

In investigating the changes that occurred in the plant, the questions formulated were restricted to providing information in the following areas: occupational structure before and after introduction of the equipment; the jobs displaced and new jobs created; the kind of work the new jobs entail; the kinds of knowledge and skills the new jobs demand; and the source of workers for filling the new jobs.

The findings of the study relate only to the automated plant described and do not necessarily reflect the experiences of other plants in the industry. Historical material, process flow charts, and other pertinent information are presented for each process to provide for a better understanding of the processes discussed.

Additional data for the study was obtained from conventional-type cement plants and from articles and other secondary sources.

Although this study is limited, we believe that even with its limitations it can be helpful to public employment offices and others through adapting the information it contains to similar situations and circumstances in their own communities.

The study was prepared by Carl E. Wesson, occupational analyst, under the supervision of Kenneth J. Bohn, field center supervisor of the California Occupational Analysis Field Center of the California State Employment Service in cooperation with the Branch of Occupational Analysis of the United States Employment Service.

Grateful acknowledgement is made to the organizations and their staff who cooperated in the preparation of this brochure. Without their contributions and assistance it would not have been possible.

HISTORY OF CEMENT

Ever since man started to build, at the dawn of civilization, he has searched for better bonding agents with which to hold together the rocks and stones used in construction. The Egyptians used impure gypsum plaster as mortar in pyramid construction. Slaked lime was used by the Greeks, and the Romans probably learned of its utility from them. Both the Greeks and Romans made a pozzolanic mortar by mixing finely ground volcanic material with lime, sand, and water. Pozzolana hardens by reacting chemically with the lime. The name derives from the Italian town Pozzuoli, where a suitable volcanic tuff was found. The Romans also used powdered pottery fragments as pozzolana. The pozzolanic cements made by mixing such materials with lime and water were found to be resistant if exposed to water, and were for a long time the only cements known to be suitable for such exposure.

Pozzolanic cement was used in such structures as the Pantheon, the famous Appian Way, the great system of aqueducts, and the Colosseum.

Despite the early use of these materials, little was known of their chemistry, and no substantial advance was made in the manufacture of lime and cement from the time of the Romans until 1756. In that year John Smeaton, who had been employed by the English government to build a lighthouse in the English Channel, discovered that an impure or clayey limestone, when burned and slaked, would harden into a solid mass under water as well as in air. This discovery of Smeaton's led the way to rapid improvement and development in the lime and cement industries.

In 1796 James Parker, of Northfleet, England, obtained a patent for the manufacture of cement, which he aptly named "roman cement." Parker's process consisted of burning certain stone or clayey products called "nodules of clay" in an ordinary limekiln, and then grinding the clinkers to a powder. Cement made in this way did not absorb water and crumble. The process rapidly gained favor among engineers and builders, and natural-cement plants sprang up all over the continent of Europe, in England, and later, about 1818, in the United States. [1]

In 1824 Joseph Aspdin took out a patent in England for the manufacture of an improved cement, produced by calcining a mixture of limestone and clay. To the resulting powder he gave the name "portland cement," because when it hardened it produced a yellow-gray mass resembling in appearance a stone found in various quarries on the Isle of Portland, England. Joseph Aspdin is given credit for making the first portland cement, and he is generally recognized as the father of the modern portland cement industry. [2]

Aspdin appears to have been the first to realize that superior hydraulic properties were obtainable by harder burning, that is, to proper fusion, instead of solely by calcination as was long the practice. However, he followed the previous practice of pulverizing by slaking and removing by hand larger pieces of unslaked harder-burned clinker. It remained for Isaac Johnson to discover, about 1845, that the harder particles after weathering and suitable mechanical grinding yielded a cement of superior qualities. Johnson, therefore, is more nearly the discoverer of the portland cement we know.

The cement industry in this country began with the discovery in 1818 of a natural-cement rock near Chitenango, New York, by Canvass White, an engineer on the Erie Canal. In 1825 cement rock was found in Ulster County, New York, and in 1828 a mill was built in Rosendale, New York. In the spring of 1866 three men from Allentown, Pennsylvania, formed the Coplay Cement Company and located a mill near that city. Mr. Saylor, one of the partners, began to experiment on portland cement from the rock in the quarries. After a great number of experiments, true portland cement was produced in 1875. This was the small beginning of the American portland cement industry.

Modern portland cement is a finely pulverized material consisting principally of certain definite compounds.

Methods of production have naturally changed greatly over the years. Early firing was in stationary, intermittently operated kilns. Production was on a small scale and the cement was ground with millstones. Kilns underwent various changes, but the most striking was the introduction of the rotary kiln. In 1877 T. R. Crampton obtained a British patent on a rotary kiln process for cement, but it was not a success. Frederick Ransome obtained British and U.S. patents in 1885 and 1886 for a process that achieved first success in the United States and led eventually to complete adoption of the rotary kiln for production of portland cement in this country. In Europe the continuously operating shaft kiln has remained a competitor.

[1] **Clinker:** The product resulting from calcining raw, pulverized stone in a kiln of a cement plant to a point of incipient fusion.

[2] **Calcination:** A process in which volatile material, such as carbon dioxide, is expelled from limestone by the application of heat to reduce the limestone to a powder.

PROCESSES IN THE MANUFACTURE OF CEMENT

TRADITIONAL PROCEDURES

The basic steps in the manufacture of cement are as follows:

1. Excavation of raw materials
2. Transportation of raw materials to plant
3. Crushing of raw materials
4. Blending of raw materials
5. Pulverizing raw materials
6. Burning raw materials to produce clinker
7. Grinding of clinker into cement

Cement is manufactured by the wet or dry process. Factors such as source and type of raw materials, moisture content of raw materials, cost of fuel and power, and the availability of water and waste-water disposal facilities dictate the type of process used and sequence of steps in processing materials.

Excavation

The excavation of raw materials is the first step in the manufacture of cement. Raw materials are excavated by quarrying or digging from open pits, mining from underground workings, and dredging from deposits covered by water. Primary and secondary blasting is required in quarrying operations. Holes are drilled into the bed or rock and charges are placed and fired to break up the rock mass. When the size of the blasted rock is such that it cannot be handled, it must be broken up further by additional drilling and secondary blasting. Materials such as clay and shale do not require blasting and are excavated by means of power shovels of various types. Mining from underground workings is performed in a manner similar to mining coal. Deposits of marl, oyster shell, or sand covered by water must be recovered by floating dredges of the hydraulic, dipper, clamshell, and bucket-ladder type.

Transportation

After the materials are excavated they are transported to the processing plant on dump trucks, railroad gondolas, mine hopper cars, ships and barges, or by belt or bucket conveyors. Most plants are located near the source of raw materials.

Crushing

The primary crushing of quarried materials is performed in one of three types of processing machines —rotary crushers, jaw crushers, or roll crushers. The material leaves the primary crusher in pieces no larger than seven inches in diameter.

Depending on the moisture content of the raw materials, they are either passed through a drier prior to the secondary crushing process, or dried from the heat generated in the secondary crushers.

The crushed materials are then fed into the secondary crushers to further reduce materials to ⅜ to ½ inch in diameter. These secondary crushers are of a type called hammer mills. The hammer mill is a steel cylinder inside of which are a number of heavy pieces of steel anchored to a revolving metal shaft. As the shaft revolves, the free ends of the "hammers" fly outward and crush the rock against a metal breaker plate and grid. The crushed rock leaving the hammer mill is passed over a vibrating screen allowing rock of small sizes to pass through while the oversize rock is returned to the mill for further reduction. The usual size of the rock leaving the secondary crusher is from ⅜ to ½ inch in diameter. The crushed materials are then conveyed on belt conveyors to stockpiles, bins, or silos for storage.

After the materials have been crushed, representative samples of the materials are taken, ground in laboratory mills, and analyzed to determine their chemical properties. From this analysis the proportions of each type of raw material needed are computed by an algebraic equation.

Raw Grinding (Pulverizing) and Blending

The crushed materials are then drawn from storage in the proportions specified so that the cement made from them will be of the right composition and uniform quality and conveyed to the grinding mills for raw grinding. Up to this point the processes to prepare the raw materials have been essentially the same whether the plant uses the dry or wet process. The materials are blended and ground in the same operation in either process. However, in the wet process, water is introduced into the mill along with the materials. The mills used for milling the materials in either the wet or dry process are the same type. The primary mill is a ball mill, and the secondary mill a tube mill. Sometimes these mills are combined into a single mill, called a compartment mill. In the dry process the materials are generally fed into the kiln feed bins after they are milled. In the wet process the water-mixed material (slurry) is pumped to slurry basins by centrifugal pumps. Sedimentation and segregation of the slurry is prevented by constant agitation. Mechanical agitators, compressed air, or combination mechanical-air agitators continually agitate the slurry. A unique illustration of the extreme flexibility of wet processing is the application of flotation to remove undesirable or unneeded constituents in the raw materials, thus making possible utilization of material sources which otherwise would be useless. However, dry processing has its advantages also, namely greater fuel economy with shorter, therefore less expensive, kilns.

Burning

All of the processing operations up to this point are to prepare and blend the various materials for burning in the kiln. This is the key process in the manufacture of cement and the kiln must be controlled with the greatest of care to produce a uniform product. Two types of kilns are used: the vertical or shaft kiln used during the infancy of the cement industry, and still used in Europe in modernized versions; and the rotary kiln, used almost exclusively in the cement industry in the United States.

The rotary kilns vary in diameter from 6 to 18½ feet, and in length from 60 to 610 feet. Wet process kilns are somewhat longer than dry process kilns inasmuch as from ¼ to ⅕ of the length is required for drying or evaporating the water from the material. The kilns are inclined a few degrees (about ½ to ¾ inch per foot of length) and rotate at a speed of from 50 to 90 revolutions per hour. The combustion of coal, gas, or fuel oil at the lower end of the kiln provides the temperatures required for incipient fusion of the materials. The temperatures at the lower end of the kiln range from 2600° F. to 3000° F.

