# CONCEPTS OF A SINGLE-FLOOR FLOUR MILL

by

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B. S. Kansas State University, 1963

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A MASTER'S THESIS

submitted in partial fulfillment of the

requirements for the degree

MASTER OF SCIENCE

Department of Flour and Feed Milling Industries

KANSAS STATE UNIVERSITY

Manhattan, Kansas

1964

Approved by:

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## INTRODUCTION

A few years ago there were numerous small and medium capacity flour mills in the United States. These mills usually served local customers if they were small mills and trade territories if they were large mills.

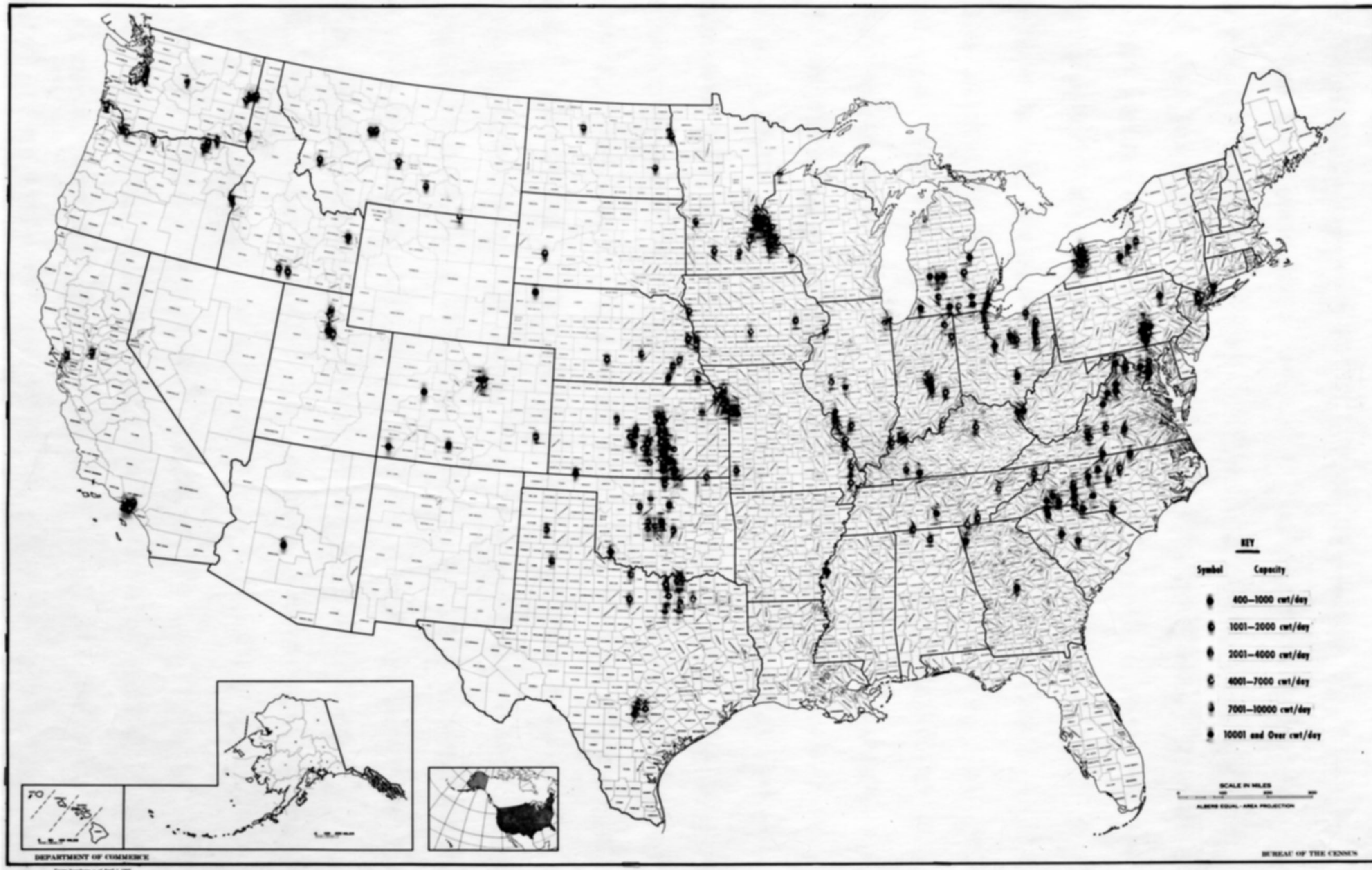
Today the number of mills is decreasing. Just recently two more medium capacity mills in Kansas ceased operations, yet other flour mills in the same town or state are doing business as usual. Why some mills succeed and others don't is a very complicated question to answer due to the number of factors involved. Some believe that there is an excess of milling capacity in the United States. Others say that labor may be the cause of mill operation problems, but neither is necessarily the answer.

Flour mill location plays a most important roll in the successful operation of a flour mill. Location is affected by such things as transportation rates, availability of grain, customer consumption areas, labor, taxes, power costs and others. The transportation rates rank high in importance. Kansas has several mills of medium size as compared to other parts of the United States (Plate I). This is natural because up until now a majority of flour mills have been built near the source of grain. It is also known that the majority of flour manufactured in Kansas is shipped to the Southeastern section of the United States to take advantage of "in transit" (i.e., milling on the direct route of shipment) transportation privileges which allow destination territory at the same total freight rate as for direct shipment. Millers and processors (13) assert that generally 10 percent, and for individual companies up to 25 percent, of their products are now sold in the destination territory. The "in transit" privileges have been in effect for shipments to the Southeastern United States for several years.

EXPLANATION OF PLATE I

Flour mill capacities and location in the United States (22).

PLATE I


KEY
Symbol
Capacity
400—1000 cwt/day
1001—2000 cwt/day
2001—4000 cwt/day
4001—7000 cwt/day
7001—10000 cwt/day
10001 and Over cwt/day
SCALE IN MILES
ALBERS EQUAL-AREA PROJECTION
DEPARTMENT OF COMMERCE
BUREAU OF THE CENSUS

It is generally agreed that the per capita consumption of flour increases as the income level decreases. Studies of income levels by Bogue and Beale (6) show that Georgia, Mississippi, Alabama, the Carolinas and part of Virginia have the lowest income levels in the United States. Thus the Southeast is the logical place to sell family flour products. Moreover, the southern states do not grow enough grain to meet their needs (13). Recently the Southern Railway announced proposed lower rates for shipment of whole grain from Mississippi River crossing points to the Southeast (13). These proposed rates have been vigorously contested by milling interests in Kansas since they do not allow "in transit" privileges and make it possible to ship grain to the Southeast at a cheaper rate than flour. "With lower rates on wheat than on flour, mills at or near the point of consumption would have an advantage over mills at or near the point of origin" (14). This discloses the problem facing the mills in Kansas: they are in many cases "out of position" and can't compete on an even basis with their counterparts in the Southeast. This is one of the most serious problems facing the milling interests in Kansas today. Clifford Hope, past president of Great Plains Wheat, Inc., stated (20), "... It would be ironical if at a time when Kansas is taking special interests to expand industry, it lost a substantial part of its second most important existing industry -- flour milling."

Other factors also determine the success of a flour mill. Availability of labor and laws governing it and availability and cost of power for operation are major factors. Condition of the actual physical plant is also important. A majority of the mills in operation now were built in the early 1900's, some of stone and brick with wooden floors. Although much of the machinery has been redesigned and modernized, many of the buildings housing it are as originally built. Many factors currently determine minimum construction and design limits. The Food and Drug Administration is now regularly inspecting the flour mills in this country for sanitation purposes. Buildings made wholly or in part of wood have many corners and concealed areas in which insect infestation might thrive. Mills with such antiquated buildings run the risk of being closed by the Food and Drug Administration because they are declared to be unsanitary and of undesirable construction. Much of the older equipment used in mills also presents problems in the area of insect infestations.

Insurance companies are also bringing pressure to bear on the owners of old wooden floored mills with outdated machinery. These mills must pay a high insurance premium since they burn much more readily than the newer concrete and masonry "fireproof" buildings. Smith (25) stated, "From old records which are available, we find that fires in flour mills were almost an everyday occurrence fifty to sixty years ago."

Many of the older buildings aren't suitable for expansion either. They are cluttered with equipment and leave little room for new machinery. In some cases a mill that would like to expand isn't able to do so because it lacks building space in existing structures and has no area in which to build an addition.

With the above problems in mind this research was carried on to determine the feasibility of building a new mill. A mill out of location has the choice of: 1) ceasing operations, 2) building a new mill elsewhere, or 3) purchasing an existing mill in the desired location. If a mill is forced to move or to rebuild for some reason it will seek to build the best, most efficient mill possible. In some circles the concept of a new building is one with several floors, but others feel that a single-floor mill would be very desirable because of the lower building costs, and more flexibility in layout. The present research is concerned with the feasibility of a single-floor mill.

## REVIEW OF LITERATURE

### Basic Processing Equipment

The basic equipment used in the milling process has changed very little in its functional purpose or constructions, although the appearances of the machines has changed considerably. Scott (24) stated, "The fact that there has been so little fundamental alterations in the process or the machines themselves is surely an indication that they have been reasonably well suited to the work they have been called on to do." Most of the equipment, with a few exceptions, used in flour milling today was invented before 1900.

Roller Mills. The first roller mills were very crude. Usually the chills were gear driven and held rigidly in place. They were driven by a belt from a shaft to one of the fast rolls and by a gear on the opposite journal meshed with one on the driven roll transmitted power to the other pair of rolls in the stand (8). The slow rolls were not powered and acted as drag rolls. Miller (21) stated that many of the first rolls failed because of excessive power requirements. There were heavy expenses of oiling and repairing rolls.

With improvements in construction the roller mill became common in flour mills. Feed rolls and spreading devices were adopted and a basic roller mill design evolved. One of the most commonly used roller mills in the United States for the last fifty years is the Allis double roller mill. A cross-section of this machine and its features is shown in Plate II. The stock entered the roller mill at the top and passed over a roll feeder to the rolls. This feeder had an adjustable gate which regulated the flow of stock and spread it into a thin sheet which fell onto the rolls. After passing through the rolls the stock fell into a hopper constructed in the base of the roller mill stand. From this hopper it was spouted by gravity through the floor to the next machine or boot of a bucket elevator.

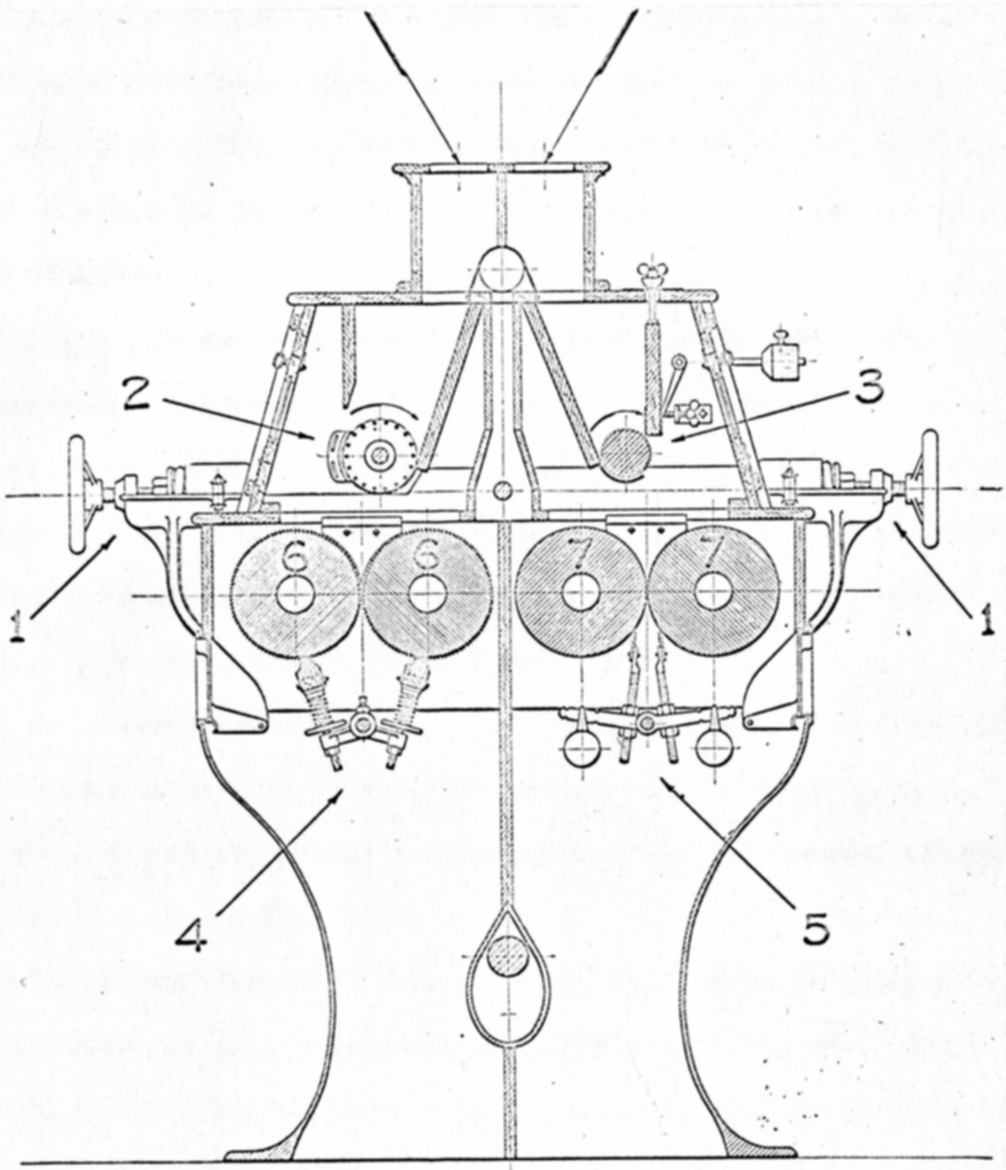
Scott stated (24) that modern roller mills are much better looking and more easily controlled than those of fifty years ago, but the basic operation remains about the same. It is built to combine lightness with strength and durability. The newer roller mills have many new features including water-cooled rolls, air and hydraulic roll settings, roller bearings, spring adjustments and automatic spreading devices. A modern 40 inch roller mill occupies about 120 cubic feet of floor area.

Standard drive fittings between rolls in the modern roller mill are simple helical gears. Some millers use chain drives since they are subject to less wear and quieter operation. A chain drive is essential when rolls run at high speeds (27). More about the driving of the roller mill itself is found in the section on equipment drives.

Sifters. The plansifter has almost entirely replaced reels and centrifugals in milling. It takes less space and provides more bolting surface. Through the years there have been many types of sifters. Included are self balancing, square, Universal, Monarch and others.

Early plansifters were operated by a fixed crank which made them operate with a fixed throw. Later the free-swing type of sifter came into use. It was driven by a central vertical shaft, supported by an overhead bearing, which powered self-balancing counterweights.

PLATE II




SECTIONAL VIEW
OF
ALLIS DOUBLE ROLLER MILL

1—Roll adjusting device.
2—Wire roll feeder.
3—Roll feeder.
4—Brushes under corrugated rolls.
5—Scrapers under smooth rolls.
6—Corrugated rolls.
7—Smooth rolls.

The plansifters were of two types: the self contained machines and those not self contained. The former are mounted in a frame and are independent and unattached to the building except for resting on the floor. If reeds are attached to the ceiling of the room the sifter is not a self contained machine.

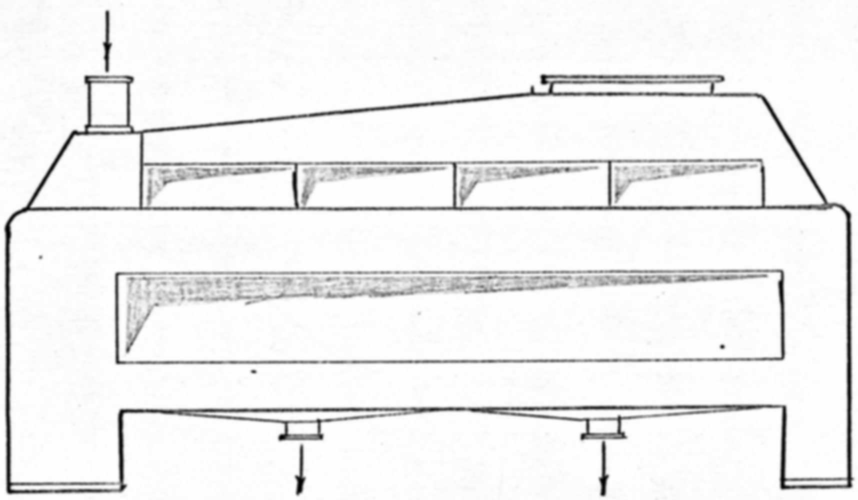
Purifiers. Kemeny (16) said, "The purifier is the most standardized, worst constructed and worst run machine in the world. Purification is dependent on aerated sieving and requires proper adjustment for good operation. The motion of a purifier is specially designed to keep the stock continuously agitated in a loose mass (18). This agitation is caused by an eccentric drive which makes the purifier screens reciprocate.

The air currents passing through the purifiers were first powered by individual fans in each purifier. The modern purifier normally doesn't have a fan, but is exhausted through a trunk system used for several purifiers and powered by a single fan.

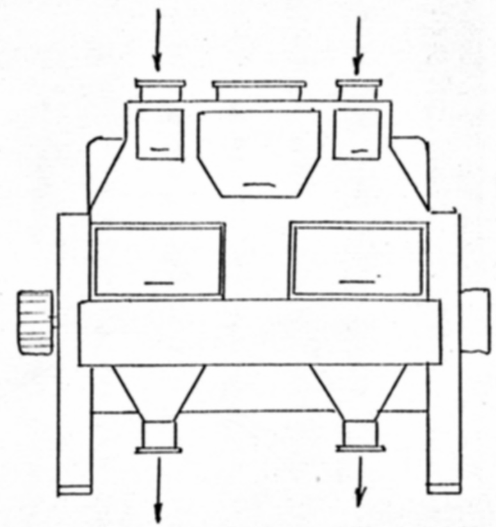
There have been changes in details and appearances, but even in the modern purifiers the same basic principles are used (23). The modern purifier is actually two separate machines, side by side in a common frame, driven by a single common shaft.

The stock is introduced to the machine through a feed gate at the high end of the reciprocating sieve. The stock either falls through the sieves or is tailed over the end of the sieve into a spout. The stock passing through the sieves falls into two hoppers running the length of the machine. This stock was collected by worms in the older machines, but now the hoppers themselves reciprocate and carry the stock to the outlet. Each hopper is built with two collecting channels and hinged flaps along the entire length

PLATE III



Side View



End View

A Modern Purifier

are moved from one side to the other to direct the stock into either of the channels (28). A modern purifier is shown in Plate III.