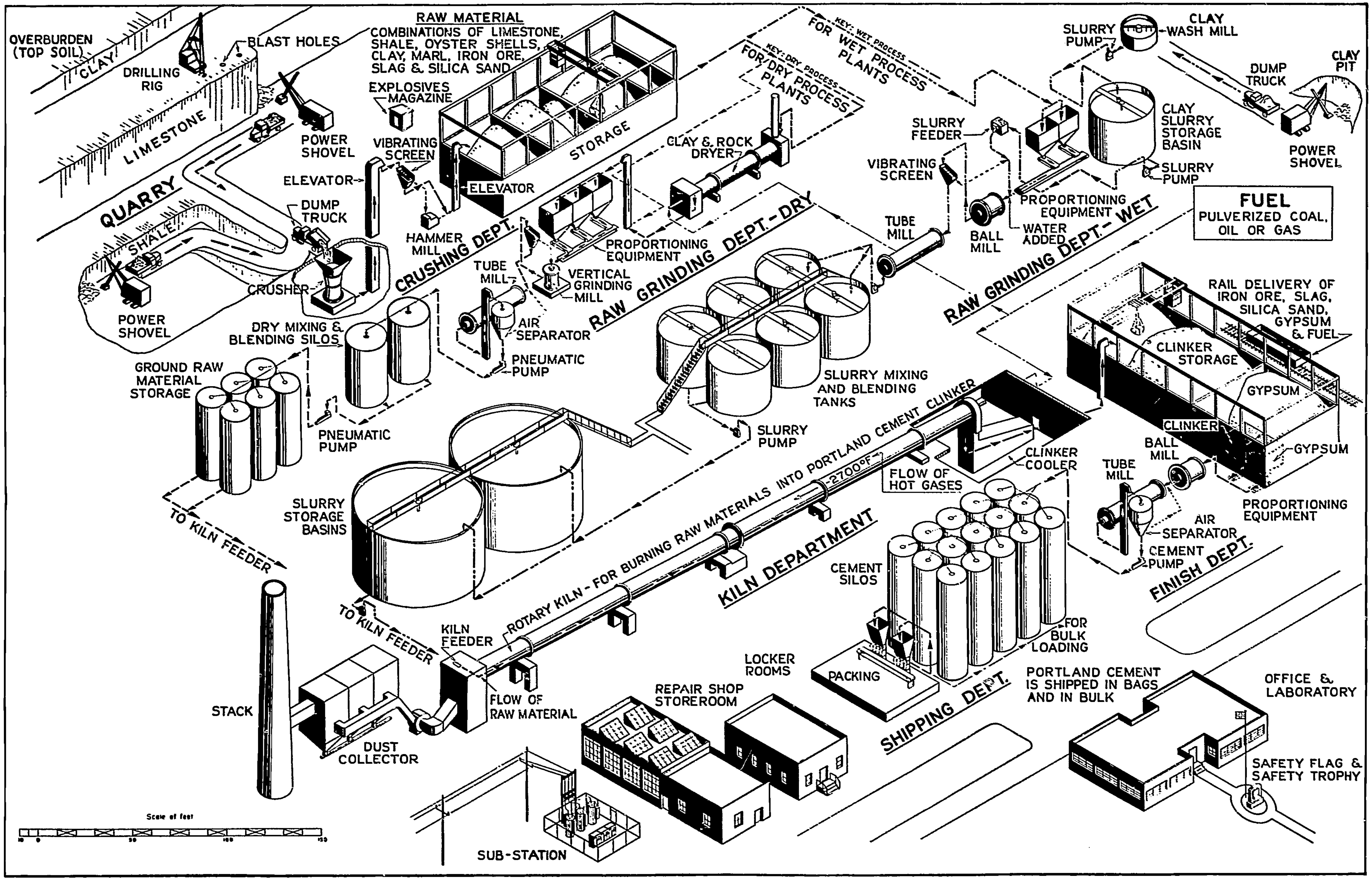
The raw materials, either dry or wet, are fed into the kiln at the upper end of the kiln. As the kiln revolves the materials roll and flow toward the lower end. As the materials flow toward the lower end they encounter higher and higher temperatures. Gases are driven off between 2600° F. and 3000° F., and incipient fusion occurs forming small, glossy, hard balls of a new substance. This substance, called clinker, is cement when ground to powder. Maintaining almost constant conditions, such as rate of feed, rotation of kiln, temperatures and pressures, is necessary to produce a uniform clinker. The clinker emerging from the kiln is cooled by air coolers and conveyed by pan and belt conveyors to storage.

Grinding (Finish Milling)

The final step in manufacturing cement is the grinding of the clinker into a very fine powder. Ball mills and tube mills of the type used in milling the raw materials are used to perform this function. After the finished cement leaves the finish mills it is conveyed by pneumatic pumps to storage bins until packed or shipped in bulk.

MANUFACTURE OF PORTLAND CEMENT

Isometric Flow Chart



Portland Cement Association
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DISCUSSION OF COMPUTER CONTROL SYSTEM

The use (or operation) of the computer control system can best be explained with a discussion.

Blending

The computer is used to assist in making the calculations; using linear programming techniques to optimize both raw material selection and pile composition. The computer is "told" the analysis of the raw mix desired. This remains in the "memory" of the machine until the pile is complete. Analyses of the materials going into the pile and their costs are stored up by the machine. Finally the computer is asked how to combine to obtain the desired mix at the lowest cost. The computer is usually asked to solve the blending problem once a day.

Controlling Kiln

A computer program is written for the control and regulation of the kiln. This program is designed to maintain the manipulated variables at levels which will keep burning-zone conditions constant.

With its memory and ability to act at high speeds the computer can keep the kiln at desired production rate. The equations in the regulation program are time-dependent, and they include the history of measurements and control actions. A variation in the feed rate, for example, that occurred hours before (and is long forgotten by the operator) is used by the control system to eliminate its adverse effect on clinker quality. The calculations and manipulations of data performed just before the set points are readjusted would require half a day if done by an engineer with a desk calculator. The computer performs this cycle every five minutes. At the same time the flexibility of the computer control system allows these calculations to be based on all pertinent data, including that received from the kiln instrumentation and from the laboratory analysis.

Finish Milling

The computer continuously records data from the ball mill instrumentation. These readings are then used to calculate those operational changes which must be made to maintain clinker grinding at maximum efficiency under all conditions.

PROCESSES IN THE MANUFACTURE OF CEMENT

AUTOMATED PROCEDURES

Crushing

The crushing system is operated by the CRUSHER OPERATOR who

CRUSHER OPERATOR
Controls the operation of primary and secondary crushers and related equipment from a panelboard. He presses switches and buttons to start in prescribed sequence such equipment as primary and secondary reducing mills, vibratory screens, conveyor feeders, and conveyors. During the operation he monitors the panelboard and equipment.

The materials are dumped directly into the primary crusher from quarry dump trucks. A 60-inch gyratory crusher accepts huge rocks from the quarry weighing as much as nine tons, and in minutes its powerful, continually gyrating pestle crushes the huge rocks against the manganese steel side plates, reducing them in size to pieces of less than six inches in diameter. This crushed rock then drops into a surge bin where it is fed onto an automatic conveyor by a vibratory wobbler feeder. This feeder allows the finer pieces of rock to be deposited on the belt conveyor first, thereby cushioning the belt, before the larger pieces are fed upon it. The belt conveyor conveys the crushed materials to a screening tower where it is deposited onto a closed loop screening system. The rock that is crushed to less than ¾ inch in diameter (called fines) passes through the screens and is discharged onto conveyors leading to rock-storage facilities. Oversized rock (larger than ¾ inch in diameter) is fed into two 600-horsepower hammer mills where a series of hammers hinged to a central axle act like whirling sledges to further crush the rock until it is small enough to pass through the fine screens. The hammers are equipped with electronic sensors that automatically control the rate of feed into the secondary mills. If the feed is too great for the mills to crush the materials, the sensors send a signal to the vibratory feeders to slow down the tonnage until the hammer mills can handle the feed. As the crushed materials are conveyed to the rock storage silos, samples are taken from the conveyor for laboratory analysis.

Central Control

The nerve center of the plant is central control where the CENTRAL-CONTROL OPERATOR and the ASSISTANT CENTRAL OPERATOR

CENTRAL–CONTROL OPERATOR ASSISTANT CENTRAL–CONTROL OPERATOR
Control the operation of conveyor system, feeders, raw grinding mills, rotary kilns, finish mills, and auxiliary equipment to process the material from storage silos into finished cement. The workers observe closed-circuit television, electronic and electrical recorders and indicators, and read printouts from a computer to detect equipment malfunctions and to determine operating efficiency.

Translated into mathematical language of the computers, the entire process of cementmaking is programmed into an "on-line digital computer," thus becoming a continuous in-line, integrated materials processing and handling system. The result is that the plant is completely automated for maximum efficiency, increased output, and constant quality control. Each plant area and operation has its own control panel, arranged clockwise around the control room in order of material flow. A schematic diagram with indicator lamps shows process and material routing at all times. Controller recorders, electronic and electrical instrumentation, and closed-circuit television furnish a continuous record of process behavior and computer action, as well as data for engineering studies. All instruments, switches, and control button sections of the panels have "manual-auto" switches to permit operation independent of the computer.

Blending

The directions for blending crushed rock are printed out by the computer from the information obtained from the rock analysis of materials performed in the laboratory, and from the tonnage of rock being processed as indicated by automatic weighing scales. The printout designates the type and composition of materials required to obtain the specified chemical composition for the manufacture of cement. Controls are set by the operator to add these materials to the crushed rock on the belt conveyor as it conveys the materials to rock storage from segregated-rock storage bins. When the materials reach the 80,000-ton rock storage building, automatic trippers deposit the materials in layers as the trippers move back and forth.