## Equipment Drives

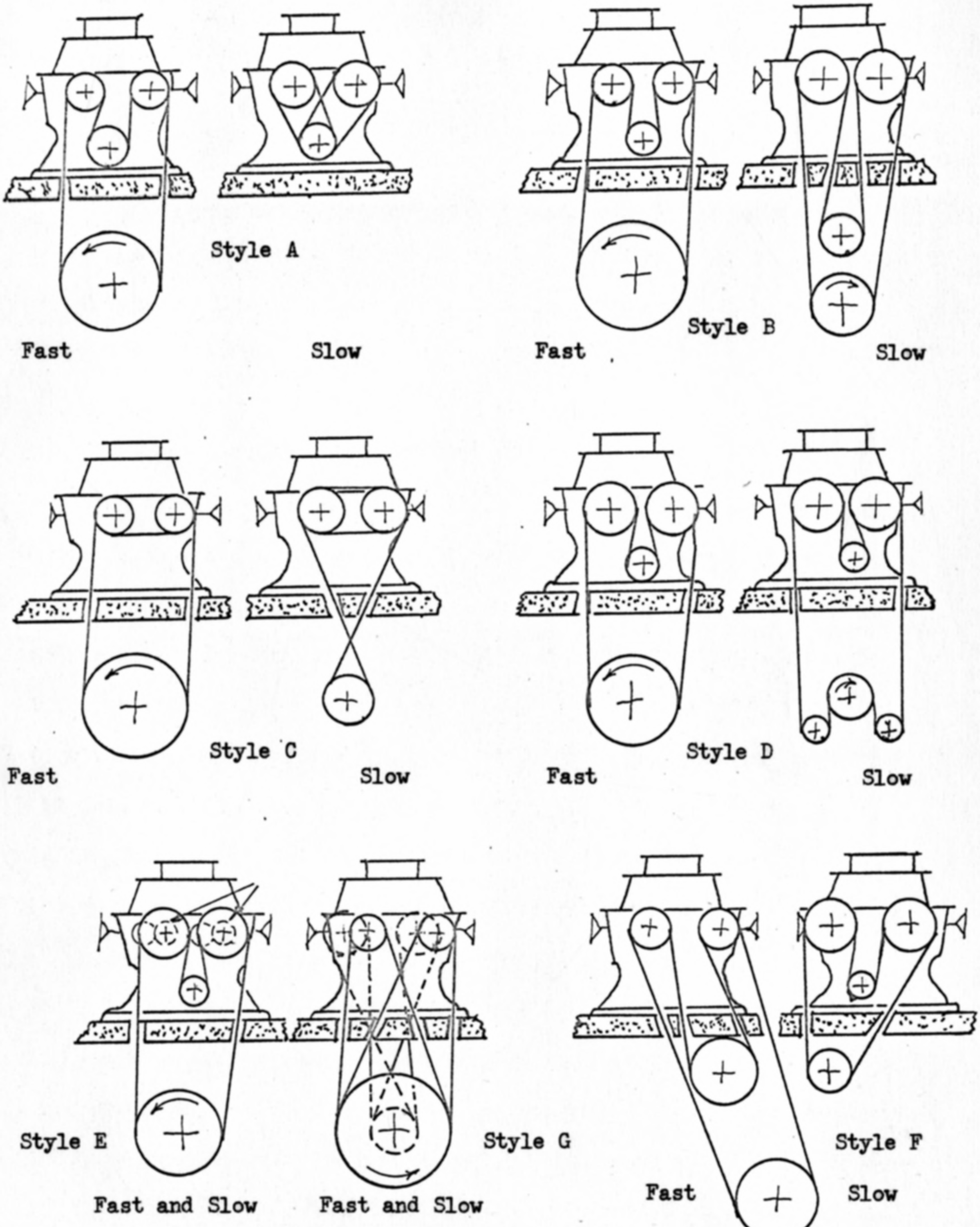
Until recently a majority of the machinery in the flour mill was driven by flat belts from a series of lineshafts. This gave rise to many styles of belt drives. Thought is now being given to using individual drives in the mill or possible group drives for certain machines.

Roller Mill Drives. The belt and lineshaft have been used almost exclusively for the driving of roller mills. In some cases separate belts were used to drive the slow and fast rolls. Many of the various types of belt roller mill drives used are shown in Plate IV. All of these drives require tight belting so no power is lost due to slippage.

Another method used to drive roller mills is shown in Plate V. It is the battery drive in which the rolls were set in line and coupled together. The battery drive system is a combination of individual style drives and lineshaft drives. This particular system required a high torque to start. One main disadvantage of the battery drive system is that no machine could be shut down independently, but it did eliminate the need for lineshafts and drive belts for each roller mill.

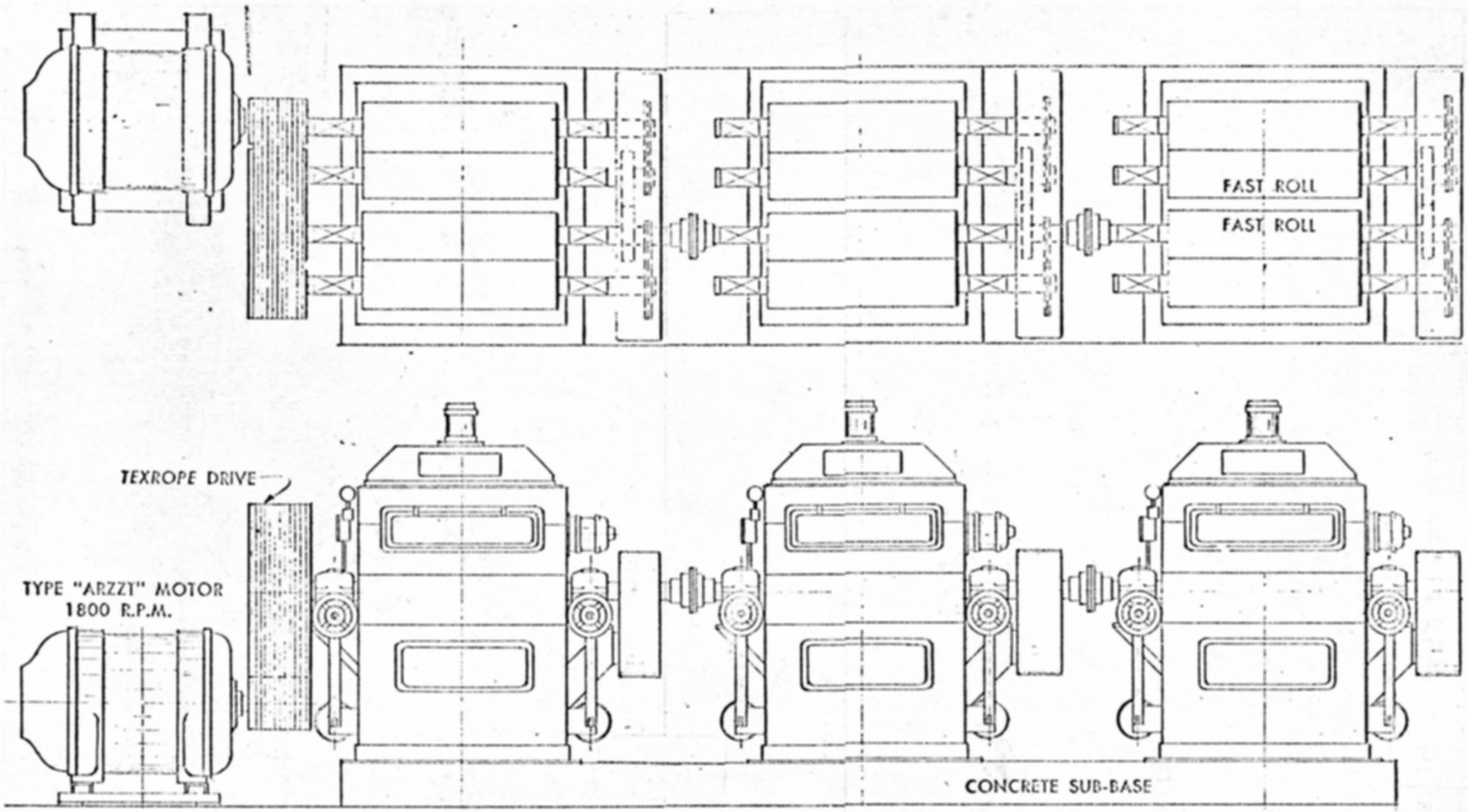
"It is in connection with roller mills that the main controversy regarding individual drives usually arises," said Donovan (9). The individual system had advantages in roller mill drives. Each motor can be sized according to the power needed for the machine. Belt transmission troubles are eliminated and push button control panels may be set up to centrally control each roller mill. A comparison of belt and individual roller mill drives is shown in Plate VI.