Blending and Final Adjustment of Raw Mix

The final blending and adjustment of the raw mix prior to grinding is exercised by withdrawing materials from any or all of eight 2,000-ton silos. The material is withdrawn from selected silos by vibrating feeders over automatic scales onto the belt conveyor system leading to the raw grinding mill feedbin which is capable of storing 150 tons of material. Adjustments are made by the operator by varying the flow rate of any one of the vibrating feeder-belt scale combinations in the system.

Raw Grinding

The grinding of the raw materials into kiln feed is the next process. The feed of materials into the ball mills from the mill feedbin is controlled by a vibratory feeder which discharges the blended materials into two huge ball mills containing thousands of forged-steel grinding balls measuring from one to four inches in diameter. As the ball mill rotates, these balls are carried part way up the side by steel ridges along the interior of the mill. The balls then cascade down on the raw mix pulverizing it until it is about 1/1300 inch in size.

Homogenizing Raw Mix Into Kiln Feed

The fine-powdered materials from the raw grinding mills are then pumped into homogenizing silos. As the raw mix is being pumped to the homogenizing silos, an analysis of the composition of the mix is made. Each silo floor is divided into four sections or quadrants, and low-pressure compressed air, fed from the bottom, causes the dry powdered material to flow upward almost like a liquid from one section to another. In this manner a rollover action is created within each quadrant. Each quadrant is rotated on a regular time cycle controlled by a timer in the central control room. The materials are completely homogenized and then pumped by pneumatic conveyor to the kiln feed silos.

Burning

All the preceding processes were performed to prepare a kiln feed of highest quality and uniform chemical composition. The burning operation is the heart of the cement manufacturing process, and the more control that can be exercised over this operation the better the product can be manufactured. Because of the large number of operating variables, such as rate of feed, ratio of fuel and air, temperature, and rotation of the kiln, kilns operated by manual control are subject to human error. By placing the operation of the kilns under computer control and electronic instrumentation that constantly transmits all operating data to the computer, the factor of human error is in a large sense eliminated. The computer analyzes the data and with operating specifications in the memory banks prints out the adjustments to be made. The finely ground raw materials are fed into the high end of the kilns (kilns are 490 feet long, 13 feet wide, and slope 7/17-inch per foot from high end to low end). As the kilns rotate (1⅓ turns per minute) the finely ground raw material rolls and slides toward the low end of the kilns. The materials are exposed to higher and higher temperatures as they travel toward the low ends of the kilns. During the two hours it takes the material to travel the length of the kilns, the materials are dried, heated, calcined, and clinkered. The materials first become incandescent and change in color from purple to violet and finally to orange. As the heat increases, carbon dioxide and other gases are driven off and the original limestone, shale, clay, and iron oxide are changed into other minerals, such as dicalcium and tricalcium silicate, tricalcium aluminate, and tetracalcium aluminoferrite. This incipient fusion takes place in the lower third of the kiln at a temperature of 2700° F. The new minerals called clinker pass over grates through which air is forced by centrifugal fans to cool the clinker. The clinker is then broken into marble-size fragments by chunkbreakers and fed onto vibrating conveyors which move it to clinker storage.

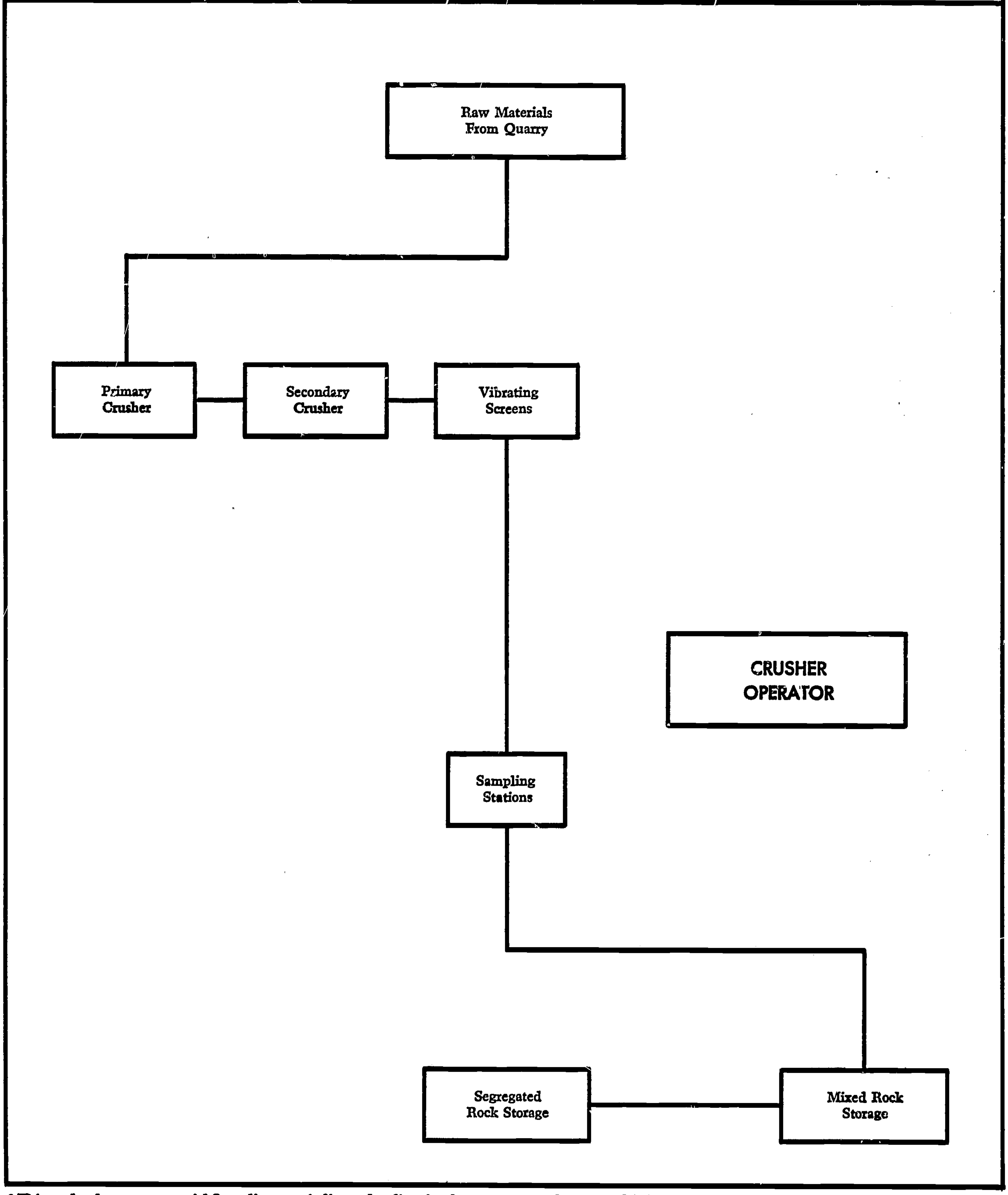
Clinker Storage

The cooled clinker conveyed from the kilns is stored in huge sectional bins having a capacity for storing 350,000 barrels of clinker and over 7,000 barrels of gypsum. A worker operates a bridge crane equipped with a six-cubic-yard clamshell bucket to move and stack the clinker or gypsum ready for delivery to the finish mills.

Finish Milling

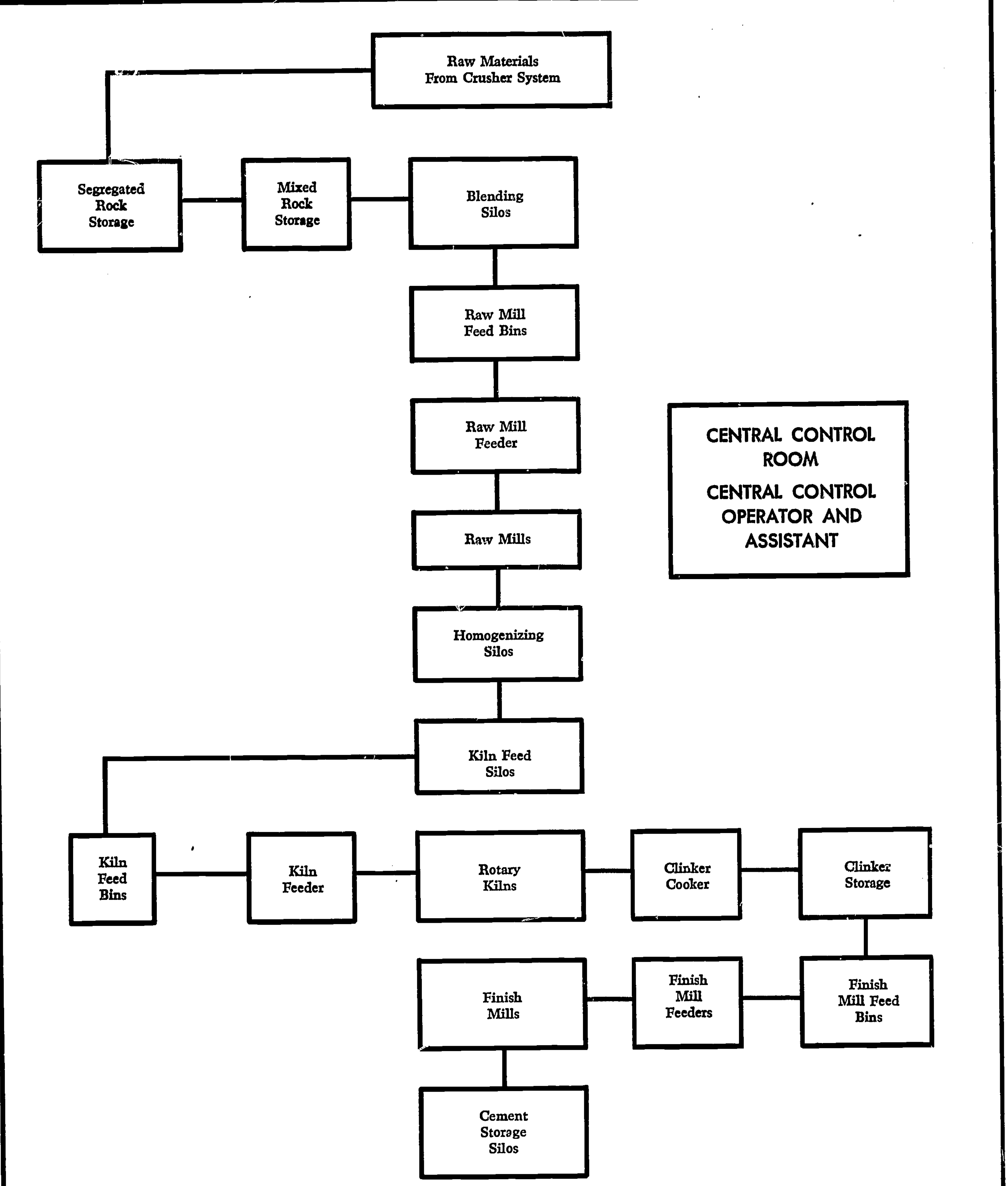
The finish-milling system is similar to the raw grinding system in that the mills are ball mills. However, these mills are longer and are charged with 160 tons of forged-steel grinding balls. It is at this stage of the process that gypsum is added which regulates the setting time when cement is used to make concrete. The proportions vary according to use, but in general, 3 percent to 5 percent gypsum is added to the clinker as it is milled. Automatically controlled conveyors are used to keep the feedbins continuously filled, and vibrating feeders and load-cell belt scales control feed rate and accurately proportion gypsum and clinker.

Chart I. CRUSHING SYSTEM [3]



[3] This and subsequent material-flow diagrams indicate the directional movement of the material being processed.

Chart II. COMPUTER–CONTROLLED PROCESSES FROM CENTRAL CONTROL ROOM



Bulk Cement Storage

The bulk cement storage system is the last of the operations controlled from the central control room by the CENTRAL-CONTROL OPERATOR. The storage system consists of 35 silos having a total capacity of storing 400,000 barrels of cement. The entire silo complex is interconnected by a system of elevators, air slides, and pumps so that cement from the finish mills can be directed to any silo or series of silos.

Bulk Handling and Loading

After the finished cement has been stored in silos, all control exercised by the CENTRAL-CONTROL OPERATOR ends. The automated bulk-handling and loading functions are controlled by the LOADING-AREA OPERATOR, who

LOADING AREA OPERATOR
Controls the operation of weighing hoppers and feeder and conveyor systems from panelboard to weigh and load finished cement into tank trucks or railroad cars, transfer cement to packhouse silos, or to recirculate cement between storage silos. He pushes buttons and turns controls to operate equipment and monitors panelboard to determine operation efficiency.

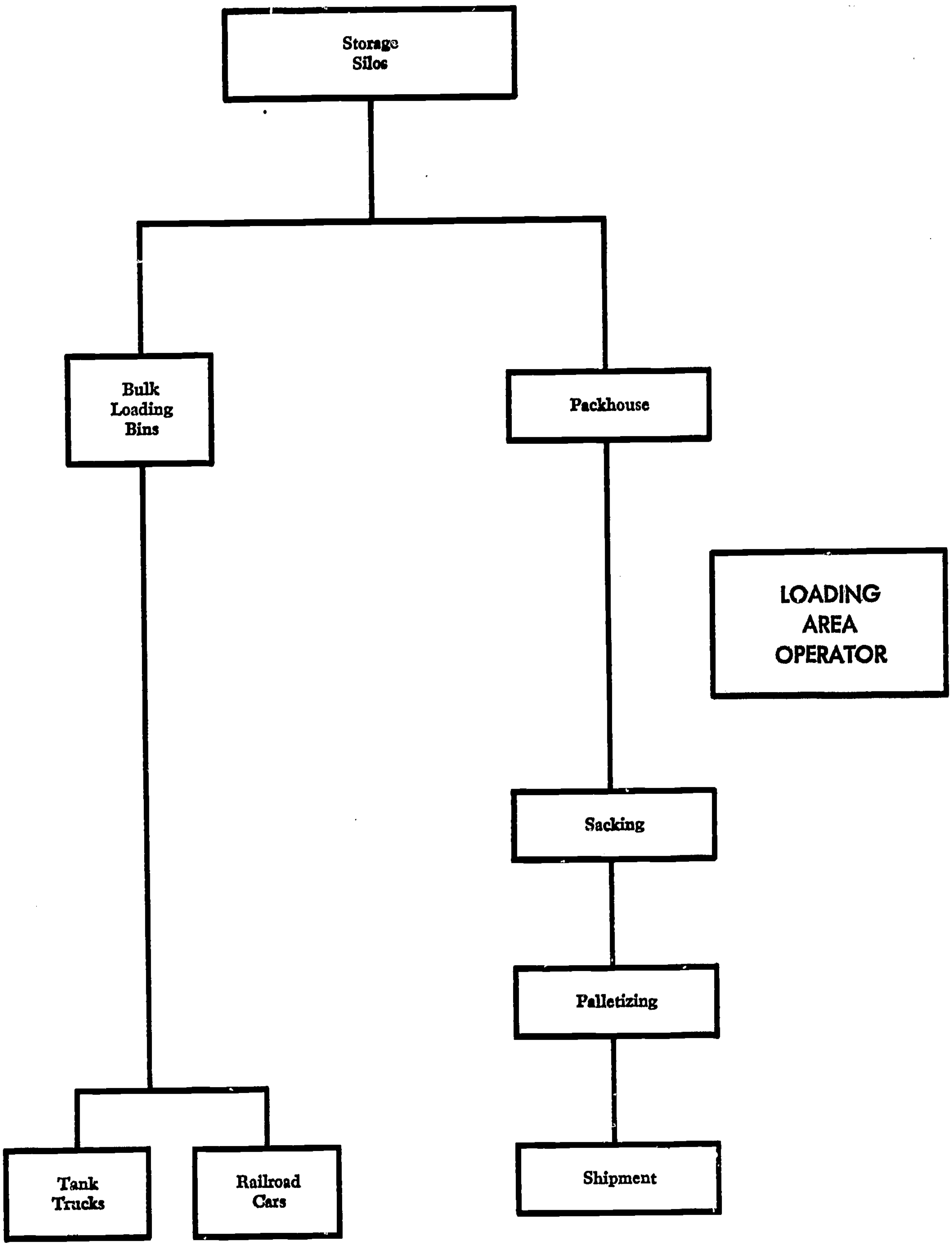
The bulk-loading facility has two drive-through scaleways equipped with seven-foot platform scales. Railroad cars or trucks are loaded with cement and weighed on the scaleways. The LOADING-AREA OPERATOR directs the LOADING-AREA HELPER to spot a railroad car or truck on the designated scale and under the loading spout. The operator then moves controls to position loading spout and to operate scales. The operator then selects the loading bin containing the type of cement specified and starts pumps and conveyor systems to draw bulk cement from the loading bin and pumps the cement into the railroad car or truck. Weights are automatically typed on dray tickets or bills of lading.

Each storage silo is equipped with a conveyor system and feeders that are electrically operated. The switches that control the operation of this equipment are mounted on the control console panelboard in the scale room. These switches, however, are always locked and can only be unlocked by supervisory personnel from the packhouse or laboratory departments. Whenever the packhouse silos or the bulk-loading bins need refilling, supervisory personnel designate the storage silo from which the cement is to be withdrawn and unlocks the interlocking selector switch. The operator is then able to start the conveyor system, open air slides, and pump the cement to either the packhouse silos or bulk-loading bins. With this system, cement may also be recirculated from one silo to another or between several silos.

Packing

The packing of cement is still done in the traditional manner. Bags have self-sealing filling valves and and when the valve of the bag is placed on the filling spout, 94 pounds of cement is automatically forced into the bag. A lever is then tripped by the worker and the filled bag of cement is discharged onto conveyors leading to any of four preselected shipping stations. Twelve to 15 bags of cement are packed every minute. One of the shipping stations is equipped with automatic palletizing equipment. This equipment automatically stacks a specified number of bags on a pallet ready for shipment.

Chart III. BULK LOADING AND HANDLING



STAFFING REQUIREMENTS

Conventional-type cement plants were studied to provide a picture of staffing requirements. Staffing can best be illustrated by comparing the staffing requirements of the automated cement plant with the staffing requirements of a conventional-type cement plant. The staffing of the plants reflect only the occupations that are directly concerned with the processing stages in the manufacture of cement.

PROCESSES	JOBS REQUIRED CONVENTIONAL PLANT	JOBS REQUIRED AUTOMATED PLANT
CRUSHING	Primary crusher operator Secondary crusher operator Secondary crusher helper Reject operator Oiler	Crusher operator Crusher oiler
BLENDING, RAW GRINDING, BURNING, FINISH MILLING	Raw miller Raw miller assistant Car dumper operator Screenman Crane operator Kiln burner Assistant kiln burner Kiln oiler Kiln drier tender Cooler dragman Flue chamberman Finish miller Ball miller Bin tender Poidometerman Tunnelman Feederman Laborers	Central-control operator Assistant central-control operator Grinding utilityman Overhead craneman
BULK LOADING AND STORAGE	Siloman F.K. pump operator Bulk loader Laborers	Loading-area operator Loading-area helper

JOBS CREATED BY INSTALLATION OF AUTOMATED EQUIPMENT

CRUSHER OPERATOR

Initially when all operations in the crushing system were combined and placed under the control of one worker, the job was filled by CRUSHER MAN from either the primary or secondary crusher.

The worker promoted to this job had 1½ years' experience in crushing system operations with at least nine months as an operator of either the primary or secondary crusher. The worker was given three weeks of on-the-job training to learn the operation of the new system.