PLATE IV




Roller Mill Lineshaft Drives

PLATE V




**Battery Drive System For Roller Mills**

## PLATE VI

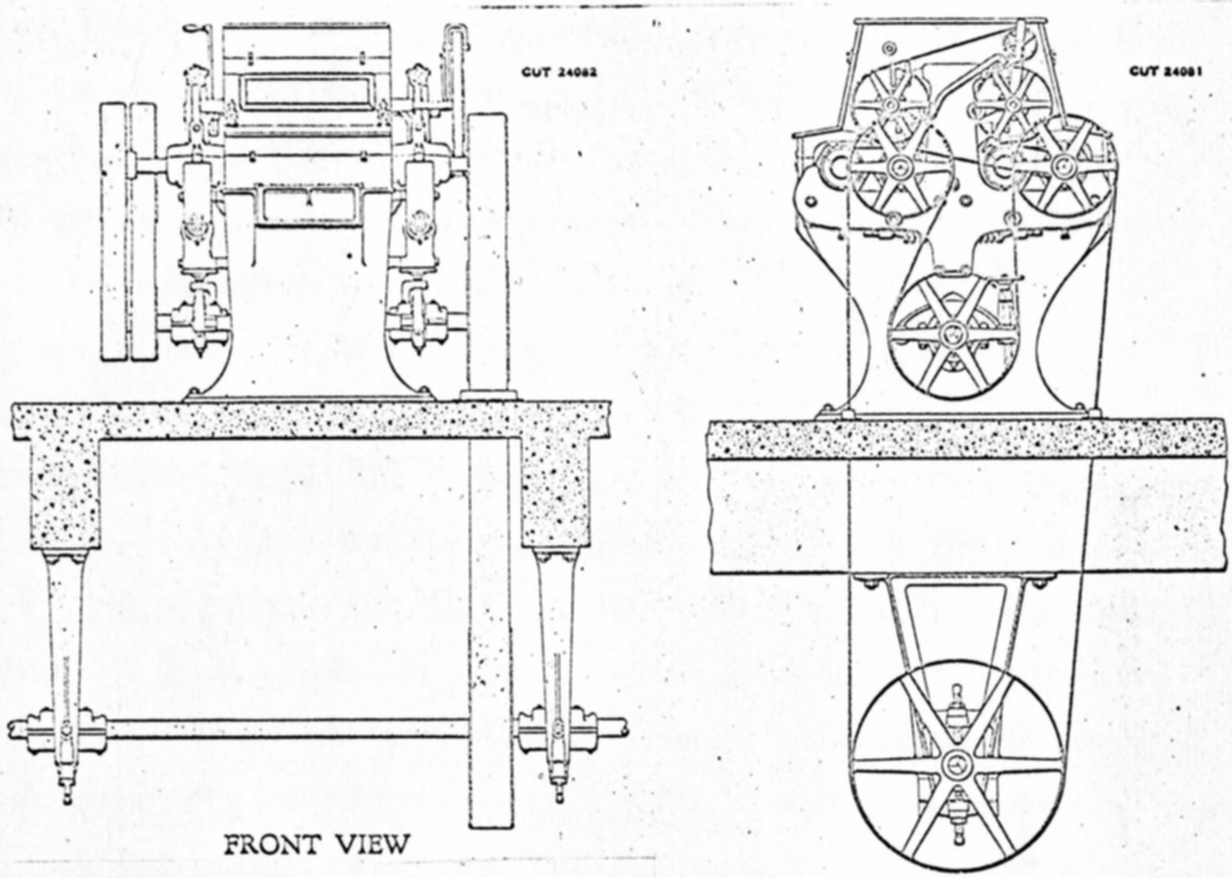



**Fig. 1 Lineshaft Drive**

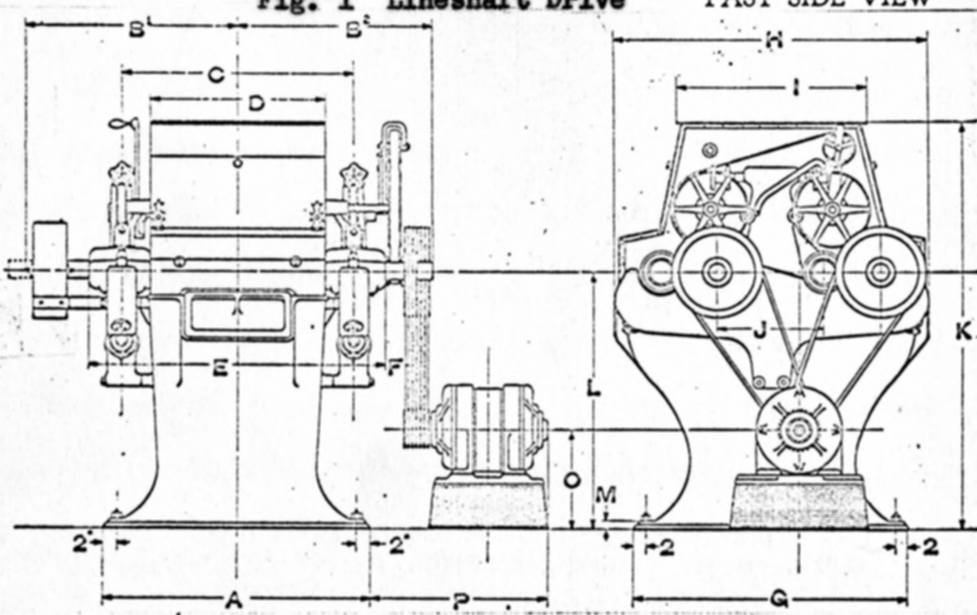



**Fig. 2 Individual Motor Drive**

**Comparison of Rollermill Drives**

<u>Sifter</u> <u>Drives</u>. The older sifters were usually driven from lineshafts too. This was done with a mule or a quarter turn drive. The belt drive arrangement used for sifter drives is shown in Figure 1, Plate VII. These drives often caused trouble because of the twisted belt drive which drove the sifter.

The trend now is to individual drives for sifters. An electric motor is mounted vertically in a frame suspended from the ceiling. V-belts are used to power a pulley which is also held in a rigid frame near the ceiling and transmits power to the sifter through universal joints and a drive shaft. A drawing of an individual drive arrangement is shown in Figure 2 of Plate VII.

<u>Purifier</u> <u>Drives</u>. Many of the old purifiers were laid out in a line in order that a small lineshaft could be used to power them. This called for more lineshafts and belt transmissions. Most of the new purifiers have self contained drives since there is adequate room inside to mount a motor.

<u>Other</u> <u>Equipment</u>. Most other equipment was driven by lineshafts too. Now most of the other machines are driven by individual drives since they are placed at random around the building and aren't always running.

<u>Lineshaft</u> <u>versus</u> <u>Individual</u> <u>Drives</u>. Donovan (9) stated, "Motors are infinitely more adaptable than lineshafting in meeting the current trend for machines to run at higher speeds, and variable speed drives are more easily adapted." A tremendous amount of lineshafting is required for a mill plus all of the hangers and belting arrangements of different sizes. Frictional transmission losses in lineshaft drives has been calculated to be between five and ten percent. This is an important factor in figuring power requirements and costs. The individual drive has the advantage of being a more positive drive with reduced friction. The individual drives are considered safer since there aren't as many bare pulleys and fast running belts.

## PLATE VII

### Sifter Drives

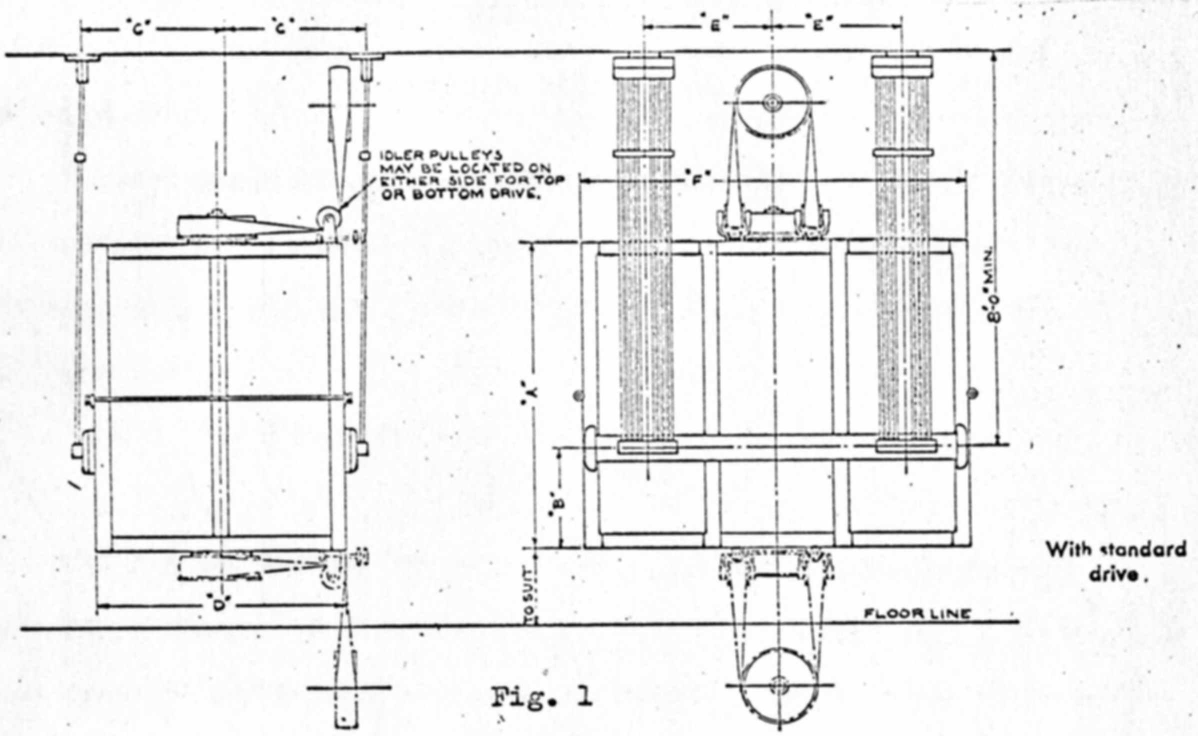



Fig. 1

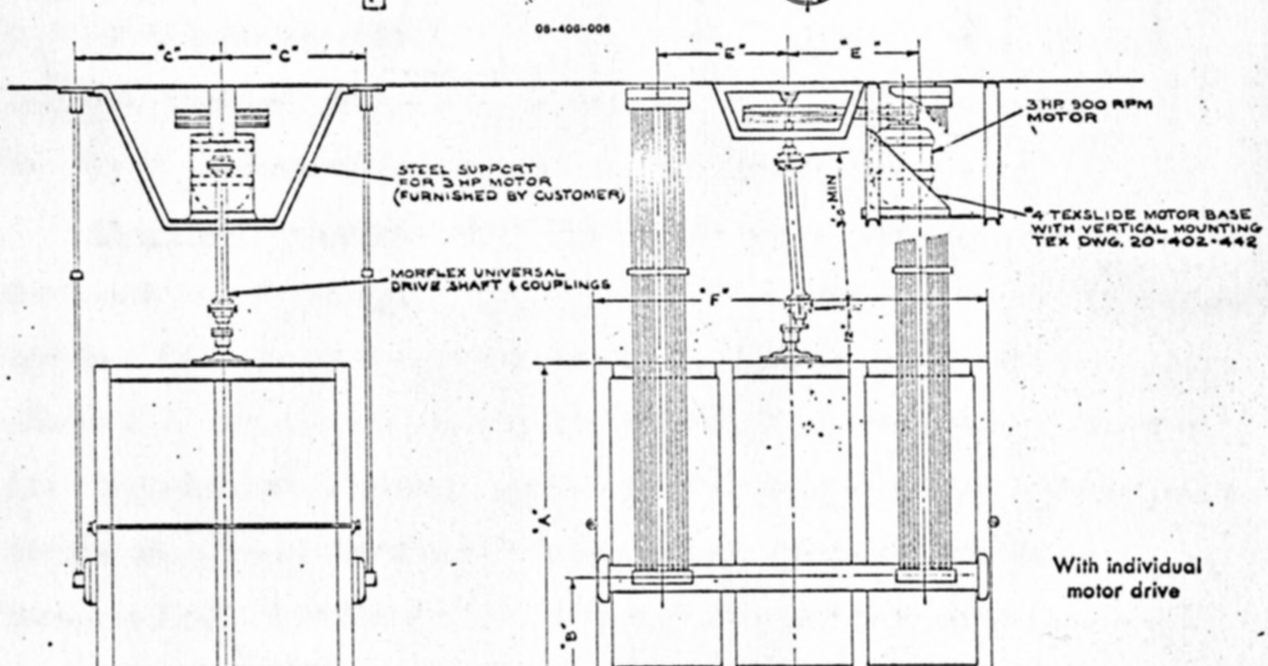



Fig. 2

The breakdown or failure of one motor in a mill with individual motors on each machine doesn't cause operations of the whole mill to cease. Even though a motor can be changed in about the same time as it requires to splice a belt, it is seldom that a motor fails if properly suited for the job it is doing.

In most cases the greater initial installation cost of individual drives as compared to lineshafts is more than compensated by maintenance costs of belting, oil, bearings and labor. Thus the individual drive continues to gain favor (9).

## Materials Handling

The milling process is very dependent on some method of conveying material. It would be impossible to operate a continuous system without some means of conveying stock between machines. For vertical conveying in a downward direction only spouting is needed. For horizontal and upward conveying some sort of conveyor is needed. This conveyor is normally of two types: mechanical conveyors and pneumatic conveyors.

Mechanical Conveyors. Many types of mechanical conveyors have been developed. These conveyors made possible the continuous automatic milling system. Prior to the development of these mechanical conveyors the mill stocks were collected in sacks and carried between the machines. "Therefore the arrangement and a correct calculation of dimensions of the transportation devices is of vital importance," stated Kozmin (17). The following paragraphs will describe some of the mechanical conveyors used.

The bucket elevator was used almost exclusively for vertical conveying in the flour mill until the advent of pneumatic conveying. It is actually a vertical belt powered by the turning of the head pulley or top pulley. The bottom pulley acts as an idler and is used to take up slack in the belt. Attached to the belt are cups and buckets which scoop up the stock at the bottom of the elevator and centrifugally discharge it at the top.

The origin of the screw conveyor isn't known, but it was used in Evan's "automatic mill" in the eighteenth century (21). It is actually a spiral screw enclosed in a fitted case. The flights of the spiral are wrapped around the hub like a ribbon on edge. As the screw turns it pushes the stock along the length of the conveyor. Miller (21) stated that few pieces of equipment in the mill or elevator suffer more from neglect than do screw conveyors. Most mills are undermanned making it impossible to properly do the necessary maintenance work.

Another type of conveyor often found in mills is the drag conveyor. It is used primarily with whole grain. The conveyor has a series of paddles connected by a chain moving along a trough and dragging the material with them.

The en masse conveyor can be used to convey stocks horizontally and up an incline. The motive force in this conveyor is a series of skeleton links that become buried in the material within the carrying run (12). The material is moved along in a solid column.

Belt conveyors are often used to carry whole grain and sacked flour. They are actually belts running in a horizontal position over a series of roller supports. Some of these belts have automatic trippers which cause the conveyor to dump at a certain point.

In some instances a vibrating conveyor is used to move the stock. It consists of a trough set at a slight incline and vibrated to keep the stock in motion.

The zipper conveyor consists of a flat base belt with two flexible side walls hinged to its edges (19). It is driven by ordinary pulleys in a manner similar to a belt conveyor. The system is very flexible and can be run in most any area with the discharages being moveable to any position along the horizontal run.

A recent invention is the air slide hopper. It is an enclosed inclined tube with minute air jets along the bottom. These jets keep the stock in the conveyor fluidized and the force of gravity causes the stock to move down the incline. This conveyor has no moving parts and could be classified under air conveyors. It requires about 15 degree incline so that it isn't practical for long runs.

A recently developed conveying system using flexible tubing has some possibilities in flour mills. It can be used to convey fine dry particles, gasses and fluids and is called the swallow pump system. The material is moved along the tubing by a series of cam operated fingers that press against the flexible tubing in sequence. This action imparts a positive unidirectional movement to the material in the tube. Although the capacity of these conveyors is low the principle could easily be adapted to larger pumps to convey greater capacities.

Pneumatic Conveying. Abbot ( 1 ) stated that the principles of pneumatic handling have been known for thirty to forty years, but until recently it wasn't used in conveying mill stocks because of the belief that it would involve excessive power consumption. The first pneumatic mill began operations in Switzerland in 1944 ( 1 ). Little did anyone realize that this first pneumatic mill would revolutionize the milling industry.

At first millers had many doubts about the pneumatic system of conveying. It was thought that the air currents would cause a high evaporative moisture loss in the stock being conveyed, but this loss was found to be only one percent or less (29). Early attempts at pneumatic conveying suffered from the fact that no really efficient cyclone collector and air lock was available. This resulted in high power consumption and made the operation quite costly. Further research was conducted in Europe and a cyclone was developed with an efficiency of better than 99.5 percent (29). An air lock with a comparatively leak proof seal was also developed. Another problem that had to be overcome in the use of pneumatics was obtaining clean air to use for conveying. This problem was overcome by cleaning up the mills and making sure that all outside air entering is either clean or filtered for removing impurities.

A majority of the mills built since the development and use of pnwumatic conveying replaced those destroyed by losses of World War II in Europe. Thus Europe was the natural place for pneumatic conveying to be used extensively and one Swiss company had built more than 250 pneumatic mills by May of 1953. ( 1 ). The building of pneumatic mills in the United States has progressed much more slowly because of excess milling capacity and low profit margins.

The idea of the pneumatic mill on a large scale level was first undertaken by General Mills in Los Angeles in 1945 ( 1 ). Since that time several mills have carried on building and remodeling programs using pneumatic conveying. "In fact, pneumatic conveying is now normally considered and evaluated for all conveying problems along with conventional screw conveyors, bucket elevators, belt conveyors, and other types of pneumatic conveyors"(5).

As the use of pneumatic conveying developed it was found to have certain advantages. Several sources (4), (18), (19) and (24) have listed the following advantages for pneumatic conveying.

1. Extremely flexible systems are possible as the material can be conveyed almost anywhere.
2. It allows flexibility in new plant design and layout.
3. It allows easier addition of new equipment and remodeling of conveying in older mills.
4. Elimination of most dust is possible.
5. Maintenance costs are reasonable.
6. The equipment is self cleaning.
7. The systems are very sanitary.
8. Stock are cooled as they are conveyed.
9. No separate exhaust system is needed on rolls and sifters.
10. Reduction of fire hazards.
11. Installations are neat in appearance.

In order to obtain an upward movement of stock in a pneumatic tube the velocity of air must be greater than the terminal velocity of the stock particles. Most handbooks on air measurements illustrate that the velocity of air at the center of a duct or pneumatic tube is about 15 percent greater than its actual mean velocity (11). In vertical conveying this difference of speed across the duct is of little importance, but it does make a difference in horizontal conveying. A particle being conveyed horizontally will fall to the bottom of the tube unless the horizontal velocity is high enough. It has been determined empirically by Gehrig and Jun (11) that a mean velocity of 60 to 70 percent greater than the terminal velocity of grain (2800 to 2900 f.p.m.) is needed to convey horizontally. Horizontal conveying speeds range from 3500 to 4500 f.p.m. for mill stocks.

One disadvantage of pneumatic conveying is the power it requires. One of the greatest losses in a pneumatic system occurs at the point where the material is introduced into the air stream. Power is required to accelerate the stock from being stationary to the necessary conveying speed. Another power loss occurs at the elbow where the stock changes direction and has to be reaccelerated. Lockwood (18) stated that no complete remedy for the high power consumption of the conveying plant is now in sight, but a carefully planned layout using first class fans and the smallest quantities of air might be efficient enough to gain the favor of millers, especially where power is cheap.

Air requirements for various stocks ranges from one half cubic foot to 15 cubic feet of air for each pound of stock. In negative pneumatic systems air ratios of four, five and six cubic feet of air per pound of stock conveyed are used (11). Positive pressure systems use as little as one half cubic foot of air per pound of material.

It is usually required that in process streams be lifted at least fifty times as it passes through the mill. As an example (19), a mill capable of producing 17,000 pounds of flour per hour will require approximately 100,000 pounds of material "in process" per hour. "It can be seen, therefore, that it is highly undesirable to rely on simplified formulas for air volumes, velocities and power requirements" (5).

There are two types of pneumatic conveying systems: the positive pressure system and the negative pressure system. The two systems use the same basic equipment including positive air lock feeders, piping systems, product receivers, air supply and possibly a filter.

Negative pressure systems. The negative pressure system is the one most commonly used in pneumatic conveying for flour mills. It is classified as a negative system because the fan is located at the terminal end of each lift. Both high and low pressure negative systems are in use. The high pressure system was the original pneumatic system and is still used in most mills. In this system the stock falls into a receiver of some sort and passes through two or more 90 degree bends before reaching the cyclone.

An offspring of the negative high pressure conveying system is the direct lift system. This system uses pneumatic pipes that lift the stock directly from the roller mill hopper and through the top of the roller mill. The system reduces the vertical lift to an absolute minimum since no floor or pickup is needed below the roller mill.

The direct lift pickup in the base of the roller mill is designed to be choke-proof. A second larger diameter pipe is placed around the conveying pipe giving an air gap between the two pipes. When the conveying pipe is buried by a rush of stock, air is pulled through the space and a choke up is eliminated. A comparison of the high pressure negative pneumatic pickups for roller mills is shown in Plate VIII.

The low pressure negative pneumatic system originated in Great Britain ( 1 ). It was designed to lower the horsepower required in conveying. From the machine the stock falls into a unit known as a diffuser. This diffuser operates at about 400 R.P.M. and throws the stock upward into the vertical pneumatic tube thus cutting down on losses in accelerating the particles. The change in direction done by the diffuser eliminates two 90 degree elbows and most of the horizontal conveying from the system. The cyclones are designed with a near vertical entry eliminating the 90 degree elbow at the top.

## PLATE VIII

### Comparison of Direct-lift and Standard Pneumatic Roller Mill Pickups

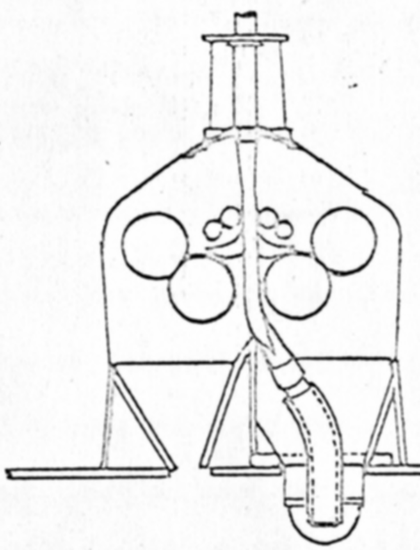


**Fig. 1**

**Direct-lift**

**Pneumatic Pickup**

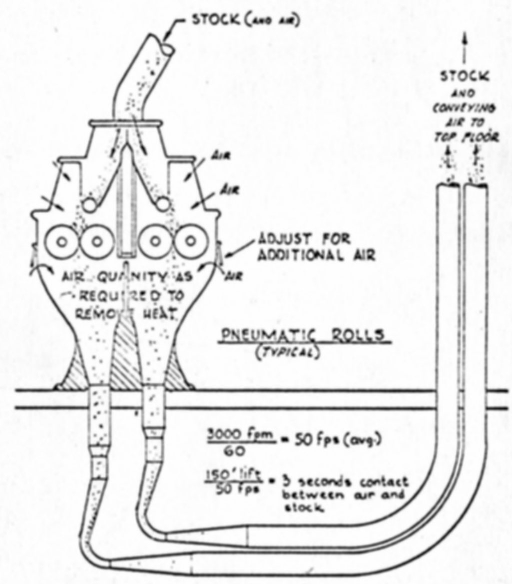



**Fig. 2**

**Standard High Pressure**

**Pneumatic Pickup**

Due to the absence of the elbows and horizontal conveying lower air speeds are required and the low pressure system needs less horsepower (29). A comparison of the three types of negative pneumatic conveying systems is shown in Plate IX. Youdale (29) summarizes the horsepower requirements necessary for the three types of negative pressure systems as found in Table 1.