CRUSHER OILER

This job was filled from the MAINTENANCE–MECHANIC HELPER group by workers who indicated a preference for processing jobs. Approximately four to six months of on-the-job training was required for the worker to learn the operation of the system and the adjustments required to keep the system in operation.

CENTRAL CONTROL OPERATOR

Former KILN BURNERS were selected to fill this job and were given specialized training. During the latter stages of the installation, and while the control system was being given preoperational tests, the workers were given extensive and comprehensive training in both operational procedures and actual operation of the system. The duration of the training varied from six to nine weeks, depending on the learning ability of the worker.

ASSISTANT CENTRAL CONTROL OPERATOR

Former KILN BURNER HELPERS were selected to fill this job. Requirements were that the worker must have experience in assisting others in controlling firing of the kilns, and that the worker must have a good overall knowledge of all the production processes, and lastly, understand the functions and operation of all the various production equipment. These workers were given two months' on-the-job training by the CENTRAL–CONTROL OPERATOR under actual production conditions.

GRINDING UTILITYMAN

The workers selected for this job were from the MAINTENANCE–MECHANIC group who had from one to two years' experience in the maintenance and repair department assisting others in the repair and overhaul of such equipment as material feeders, separator valves, air-slide equipment, and conveyors. Approximately two to three months of on-the-job training was required for the worker to learn operating procedures and to acquire experience in adjusting and performing operational maintenance on equipment.

KILN UTILITYMAN

The workers selected for this job were from the MAINTENANCE–MECHANIC HELPER group who had from one to two years' experience in the maintenance and repair department assisting others in the repair and overhaul of kiln equipment and auxiliary equipment, such as conveyors and material feeders. Approximately two to three months of on-the-job training was required for the worker to learn operating procedures and to acquire experience in the adjustment and operational repair requirements to become proficient.

LOADING AREA OPERATOR

BULK–CEMENT LOADERS were selected for this job who had from one to one-and-a-half years' experience related to bulk-loading and weighing operations with at least six months' experience as operator of the bulk-loading and weighing equipment. The workers selected were given two months' on-the-job training on the new equipment and transfer system during its installation and were proficient in its operation when it became operative.

LOADING AREA HELPER

No previous experience was required for this job. Two weeks to one month was required for the worker to become proficient. Workers in the LABORER classification were selected.

COMPUTER MAINTENANCE MAN

Workers selected to fill this job were recruited from the journeyman ELECTRICIAN classification. The workers were given extensive training on maintenance and repair of the computer and electronic theory by the computer manufacturer. The duration of the course was approximately two months. On-the-job training was also provided during installation and preoperative tests.

ELECTRONIC MAINTENANCE MAN

The workers selected to fill this job were recruited from the journeyman ELECTRICIAN classification. No formal training was given to these workers, but the manufacturer's representative gave informal instruction to the workers on maintenance and repair procedures for the various electronic systems as the systems were installed. This instruction continued until the workers could perform the required maintenance and repair functions proficiently.

ARRANGEMENT AND CONTENT OF JOB DESCRIPTIONS

The occupational descriptions are arranged alphabetically according to their titles. After the title, there appears first the code number which identifies the job within the classification structure of the *Dictionary of Occupation Titles*, third edition, published in 1965. Immediately following this code, there appears in parentheses a second code number. This is the occupational code in the second edition of the *Dictionary* published in 1949. It is presented here only to save time and minimize inconvenience in converting from the codes in the second edition to those contained in the third edition of the *Dictionary*.

The narrative portion of each job description is arranged as follows:

Job Definition. This provides a brief description of the duties involved in a particular job. It provides an understanding of the tasks that are performed and the skills and knowledges that are necessary to the performance of these tasks. The job definitions will be essentially in the same form in a future release of the *Dictionary*.

Education, Training, and Experience. This section provides an indication of the amount of education and the level of training and experience usually required for employment in the occupation.

Special Characteristics. This section provides some estimate of the worker trait requirements pertinent to the specific jobs.

Aptitudes: These are the specific capacities or abilities required of an individual in order to facilitate the learning of some task or job duty. This component is made up of 11 specific aptitude factors, and is a modification of the aptitudes contained in the general aptitude test battery developed in the Bureau of Employment Security. Those aptitudes were selected which seem to be significant in the job, and were identified in terms of specific work situations. The factor of intelligence, however, was not rated because of the difficulty in writing meaningful descriptive statements (ref. appendix).

Interests: This component is defined as a preference for certain types of work activities or experiences, with accompanying rejection of contrary types of activities or experiences. Five pairs of interest factors are provided so that a positive preference for one factor of a pair also implies rejection of the other factor of that pair (ref. appendix).

Temperaments: The temperament component consists of 12 factors defined in terms of specific work situations that suggest different temperament-trait requirements. Each work situation describes a type of activity that demands a different adjustment on the part of the individual workers. Those temperament factors were selected that appeared to be significant in the job, and were identified in terms of specific work duties (ref. appendix).

Physical Activities and Environmental Conditions: These refer to (a) the physical activities required to be met by the work, and (b) the working environment which makes specific demands upon a worker's physical capacities. There are six physical activities factors and seven environmental conditions factors. Those factors were selected that were significant in the job in the sense that they met established criteria of essentiality for successful performance (ref. appendix).

JOB DESCRIPTIONS AND WORKER REQUIREMENTS

ASSISTANT CENTRAL CONTROL OPERATOR
579.782
(*6-67)

Job Definition

Assists CENTRAL–CONTROL OPERATOR in controlling the operation of raw grinding mills, rotary kilns, finish mills, and auxiliary equipment to produce finished cement: Monitors area of panelboard designated by CENTRAL–CONTROL OPERATOR during equipment startup or adjustment procedures. Observes operating equipment for evidence of malfunction and reports corrections, adjustments, or repairs needed to operator. Adjusts separator valves and airslides as directed, using handtools. Occasionally relieves CENTRAL–CONTROL OPERATOR during brief absences from control room.

Education, Training, and Experience

High school graduate is preferred.

Source of workers: Experienced kiln-burner helpers. Workers selected would be given two months' additional on-the-job training. Such training is usually given by experienced central control operators.

Special Characteristics

Aptitudes: Verbal ability is required in understanding oral directions relating to operations given by CENTRAL–CONTROL OPERATOR and in comprehending written matter in operating and manufacturing manuals. Clerical perception is required in monitoring panelboards. Form perception is required to detect equipment malfunctions.

Interests: A preference for working with machines and processes to continually operate and monitor the equipment that comprises the automated system. Interest in activities of concrete and organized nature to consistently operate equipment according to specific and detailed oral instructions.

Temperaments: Performs a variety of tasks requiring frequent change to monitor equipment. Follows specific instructions to operate equipment.

Physical Activities and Environmental Conditions: Work is sedentary and only occasionally is the worker required to exert physical strength in making adjustments to such equipment as separator valves and air slides. Reaching and handling of controls in control room is involved when making adjustments on operating equipment. Near acuity of vision is required when monitoring sections of panelboards to read recording and indicator instruments.

CENTRAL CONTROL OPERATOR
579.782
(*6-67)

Job Definition

Controls the operation of conveyor systems, feeders, raw grinding mills, rotary kilns, finish mills, and auxiliary equipment, from panelboard in central room to convey, grind, and blend raw materials, fuse raw materials into clinker, and to grind clinker into finished cement, following on-line processing computer data, and observing closed-circuit television and electronic and electrical recorders and indicators: Presses buttons and moves controls to start rock-storage conveyor system to convey crushed limestone, shale, and clay to storage bins, draw raw materials from storage bins for blending purposes, and to convey materials to raw mill-feet silos. Observes signal lights, level indicators, and weightometer reading to detect equipment malfunctions in system, determine bin levels, and to determine rate of flow of materials, and adjusts controls, as required, to obtain specified operating efficiency. Presses buttons to start raw grinding mills and auxiliary equipment, such as conveyor system, and feeders, to proportion, blend, and grind raw materials. Presses buttons and switches to start rotary kilns and auxiliary equipment, such as draft fans, kiln feeders, preheaters and cooling systems in prescribed sequence to prepare for burning operations. Observes gages, indicators, and recorders on panelboard and inside of kilns through closed-circuit television and adjusts kiln controls following data recorded on printout of online processing computer to obtain highest quality clinker. Presses buttons and moves controls to start conveyor systems to convey clinker through coolers to storage silos, and to draw clinker from storage silos and convey it to finish mills. Presses buttons to start finish mills. Turns controls to regulate rate of clinker feed into mill so that cement of specified fineness is obtained. Presses buttons and turns controls to control operation of dust collector and separator systems and to reclaim salvageable materials. Presses buttons and turns controls to pump finished cement into storage silos. Notifies supervisory personnel when equipment requires major repair work. Gives work direction to ASSISTANT CENTRAL–CONTROL OPERATOR in performing duties.

Education, Training, and Experience

High school graduation is usually required.

Source of workers: Experienced kiln-burners. Such workers selected would receive two months' additional

* This job is new to the economy. It did not exist in the time of the 2nd edition (and hence was not included in the DOT).

training by representatives of the manufacture of the machine. Workers without this specific experience would not be qualified for this occupation.

Special Characteristics

Aptitudes: Verbal ability is required to comprehend operating instructions from operation manuals and manufacturer's guides. Numerical ability is required at the level of arithmetic to prepare operating records. An understanding of data processing symbols is essential to discuss operating difficulties with maintenance personnel. Clerical perception is required to adhere to operating instructions. Manual and finger dexterity is required to operate controls of panelboards.

Interests: A preference for working with machines and processes to continuously operate and monitor the equipment that comprises the automated system. Interest in activities of concrete and organized nature to operate equipment according to operating instructions in manuals and manufacturer's guides.

Temperaments: Performs a variety of tasks subject to change in the operation of panelboards. Adheres to high level of accuracy to operate systems effectively. Applies specified predetermined actions in the event of equipment malfunctions.