Table 1. Horsepower requirements for negative pressure pneumatic systems.

| Type of system | Horsepower required |
|---|---|
| High pressure | 1.8 to 2.6 Hp/cwt |
| Low pressure | 1.4 to 2.3 Hp/cwt |
| Direct lift | 1.6 to 2.4 Hp/cwt |

Positive pressure systems. The positive pressure system was developed because of the limited capacities of the suction system. This system requires only one half cubic foot of air per stock as stated before. A positive displacement air pump is located at the head end of the system. The stock is introduced through an air lock and is pushed by the air up into the cyclone.

In special cases a single pump may be used to drive separate positive lifts. In this case a "sonic" valve is used so that if one machine doesn't function properly the reverse air wave is stopped at the valve and doesn't affect the other machines of the system. This sonic valve is located between the trunk line from the blower and the feed inlet.

Plate IX

Negative Pneumatic Pickup Systems Used

in Flour Mills

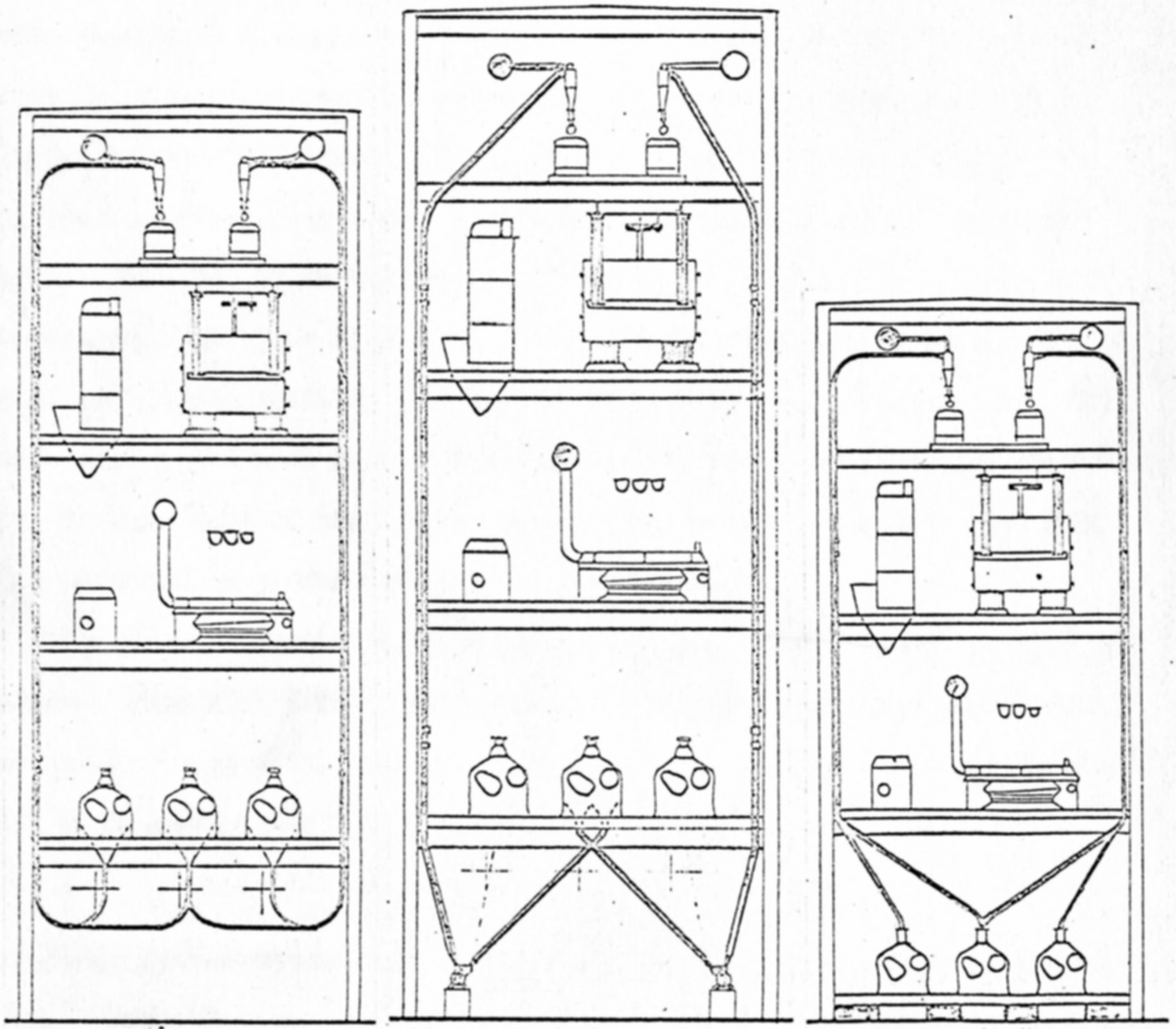


Fig. 1 High Pressure System

Fig. 2 Low Pressure System

Fig. 3 Direct-lift System

## Power Requirements

One of the largest expenses in milling is for power. Some mills consume more power than others of the same capacity. This is usually due to poor planning. The mill may have excessive shafting, poor bearings or an excess of machinery. Some of the older mills are driven by lineshafts and belts powered by a single motor which powers the whole mill. The motor is placed in a separate room and powers the lineshafts via leather or V-balta ropes. Dedrick (8) stated that the power absorbed by lineshafting in different manufacturing plants ranges from 19 to 80 percent of the total power. Even with plain bearings, shafting in modern flour mills shouldn't absorb more than 13 to 15 percent of the power. Properly installed, lubricated and aligned shafting is necessary to keep power consumption low. The power used by the mill is one of the production costs and Rozsa (30) stated that in these days of keen competition for trade even a one half cent per sack reduction in production costs is significant.

The power is divided between different departments of the mill plant as follows: Main mill drive, 75%; cleaning department, 12 - 18%; packers and conveyors, 7 - 8% (15). The division of power in the modern bucket elevator mill is given in Table 2 (8).

Table 2. Division of power in a modern flour mill.

| Machinery | Percent |
|---|---|
| Grinding machinery, rolls | 40 |
| Separating and bolting | 14 |
| Auxiliary machines | 13 |
| Grain cleaning | 16 |
| Elevators and shafting | 17 |

## Mill Design and Layout

Development of Flour Mills. The first flour mills were sacking mills. In these mills it was necessary to sack the stock after each machine and carry it to the next machine. The first "automatic mill" was designed by an American, Oliver Evans, late in the eighteenth century (21). It was the first continuous mill and employed bucket elevators and spiral conveyors. The Americans were the first to use elevators and conveyors in processing. Kozmin (17) said, "Thus everything tending to progress in the techniques of the furnishing of mills in the end of the eighteenth and first quarter of the nineteenth centuries belongs to the initiative of the Americans."

By the start of the twentieth century flour mills were pretty well mechanized. The mills were classified as either single sided or double sided mills depending on the location of the bucket elevators. The single sided mill had the elevators along one wall while the double sided mill had the elevators in the center. Examples of both types of mills are shown in Plate X. The single sided mill was ideal for expansion because it could be expanded sideways and turned into a double sided mill.

The early 1900's mills had four main building areas; the warehouse, cleaning house, mill and power plant. The mill buildings were four to five stories high and in some cases as many as nine stories high. The latter occurred when the five story mill was built atop a warehouse. The first floor of the mill was the mainshaft floor and contained many elevator boots. The rolls were located on the second floor, spouting on the third, purifiers on the fourth and sifters on the fifth. Often a sixth floor housed the heads of the bucket elevators and the air filters used for the exhaust system.