Physical Activities and Environmental Conditions: Work is sedentary as physical effort is limited to pushing buttons and adjusting controls. Frequent walking and standing is required in reading indicators and recorders in the various sections of the panelboards covering three sides of the control room. Reaching and handling of controls is involved to start up, adjust, or change operation of systems. Talking and listening is involved in the direction of the ASSISTANT CENTRAL-CONTROL OPERATOR and other workers stationed at kiln and grinding stations. Near accuity of vision is required to read instruments and recorders while adjusting controls. Work is performed in an enclosed air-conditioned control room that is soundproof.

COMPUTER MAINTENANCE MAN
828.281
(5-83.444)

Job Definition

Inspects, tests, adjusts, and repairs electronic digital computer and related electronic instrumentation used to control automated processes in manufacturing cement, following schematics, diagrams, and handbook instructions: Inspects computer and related instrumentation to locate causes of malfunction. Solders faulty or loose connections, files contacts, or adjusts phasing, using handtools and soldering iron. Tests suspected circuits and components, using oscillators, signal generators, oscilloscopes, and following schematic diagrams. Replaces defective parts, such as tubes, coils, resistors, and capacitors. Writes reports showing maintenance work performed. Cleans accessible parts of computer daily with solvent.

Education, Training, and Experience

High school graduation is usually required.

Source of workers: Journeyman electricians. Workers selected would receive an additional two months of on-the-job training given by representatives of the manufacturer of the computer.

Special Characteristics

Aptitudes: Verbal ability is required to comprehend technical data from manufacturer's operating and repair manuals and confer with operating personnel regarding computer malfunctions. Numerical ability is required to prepare and solve formula requiring use of algebra and trigonometry. Spatial ability is required to visualize circuitry of computer from schematics and diagrams. Form perception is required to recognize computer components in relationship to other computer components and to detect malfunctions. Finger and manual dexterity is required to use small tools and a variety of electrical and electronic equipment in maintaining computer in specified operation. Clerical perception required to perceive print-out data. Color discrimination required to recognized color-coded wiring.

Interest: Interest in scientific and technical subjects. Keeps abreast of development in field by reading technical journals concerned with the repair of electronic equipment.

Temperaments: Performs a variety of tasks to diagnose equipment failure using test equipment such as voltmeters, oscillators, and oscilloscopes. Makes decisions concerning performance of equipment based on reference manuals and tests. Works to precise and established standards of accuracy following specifications.

Physical Activities and Environmental Conditions: Work is light, but involves frequent standing and walking, and requires lifting of tools and equipment weighing up to 15 pounds. Reaching and handling involved in repairing computer or installing components. Near visual acuity required when installing components and tracing out circuits, and in reading precision measuring instruments. Work is inside.

CRUSHER OILER
570.885
(*6-67)

Job Definition

Performs the following duties involved in crushing raw materials, such as limestone, clay, and shale, in an automated cement plant: Starts crusher system equipment, such as secondary crushers, vibratory screens,

* This job is new to the economy. It did not exist in the time of the 2nd edition (and hence was not included in the DOT).

feeders, and conveyors, as directed by CRUSHER OPERATOR. Observes operating equipment for indications of malfunctions and notifies CRUSHER OPERATOR of irregularities found. Adjusts equipment as directed. Performs minor equipment repairs, using handtools. Assists maintenance and repair personnel during major repairs of equipment. Greases conveyors, feeders, and other equipment of the crushing system using greasegun and fills oil reservoirs. Occasionally relieves CRUSHER OPERATOR for short periods.

Education, Training, and Experience

High school graduation is preferred.

Source of workers: Experienced maintenance helpers. Such workers selected would receive four to six months' on-the-job training to learn the operation of the system. Generally, any worker having this type of experience in the cement industry would qualify.

Special Characteristics

Aptitudes: Verbal ability is required to confer with operating personnel regarding equipment startups and equipment malfunctions. Manual dexterity is required in making minor repairs to equipment with handtools and in starting equipment.

Interests: A preference for working with machines and processes to continually maintain and adjust conveyors, feeders, and other parts of crushing system. Interest in activities of concrete and organized nature to maintain and repair equipment according to specific instructions.

Temperaments: Performs a variety of tasks to repair equipment and start equipment following specific instructions. Works to precise standards of repairing equipment indicated by repair manuals and instructions.

Physical Activities and Environmental Conditions: Work is medium, involving almost continuous walking, standing, and lifting parts and tools weighing up to 20 pounds. Worker is required to climb a ladder 125 feet to the top of the screening tower to inspect vibratory screens and feeders. Reaching and handling involved in adjusting equipment of system and in using tools to make repairs. Working area is continually noisy due to vibratory screens and crushers operating. Dust continually in air from crushing and screening operations.

CRUSHER OPERATOR
570.885
(6-67.030)

Job Definition

Controls the operation of primary and secondary crushers, and related auxiliary equipment from panelboard, to crush quarried limestone and shale to specified size for making cement: Presses buttons and switches to start, in prescribed sequence, such equipment as primary reducing mills and secondary reducing mills, vibratory screens, conveyor feeders, and conveyors. Signals workers to dump materials into crusher. Observes composition of material dumped into crusher to detect variations in the amount of clay, shale, or limestone and notifies supervisory personnel as required. Observes lights on panelboard to insure that equipment is operating in prescribed manner. Clears chokeups in crusher with bar or directs operator of crane in clearing chokeups. Inspects equipment at prescribed intervals to detect operating irregularities and notifies supervisory personnel when conditions require attention by other personnel. Directs other workers in oiling and greasing equipment. Writes daily report on tonnage of rock crushed. Occasionally operates overhead crane to clear chokeups.

Education, Training, and Experience

High school graduation is usually required.

Source of workers: Experienced primary or secondary crusher operators. Workers selected would receive additional on-the-job training of three weeks to learn the operation of the system. Workers without this specific experience would not qualify.

Special Characteristics

Aptitudes: Verbal ability is required to comprehend work orders regarding crushing operations, and in directing workers concerned with oiling and greasing equipment in crushing system. Manual and finger dexterity is required in adjusting controls and in clearing chokeups in system with prybars.

Interests: A preference for working with machines and processes to continually operate and monitor crushing equipment. Interest in activities of concrete and organized nature to consistently operate equipment according to established operating procedures.

Temperaments: Follows work orders and set procedures to crush cement. Works to precise and established standards in operating crushing system to crush rock to specified size.

Physical Activities and Environmental Conditions: Work is sedentary. Some physical exertion is required in clearing chokeups in system with prybar weighing about 15 pounds. Worker spends most of the time either standing or walking. Reaches and handles controls to adjust operation of system. Near acuity of vision is required to read gages and indicators. Work area is noisy from equipment operating, making it difficult to conduct conversation in ordinary tones. Atmospheric conditions are dusty.

ELECTRONICS MAINTENANCE MAN
828.281
(5-83.444)

Job Definition

Installs, calibrates, and maintains electronic equipment such as closed-circuit television systems, amplifiers, level-indicator devices, and electronic instruments used in controlling the manufacturing processes in a cement plant, following layout diagrams, schematics, and installation manuals: Installs and alines equipment, such as cameras, transmitters, receivers, and amplifying and indicating devices in various plant locations, such as central control room, kilns, bins, and silos, using signal generators, oscillators, and handtools, and applying knowledge of plant layout. Tests installed equipment and instruments, using oscilloscopes, tube testers, voltmeters, and analyzers, and makes adjustments as necessary. Diagnoses malfunctioning equipment and repairs or replaces defective parts such as tubes, coils, condensers, and capacitors. Solders loose connections. Writes report showing maintenance work performed.

Education, Training, and Experience

High school graduation is required.

Source of workers: Journeyman electricians. Workers selected would receive additional on-the-job training in maintaining the various electronic equipment in the plant until they become proficient. Generally, other workers having experience in maintaining industrial electronic equipment would qualify.

Special Characteristics

Aptitudes: Verbal ability is required to comprehend technical data from manufacturer's operating and repair manuals. Numerical ability is required to prepare and solve formulas requiring use of algebra and trigonometry. Spatial ability is required to visualize circuitry and components of the various equipment from blueprints and schematic diagrams. Form perception is required to recognize equipment malfunctions. Finger and manual dexterity is required to use small tools and a variety of electrical equipment installations.

Interests: Interest in scientific and technical subjects. Keeps abreast of development in field by reading technical journals and manufacturer's catalogs concerned with the repair of electronic equipment.

Temperaments: Performs a variety of tasks to diagnose equipment failures. Makes decisions in regard to causes of malfunctions based on own knowledge, test data, and manuals. Must perform maintenance and repairs to exacting standards indicated by written specifications.

Physical Activities and Environmental Conditions: Work is light. Frequent standing and walking, and lifting of tools and equipment weighing up to 15 pounds are involved. Frequently climbs to heights of seven or eight feet and balances self when repairing equipment. Reaching and handling of tools is involved in maintenance and repair of electronic equipment and instrumentation. Near visual acuity is required when installing electronic components, tracing out electronic circuitry, and in reading precision measuring equipment. Worker performs duties around operating equipment where noise frequently exceeds 90 decibels. Worker is subject to shocks when working on high voltage equipment.

GRINDING UTILITYMAN
921.883
(7-88.210)

Job Definition

Maintains grinding machinery and auxiliary equipment in an automated cement manufacturing plant: Observes and inspects operating equipment such as feeders, conveyors, separators, and air slides for evidences of abnormal conditions such as lubrication leaks, material chokeups, material spills, and other failures. Repairs or replaces defective parts that can be made safely while equipment is operating, using handtools. Notifies supervisory personnel or CENTRAL-CONTROL OPERATOR when equipment needs major repairs. Adjusts operating equipment, such as air slides, separator valves, and other flow apparatus as directed by CENTRAL-CONTROL OPERATOR. Greases equipment such as material feeders and conveyors, and fills bearing reservoirs with oil. Unclogs chokeups with bar and cleans up material spills with shovel. Assists maintenance and repair personnel during major repairs.