PLATE X

**Comparison of Single and Double-sided**

**Flour Mills**

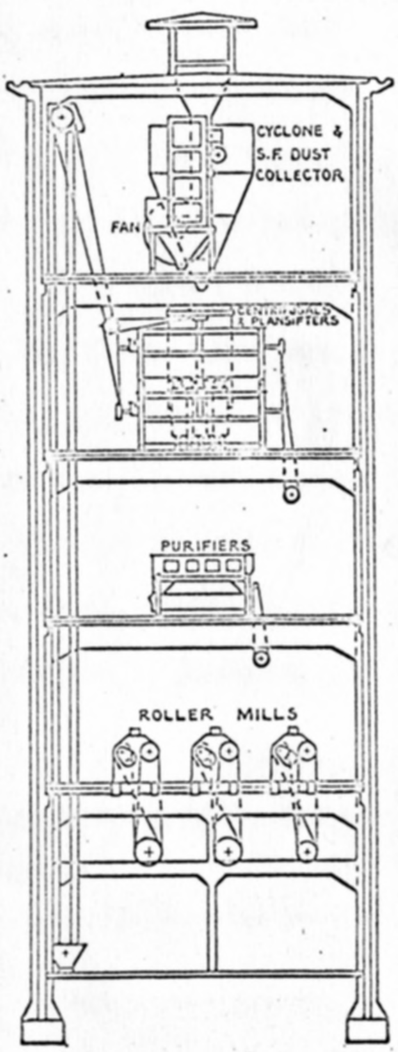



**Fig. 1**

**Single-sided**

**Flour Mill**

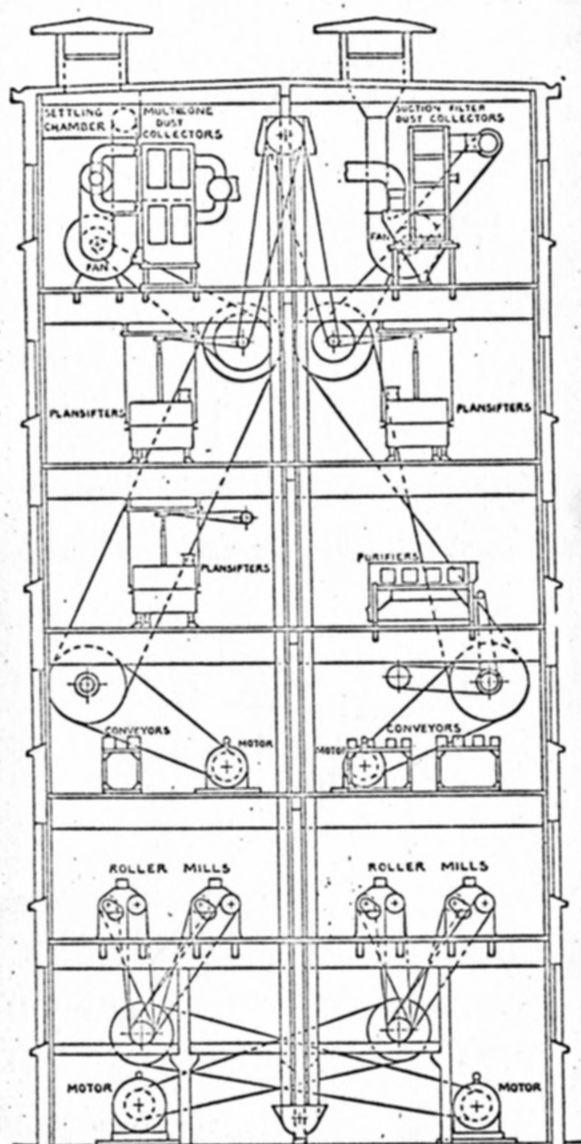



**Fig. 2**

**Double-sided**

**Flour Mill**

The width of the mill building was dependent on its type and the machinery used. The minimum width for a single sided plansifter mill with two lines of rolls was 23 feet (18). For three lines of rolls 27 feet was required. The minimum widths of the double sided mill were just double that of the single sided mill.

The floor heights of the mills of fifty years ago had to be tall enough for gravity flow and to allow headroom under conveyors and shafting. In most cases spouting determined the height of the floor. A summary of building requirements for different capacity mills of 1910 is shown in Plates XI through XIII. The capacities in these mills is given in barrels which may be converted to hundredweight by the formula:

1 barrel = 1.96 hundredweight (cwt)

The floors were usually of wood and divided into eight foot bays. This allowed easy layout of lineshafts and sprinkling equipment. The foundations needed a soil bearing capacity of 6000 pounds per square foot (p.s.f.) beneath them in order to support the building. Sometimes it was necessary to drive piles. Table 3 gives the minimum floor heights and loadings as recommended by Lockwood (18).

Table 3. Floor heights and loadings.

| Floor | Minimum height | Floor loading |
|---|---|---|
| Basement | 16 feet | 200 p.s.f. |
| Roll floor* | 14 feet | 300 p.s.f. |
| Purifier floor | 14 feet | 200 p.s.f. |
| Sifting floor | 14 feet | 200 p.s.f. |
| Top floor | 16 feet | 200 p.s.f. |

*If two roll floors are used the lower roll floor height should be 16 feet.

EXPLANATION OF PLATES XI THROUGH XIII

1910 Standard building data.

| | Capacity in Barrels | Style of Building | Mill & Cleaning House: Drawing No. of Bldg. Plan | Drawing No. of Mach. Plan | Size of Mill Including Cleaning House | Size of Cleaning House | Height and No. of Floors | Height of Attic or Texas | Height of Basement | Storage in Bushels | Powerhouse: Location | Style of Building | Size | Warehouse: Location | Style of Building | Size | No. of Floors |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ⊠ | 30 | WOOD | B564 | M2706 | 28'-0×36'-0 | NONE | 1ST-11'-0" | 8'-0" ATT. | 9'-0" | NONE | END OF BLDG. | BRICK | 28'-0"×22'-0" | NONE | | | |
| | | BRICK | | | | | 2ND-11'-0" | | | | | | | | | | |
| | | CONCRETE | | | | | 3RD-11'-0" | | | | | | | | | | |
| ⊠ | 40 | WOOD | B564 | | 28'-0"×36'-0" | NONE | 1ST-11'-0" | 8'-0" ATT. | 9'-0" | NONE | END OF BLDG | BRICK | 28'-0"×22'-0" | NONE | | | |
| | | BRICK | | | | | 2ND-11'-0" | | | | | | | | | | |
| | | CONCRETE | | | | | 3RD-11'-0" | | | | | | | | | | |
| ⊠ | 50 | WOOD | B567 | M2712 | 32'-0"×42'-0" | NONE | 1ST-12'-0 | 8'-0" ATT. | 9'-0" | NONE | END OF BLDG. | BRICK | 32'-0"×22'-0 | NONE | | | |
| | | BRICK | B568 | | 32'-0"×42'-0" | NONE | 2ND-12'-0" | 8'-0" ATT. | 9'-0" | NONE | END OF BLDG. | BRICK | 32'-0"×22'-0" | NONE | | | |
| | | CONCRETE | | | | | 3RD-12'-0" | | | | | | | | | | |
| ⊠ | 60 | WOOD | B567 | | 32'-0"×42'-0" | NONE | 1ST-12'-0 | 8'-0" ATT. | 9'-0" | NONE | END OF BLDG. | BRICK | 32'-0"×22'-0" | NONE | | | |
| | | BRICK | B568 | | 32'-0"×42'-0" | NONE | 2ND-12'-0 | 8'-0" ATT. | 9'-0" | NONE | END OF BLDG. | BRICK | 32'-0"×22'-0" | NONE | | | |
| | | CONCRETE | | | | | 3RD-12'-0" | | | | | | | | | | |
| ⊠ | 75 | WOOD | B570 | M2721 | 32'-0"×48'-0" | NONE | 1ST-13'-0" | 8'-0" ATT. | 9'-0" | 4000 | END OF BLDG. | BRICK | 32'-0"×22'-0" | NONE | | | |
| | | BRICK | | | | | 2ND-12'-0" | | | | | | | | | | |
| | | CONCRETE | | | | | 3RD-12'-0" | | | | | | | | | | |
| ⊠ | 100 | WOOD | B573 | M2724 | 32'-0"×50'-0 | NONE | 1ST-13'-0" | 8'-0" ATT. | 9'-0" | 4000 | END OF BLDG. | BRICK | 32'-0"×22'-0" | NONE | | | |
| | | BRICK | B574 | | 32'-0"×50'-0" | NONE | 2ND-12'-0 | 8'-0" ATT. | 9'-0" | 4000 | END OF BLDG. | BRICK | 32'-0"×22'-0" | NONE | | | |
| | | CONCRETE | | | | | 3RD-12'-0" | | | | | | | | | | |
| ⊠ | 125 | WOOD | B573 | | 32'-0"×50'-0" | NONE | 1ST-13'-0" | 8'-0" ATT. | 9'-0" | 4000 | END OF BLDG. | BRICK | 32'-0"×22'-0" | NONE | | | |
| | | BRICK | B574 | | 32'-0"×50'-0" | NONE | 2ND-12'-0" | 8'-0" ATT. | 9'-0" | 4000 | END OF BLDG. | BRICK | 32'-0"×22'-0" | NONE | | | |
| | | CONCRETE | | | | | 3RD-12'-0" | | | | | | | | | | |
| ⊠ | 150 | WOOD | B576 | | 36'-0"×62'-0" | NONE | 1ST-13'-0 | 9'-0" TEX. | 10'-0" | 10 000 | END OF BLDG. | BRICK | 36'-0"×30'-0" | NONE | | | |
| | | BRICK | B577 | M2737 | 36'-0"×62'-0" | NONE | 2ND-14'-0 | 9'-0" TEX. | 10'-0" | 10 000 | END OF BLDG. | BRICK | 36'-0"×30'-0" | NONE | | | |
| | | CONCRETE | | | | | 3RD-13'-0" | | | | | | | | | | |
| ⊠ | 175 | WOOD | B576 | | 36'-0"×62'-0" | NONE | 1ST-13'-0" | 9'-0" TEX. | 10'-0" | 10 000 | END OF BLDG. | BRICK | 36'-0"×30'-0" | NONE | | | |
| | | BRICK | B577 | | 36'-0"×62'-0" | NONE | 2ND-14'-0" | 9'-0" TEX. | 10'-0" | 10 000 | END OF BLDG. | BRICK | 36'-0"×30'-0" | NONE | | | |
| | | CONCRETE | | | | | 3RD-13'-0" | | | | | | | | | | |
| ○ | 200 | WOOD | | | | | | | | | | | | | | | |
| | | BRICK | B580 | M2746 | 36'-0"×60'-0" | STAND. NONE<br>"A" PLANS 36'-0"×14'-0" | 1ST-15'-0"<br>2ND-13'-0"<br>3RD-14'-0"<br>4TH-12'-0"<br>5TH-9'-0" | NONE | NONE | MLG. BIN | END OF BLDG. | BRICK | 36'-0"×36'-6" | OPP. END OF P.H. | BRICK | 36'-0"×48'-6" | 1 |
| | | CONCRETE | | | | | | | | | | | | | | | |
| | 250 | WOOD | | | | | | | | | | | | | | | |
| | | BRICK | B583 | M2749 | 36'-0"×60'-0" | NONE | 1ST-15'-0"<br>2ND-13'-0"<br>3RD-14'-0"<br>4TH-13'-0" | 10'-0" TEX. | NONE | MLG. BIN | END OF BLDG | BRICK | 36'-0"×42'-6" | OPP. END OF P.H. | BRICK | 36'-0"×56'-0" | 1 |
| | | CONCRETE | | | | | | | | | | | | | | | |
| | 300 | WOOD | | | | | | | | | | | | | | | |
| | | BRICK | B583 | | 36'-0"×60'-0" | NONE | 1ST-15'-0"<br>2ND-13'-0"<br>3RD-14'-0"<br>4TH-13'-0" | 10'-0" TEX. | NONE | MLG. BIN | END OF BLDG | BRICK | 36'-0"×42'-6" | OPP. END OF P.H. | BRICK | 36'-0"×56'-0" | 1 |
| | | CONCRETE | | | | | | | | | | | | | | | |
| | 400 | WOOD | | | | | | | | | | | | | | | |
| | | BRICK | | | 38'-0"×77'-0 | 38'-0"×17'-0 | 1ST-17'-0"<br>2ND-13'-0"<br>3RD-14'-0"<br>4TH-14'-0" | 11'-0" TEX. | NONE | MLG. BIN | END OF BLDG. | BRICK | 46'-0"×46'-0 | OPP. END OF P.H. | BRICK | 38'-0"×70'-0" | 1 |
| | | CONCRETE | | | | | | | | | | | | | | | |
| ⊗ | 500 | WOOD | | | | | | | | | | | | | | | |
| | | BRICK | | M2758 | 38'-0"×77'-0 | 38'-0"×17'-0" | 1ST-17'-0"<br>2ND-13'-0"<br>3RD-14'-0"<br>4TH-14'-0" | 11'-0" TEX. | NONE | MLG. BIN | END OF BLDG. | BRICK | 46'-0"×46'-0 | OPP. END OF P.H. | BRICK | 38'-0"×70'-0" | 1 |
| | | CONCRETE | | | | | | | | | | | | | | | |
| ⊗ | 600 | WOOD | | | | | | | | | | | | | | | |
| | | BRICK | B589 | | 38'-0"×84'-0" | 38'-0"×19'-6" | 1ST-17'-0"<br>2ND-13'-0"<br>3RD-14'-0"<br>4TH-14'-0" | 11'-0" TEX. | NONE | MLG. BIN | END OF BLDG. | BRICK | 46'-0"×46'-0" | OPP. END OF P.H. | BRICK | 38'-0"×70'-0" | 1 |
| | | CONCRETE | | | | | | | | | | | | | | | |
| | 750 | WOOD | | | | | | | | | | | | | | | |
| | | BRICK | | M2764 | 40'-0"×85'-0" | 40'-0"×26'-0" | 1ST-17'-0"<br>2ND, 3RD, 4TH-14'-0"<br>5TH-13'-0" | NONE | NONE | MLG. BIN | END OF BLDG. | BRICK | 40'-0"×18'-0" | OPP. END OF P.H. | BRICK | 40'-0"×70'-0" | 4 |
| | | CONCRETE | | | | | | | | | | | | | | | |
| | 1000 | WOOD | | | | | | | | | | | | | | | |
| | | BRICK | | M2767 | 42'-0"×95'-0" | 42'-0"×27'-0" | 1ST-18'-0"<br>2ND-15'-0"<br>3RD-15'-0"<br>4TH-15'-0" | 15'-0" TEX. | NONE | MLG. BIN | END OF BLDG. | BRICK | 50'-0"×60'-0" | OPP. END OF P.H. | BRICK | 42'-0"×70'-0" | 3&T. |
| | | CONCRETE | | | | | | | | | | | | | | | |