Education, Training, and Experience

High school graduation is preferred.

Source of workers: Experienced maintenance helpers. Such workers selected would receive two to three months' on-the-job training to learn the maintenance of the system. Generally, any workers having maintenance experience in the cement industry would qualify.

Special Characteristics

Aptitudes: Verbal ability is required to confer with operating personnel regarding equipment malfunctions. Spatial ability is required to detect malfunctions in equipment. Manual and finger dexterity is required in using handtools to repair and adjust air slides, separator valves, and other flow apparatus.

Interests: A preference for working with machine and processes to continuously maintain and adjust grinding machinery and auxiliary equipment. Interest in activities of concrete and organized nature to maintain and repair equipment according to specific oral instructions.

Temperaments: Performs a variety of tasks to repair equipment, following work orders and oral instructions. Works to precise standards of repairing equipment indicated by repair manuals and instructions.

Physical Activities and Environmental Conditions: Work is medium. Constant walking throughout kiln area to observe and inspect the operation of equipment is involved. Lifts and carries tools and parts weighing up to 25 pounds. Frequently climbs to various levels in the kiln area to inspect and repair equipment. Reaching and handling are required in adjusting and repairing equipment. Work area is noisy due to machinery and equipment in operation.

KILN UTILITYMAN
921.883
(7-88.210)

Job Definition

Maintains rotary kilns and auxiliary equipment in an automated cement manufacturing plant: Observes and inspects the operation of kilns and equipment, such as kiln feeders, preheaters, clinker coolers, fans, feed and clinker conveyors for evidences of abnormal conditions, such as lubrication leaks, material chokeups, and material spills. Feels bearings for evidence of overheating. Repairs or replaces defective parts that can be made safely while equipment is operating, using handtools. Notifies CENTRAL-CONTROL OPERATOR when major repairs are required. Unclogs chokeups with bar and cleans up material spills with shovel. Adjusts the operation of conveyor and feeders as directed by CENTRAL-CONTROL OPERATOR. Greases conveyors, feeders, and other equipment with greasegun and fills bearing reservoirs with oil. Assists maintenance and repair personnel during major repairs of equipment and relining of kilns.

Education, Training, and Experience

High school graduation is preferred.

Source of workers: Experienced maintenance helpers. Such workers selected would receive two to three months' on-the-job training to acquire experience maintaining kiln equipment. Generally, any worker having maintenance experience in the cement industry would qualify.

Special Characteristics

Aptitudes: Verbal ability is required to confer with operating personnel regarding equipment malfunctions. Spatial ability is required to detect malfunctions in equipment. Manual and finger dexterity is required in using handtools to repair machinery and to adjust separator valves or air-slide equipment.

Interests: A preference for working with machines and processes to continuously maintain and adjust rotary kilns and auxiliary equipment. Interest in activities of concrete and organized nature to maintain and adjust equipment according to specific instructions.

Temperaments: Performs a variety of tasks to repair such equipment as feeders, coolers, and conveyors, following work orders and oral instructions. Works to precise standards of accuracy indicated by repair manuals and instructions.

Physical Activities and Environmental Conditions: Work is medium. Constant walking throughout the grinding department to observe the operation of the machinery and equipment is involved. Duties also require the worker to lift and carry tools and parts weighing up to 25 pounds. Worker frequently climbs to the various operating levels in the grinding department to inspect and repair equipment. Reaching and handling are required in adjusting and repairing equipment. Working area is noisy due to machinery and equipment in operation.

LOADING AREA HELPER
914.887
(8-67.01)

Job Definition

Performs the following duties as directed by the LOADING-AREA OPERATOR: Opens doors or handhole plates on railroad cars or tank trucks and inspects their interiors for cleanliness. Washes interiors with water when necessary. Spots railroad cars on railroad scales using powered car mover or directs spotting of tank trucks on truck scales for bulk loading of cement. Closes and fastens doors and handhole plates and affixes seals to tank cars or railroad cars after they have been loaded with cement. Sweeps loose cement from tops of cars and trucks. Cleans area around truck and railroad scales with power sweeper.

Education, Training, and Experience

High school graduate is preferred.

Source of workers: Generally, no experience requirements for entry into this occupation, but any experience in lower level jobs in the cement industry is desirable.

Special Characteristics

Aptitudes: Manual dexterity is required in performing cleaning duties and spotting railroad cars.

Interests: A preference for activities of a routine concrete, organized nature to continuously perform the duties involved in washing trucks and railroad cars, spotting railroad cars, and cleaning work areas, according to specific instructions.

Temperaments: Worker must adjust to a repetitive work routine following specific oral instructions.

Physical Activities and Environmental Conditions: Work is heavy, involving constant physical exertion due to the nature of the job. The worker is constantly standing or walking, and lifting tools and materials weighing up to 20 pounds. The worker is frequently required to climb on and off railroad cars in performing duties. Reaching and handling are involved in cleaning duties and in using power sweeper.

LOADING AREA OPERATOR
914.885
(6-67.130)

Job Definition

Controls the operation of weighing hoppers and feeder and conveyor systems from panelboard to weigh and load bulk cement into tank trucks or railroad cars, and transfer cement from storage silos to packinghouse silos, or to recirculate cement between storage silos, following work orders: Reads dray ticket or bill of lading to determine the type and tonnage of cement to be loaded. Signals workers to spot tank truck on truck scale or to spot railroad car on railroad scale. Moves control to lower loading spout into opening on top of truck or railroad car. Sets selector switch to draw cement from specified bin and pushes buttons to start feeder and conveyor system to load truck or railroad car with specified tonnage of cement. Stops equipment when cement has been loaded and pushes buttons on scale control panel to automatically weigh and record tonnage of cement loaded. Turns controls to start up feeder and conveyor systems to transfer cement from storage silos to packinghouse silos or to loading bins or to recirculate cement between storage silos. Observes level indicators and notifies supervisory personnel when silos are running out of cement so that cement can be drawn from other silos. Prepares daily report of loading activities. Gives work instructions to LOADING-AREA HELPER.

Education, Training, and Experience

High school graduate is preferred.

Source of workers: Experienced bulk-cement loaders. Workers selected would receive two months' on-the-job training to learn bulk loading and transfer system.

Special Characteristics

Aptitudes: Verbal ability is required to understand oral and written instructions to perform duties. Clerical perception is required in noting dray tickets and bills of lading to load cement from specified bins. Finger and manual dexterity is required to flip switches and move controls to perform loading operations.

Interests: A preference for working with machines and processes to continuously weigh and load bulk cement into railroad cars and trucks. Interest in activities of a concrete and organized nature to weigh and load cement following specific work orders.

Temperaments: Follows written or oral instructions specifying type and tonnage of cement to load. Works to established standards of accuracy in loading cement.

Physical Activities and Environmental Conditions: Work is light. Reaching and handling are involved in setting selector switches and moving controls to start conveyor systems and feeders. Near visual acuity is required in reading gages and indicators and setting speeds of equipment. Work is performed inside.

SUMMARY

Analysis of data obtained through research and data collected during the study reveals that manufacturers of cement, like those in so many other industries, are automating their manufacturing processes. In fact, it may be stated that the cement industry is going through one of the greatest remodernization eras that could be experienced by any industry.

Management of one of the companies stated, "When one of the companies in this area becomes fully automated, all the rest of us must do likewise to remain in a competitive position." There are several reasons for this trend, but one of the most important is the very rigid standards established by the construction industry and the government for the quality and characteristics of the cement the companies produce. Cement is being used more and more in the construction industry and more uses are being developed every year. Architectural designs using concrete that would have been fantasy in yesteryears are, in fact, reality today.

Stringent quality control practices are not new to the cement industry. The industry has always leaned toward highly mechanized equipment for quality control purposes. When highly mechanized equipment was installed a few years ago, workers were required only to manually operate or monitor this type of equipment. This type of equipment eliminated workers that were feeding materials into various equipment or operating materials handling equipment such as conveyors, hoists, and feeders.

With the development of reliable electronic and electrical instrumentation and remote control systems, even more radical changes occurred. The on-station worker is no longer needed to operate or monitor this latest equipment.

In automating its cement manufacturing plant, the ABC Cement Company's goal was to achieve the industry's highest standards of quality. The greatest single element responsible for the company reaching that goal was the installation of an on-line digital computer to keep a watchful eye on every facet of the cement-making process. Many other benefits, in addition to a far more rigid control on the quality of cement produced, were derived. Some of these benefits were: Kilns were operated more efficiently; nonproductive downtime for maintenance and repair was reduced; costs of maintenance and repair were reduced; and average production was increased.

In comparing the staffing requirements of the ABC plant with the conventional type cement plant staffing requirements, it is obvious that certain workers are not necessary in a completely automated cement plant. Available employment figures of the ABC plant indicate a decrease in employment of about 13 percent. Changeover to automated systems in this industry implies a definite reduction of on-station workers.

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INDEX OF OCCUPATIONAL TITLES

APPENDIX

Worker Traits

Aptitudes:

1. Verbal. Ability to understand meanings of words and ideas associated with them, and to use them effectively. To comprehend language, to understand relationships between words, and to understand meanings of whole sentences and paragraphs. To present information or ideas clearly.

2. Numerical. Ability to perform arithmetic operations quickly and accurately.

3. Spatial. Ability to comprehend forms in space and understand relationships of plane and solid objects. May be used in such tasks as blueprint reading and in solving geometry problems. Frequently described as the ability to "visualize" objects of two or three dimensions, or to think visually of geometric forms.

4. Form Perception. Ability to perceive pertinent detail in objects or in pictorial or graphic material. To make visual comparisons and discriminations and see slight differences in shapes and shadings of figures and widths and lengths of lines.

5. Clerical Perception. Ability to perceive pertinent detail in verbal or tabular material. To observe differences in copy, to proofread words and numbers, and to avoid perceptual errors in arithmetic computation.

6. Motor Coordination. Ability to coordinate eyes, and hands or fingers rapidly and accurately in making precise movements and with speed. Ability to make a movement-response accurately and quickly.

7. Finger Dexterity. Ability to move the fingers and manipulate small objects with the fingers rapidly or accurately.

8. Manual Dexterity. Ability to move the hands easily and skillfully; to work with the hands in placing and turning motions.

9. Eye-Hand-Foot Coordination. Ability to move the hand and foot coordinately with each other in accordance with visual stimuli.

10. Color Discrimination. Ability to perceive or recognize similarities or differences in colors, or in shades or other values of the same color. To identify a particular color, or to recognize harmonious or contrasting color combinations, or to match colors accurately.

11. Intelligence. General learning ability. The ability to "catch on" or understand instructions and underlying principles. Ability to reason and make judgments. Closely related to doing well in school.

Interests:

1. Situations involving a preference for activities dealing with things and objects. vs. 6. Situations involving a preference for activities concerned with people and the communication of ideas.

2. Situations involving a preference for activities involving business contact with people. vs. 7. Situations involving a preference for activities of a scientific and technical nature.

3. Situations involving a preference for activities of a routine, concrete, organized nature. vs. 8. Situations involving a preference for activities of an abstract and creative nature.

4. Situations involving a preference for working for people for their presumed good, as in the social welfare sense, or for dealing with people and language in social situations. vs. 9. Situations involving a preference for activities that are nonsocial in nature, and are carried on in relation to processes, machines, and techniques.

5. Situations involving a preference for activities resulting in prestige or the esteem of others. vs. 10. Situations involving a preference for activities resulting in tangible productive satisfaction.

Temperaments:

1. Situations involving a variety of duties often characterized by frequent change.

2. Situations involving repetitive or short-cycle operations carried out according to set procedures or sequences.

3. Situations involving doing things only under specific instruction, allowing little or no room for independent action or judgment in working out job problems.

4. Situations involving the direction, control, and planning of an entire activity or the activities of others.

5. Situations involving the necessity of dealing with people in actual job duties beyond giving and receiving instructions.

6. Situations involving working alone and apart in physical isolation from others, although activity may be integrated with that of others.

7. Situations involving influencing people in their opinions, attitudes, or judgments about ideas or things.

8. Situations involving performing adequately under stress when confronted with the critical or unexpected or when taking risks.

9. Situations involving the evaluation (arriving at generalizations, judgments, or decisions) of information against sensory or judgmental criteria.

0. Situations involving the evaluation (arriving at generalizations, judgments, or decisions) of information against measurable or verifiable criteria.

X. Situations involving the interpretation of feelings, ideas, or facts in terms of personal viewpoint.

Y. Situations involving the precise attainment of set limits, tolerances, or standards.

Physical Activities Factors:

1. Lifting, Carrying, Pushing, and Pulling. These are the primary "strength" physical requirements, and generally speaking a person who engages in one of these activities can and does engage in all. Specifically, each of these activities can be described as:

Lifting—Raising or lowering an object from one level to another; includes upward pulling.

Carrying—Transporting an object, usually holding it in the hands or arms, or on the shoulder.

Pushing—Exerting force upon an object so that the object moves away from the force. This includes slapping, striking, kicking, and treadle actions.

Pulling—Exerting force upon an object so that the object moves toward the force; includes jerking.

The five degrees of physical activities factor No. 1 are as follows:

(a) Sedentary Work—Lifting 10 pounds maximum and occasionally lifting and/or carrying articles, such as dockets, ledgers, and small tools. Although a sedentary job is defined as one which involves sitting, a certain amount of walking and standing is often necessary in carrying out job duties. Jobs are rated sedentary if walking and standing are required only occasionally and all other sedentary criteria are met.

(b) Light Work—Lifting 20 pounds maximum with frequent lifting and/or carrying of objects weighing up to 10 pounds. Also, even though the weight lifted may be only a negligible amount, a job is rated in this category (1) when it requires walking or standing to a significant degree; or (2) when it requires sitting most of the time but entails pushing and pulling of arm and/or leg controls.

(c) Medium work—Lifting 50 pounds maximum with frequent lifting and/or carrying of objects weighing up to 20 pounds. Consideration (2) under light work may apply here.

(d) Heavy Work—Lifting 100 pounds maximum with frequent lifting and/or carrying of objects weighing up to 50 pounds.

(e) Very Heavy Work—Lifting objects in excess of 100 pounds with frequent lifting and/or carrying of objects weighing up to 50 pounds or more.

2. Climbing and/or Balancing. These activities are defined as follows:

Climbing—Ascending or descending ladders, stairs, scaffolding, ramps, poles, ropes, and the like, using feet and legs and/or hands and arms.

Balancing—Maintaining body equilibrium to prevent falling when walking, standing, crouching, running on narrow, slippery, or erratically moving surfaces; or maintaining body equilibrium when performing gymnastic feats.

3. Stooping, Kneeling, Crouching, and/or Crawling. These activities are defined as:

Stooping—Bending the body downward and forward by bending the spine at the waist.

Kneeling—Bending the legs at the knees to come to rest on the knee or knees.

Crouching—Bending the body downward and forward by bending the legs and spine.

Crawling—Moving about on the hands and knees or hands and feet. The activities in this factor involve full use of the lower extremities as well as the back muscles. Therefore, stooping rarely is rated when the worker is performing this act while in a sitting position.

4. Reaching, Handling, Fingering, and/or Feeling. These activities involve the use of one or both of the upper extremities and are defined as follows:

Reaching—Extending the hands and arms in any direction.

Handling—Seizing, holding, grasping, turning, or otherwise working with the hands or hand (fingering not involved).

Fingering—Picking, pinching, or otherwise working with the fingers primarily (rather than with the whole hand or arm as in handling).

Feeling—Perceiving attributes of objects such as size, shape, temperature or texture by means of receptors in the skin, particularly those of the finger tips.

5. Talking and/or Hearing. These activities are defined as follows:

Talking—Expressing or exchanging ideas by means of spoken words.

Hearing—Perceiving the nature of sounds by the ear.

The ability to talk is important for those job-worker situations in which the individual must impart oral information to clients or to the public, and in those situations in which he must convey detailed or important spoken instructions to other employees accurately, loudly, or quickly.

Hearing is important for those job-worker situations which require the ability to receive detailed information through oral communication, and to make fine discriminations in sounds, such as making fine adjustments on running engines.

6. Seeing. Seeing is the ability to perceive the nature of objects through the eye. The more important aspects of vision are: (1) acuity, far or near; (2) depth perception; (3) field of vision; (4) accommodation; and (5) color vision. These aspects of vision are defined as follows:

Acuity, far is sharpness of vision at a distance of 20 feet or more.

Acuity, near is sharpness of vision at 20 inches or less.

Depth perception is three-dimensional seeing and is an important factor in judging distances and space relationships so as to see objects where and as they actually are. Two-eyed vision is involved here.

Field of vision is the area that can be seen up or down or to the right or left while the eyes are fixed on a given point.

Accommodation is the adjustment of the lens of the eye to bring an object into sharp focus. This item is especially important when doing near-point work at varying distances from the eye.

Color vision is the ability to identify and distinguish colors.

Environmental Condition Factors:

1. Work Location

Inside—Protection from weather conditions but not necessarily from temperature changes.

Outside—No effective protection from weather.

Inside is rated if the worker spends approximately 75 percent or more of his time inside. Outside is to be rated if the worker spends approximately 75 percent or more of his time outside. Those job-worker situations which may occur inside or outside are rated "B." Inside or outside should be interpreted as being synonymous with indoors or outdoors.

2. Extreme Cold With or Without Temperature Changes. These conditions are defined as follows:

Extreme cold — Temperature sufficiently low to cause marked bodily discomfort unless the worker is provided with exceptional protection.

Temperature changes—Variations in temperature which are sufficiently marked and abrupt to cause marked bodily reactions.

3. Extreme Heat With or Without Temperature Changes. These conditions are defined as follows:

Extreme heat — Temperature sufficiently high to cause marked bodily discomfort unless the worker is provided with exceptional protection.

Temperature changes—Variations in temperature which are sufficiently marked and abrupt to cause marked bodily reactions.

4. Wet and/or Humid. These conditions are defined as follows:

Wet—Contact with water or other liquids.

Humid—Atmospheric condition with moisture content sufficiently high to cause marked bodily discomfort.

5. Noise and/or Vibration. For this factor to be rated, there must be sufficient noise either constant or intermittent, to cause marked distraction or possible injury to the sense of hearing and/or sufficient vibration (which is the production of an oscillating movement or strain on the body or its extremities from repeated motion or shock) to cause bodily harm if endured day after day.

6. Hazards. This category includes a variety of industrial hazards, such as proximity to moving mechanical parts, electrical shock, working on scaffolding and high places, exposure to burns and radiant energy, and exposure to all types of explosives, all of which involve the risk of bodily injury.

7. Fumes, Odors, Toxic Conditions, Dust, and Poor Ventilation. These conditions are grouped because they all effect the respiratory system or the skin and are defined as follows:

Fumes—Smoky or vaporous exhalations, usually odorous, thrown off as the result of combustion or chemical reaction.

Odors—Noxious smells, either toxic or nontoxic.

Toxic conditions—Exposure to toxic dust, fumes, gases, vapors, mists, or liquids which cause general or localized disabling conditions as a result of inhalation or action on the skin.

Dust—Air filled with small particles of any kind, such as textile dust, flour, wood, leather, feathers, etc., and inorganic dust, including silica and asbestos, which make the workplace unpleasant or are the source of occupational diseases.

Poor ventilation—Insufficient movement of air causing a feeling of suffocation; or exposure to drafts.

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