⊠ STANDARD MILL CONSTRUCTION ⊗ SEMI MILL CONSTRUCTION ○ FULL MILL CONSTRUCTION

# DATA ON STANDARD BUILDING PLANS

## NORDYKE & MARMON COMPANY

G.T.D. JAN. 6-1910

ENV. 228 DR.

PLATE XI

# DATA ON STANDARD BUILDING PLANS
## NORDYKE & MARMON COMPANY

Nov. 14. '12

| MILL & CLEANING HOUSE | | | | | | | PWRHOUSE | | WAREHOUSE | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | LOCATED AT END BLDG. CONCRETE OR OTHER FIRE PROOF ROOF. | | | | | |
| CAPACITY IN BARRELS | STYLE OF BUILDING | DRAW. NO. OF BLDG. PLAN | DRAW. NO. OF MACH. PLAN | SIZE OF MILL INCL. CLEANING HOUSE | SIZE OF CLEANING HOUSE | STORAGE IN BUSHELS | STYLE OF BUILDING | SIZE OF BUILDING | LOCATION | STYLE OF BUILDING | SIZE OF BUILDING | HEIGHT AND NUMBER OF FLOORS CU. = CUPOLA |
| 1500 | BRICK & CON. | | | 46' × 116' | 46' × 34' | MLG. BIN | BRICK & CON. | 52' × 62' | END OPP. P.H. | BR. & CON. | 46' × 96' | 4 - 11' FLOORS |
| 2000 | BRICK & CON. | | | 52' × 140' | 52' × 42' | MLG. BIN | BRICK & CON. | 52' × 68' | END OPP. P.H. | BR. & CON. | 52' × 96' | 4 - 11' FLOORS |
| 2500 | BRICK & CON. | | | 52' × 154' | 52' × 42' | MLG. BIN | BRICK & CON. | 57' × 70' | END OPP. P.H. | BR. & CON. | 52' × 110' | 4 - 11' FLOORS |
| 3000 | BRICK & CON. | | | 52' × 174' | 52' × 48' | MLG. BIN | BRICK & CON. | 60' × 80' | ACROSS R.R. | BR. & CON. | 70' × 168' | 4-11' FL. & 3-14' FL. IN CU. 30' × 70' |
| 4000 | BRICK & CON. | | | 52' × 196' | 52' × 56' | MLG. BIN | BRICK & CON. | 66' × 80' | ACROSS R.R. | BR. & CON. | 70' × 168' | 4-11' FL. & 3-14' FL. IN CU. 30' × 70' |
| TWO 1000 UNITS | BRICK & CON. | | | 52' × 142' | 52' × 42' | MLG. BIN | BRICK & CON. | 52' × 68' | END OPP. P.H. | BR. & CON. | 52' × 96' | 4 - 11' FLOORS |
| TWO 2000 UNITS | BRICK & CON. | | | 56' × 192' | 56' × 48' | MLG. BIN | BRICK & CON. | 66' × 80' | ACROSS R.R. | BR. & CON. | 70' × 168' | 4-11' FL. & 3-14' FL. IN CU. 30' × 70' |
| TWO 3000 UNITS | BRICK & CON. | | | 72' × 242' | 72' × 48' | MLG. BIN | BRICK & CON. | 72' × 110' | ACROSS R.R. | BR. & CON. | 70' × 168' | 4-11' FL. & 3-14' FL. IN CU. 30' × 70' |


ENV. 228 DR.

PLATE XII

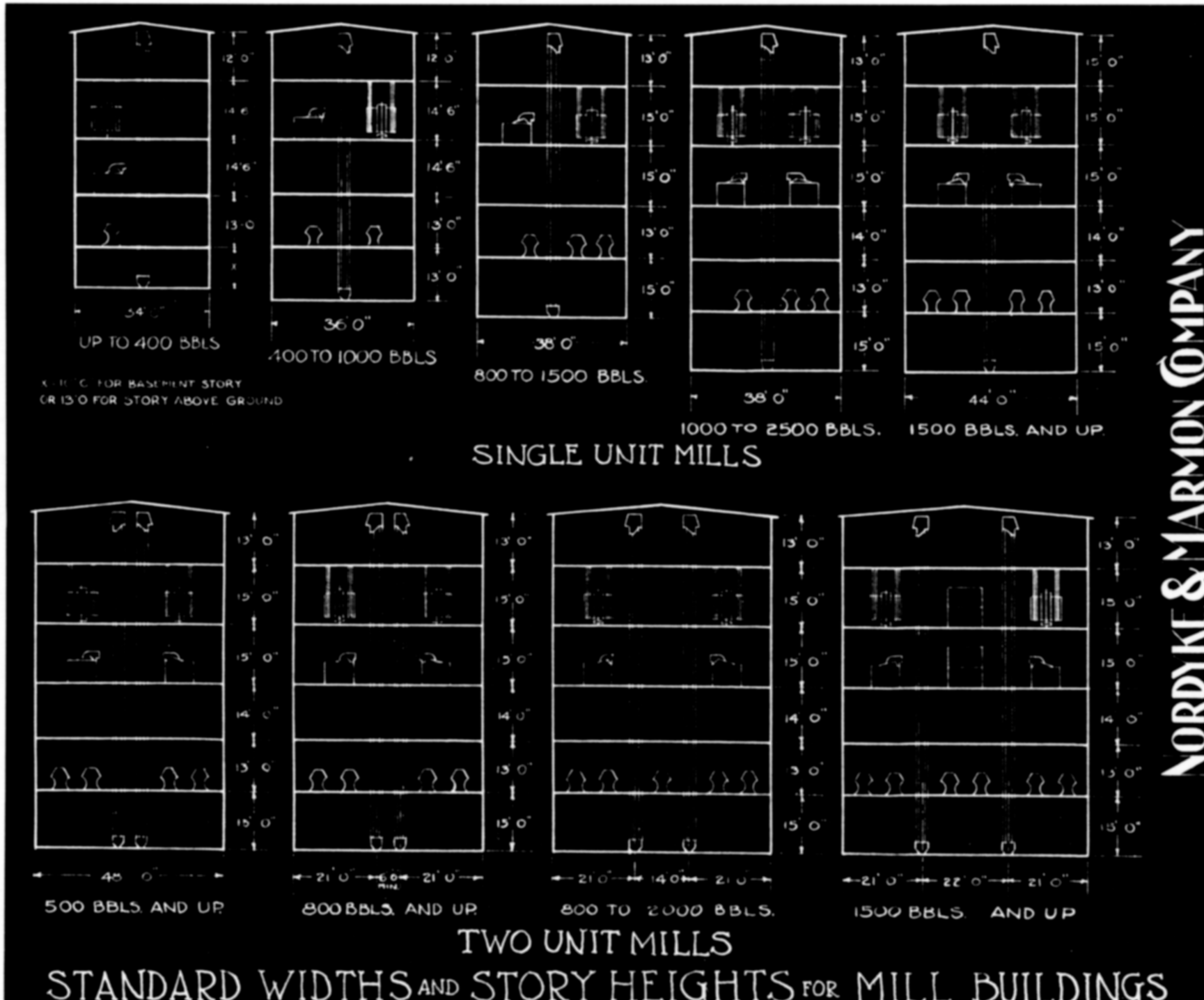

NORDYKE & MARMON COMPANY
12' 0"
14' 6"
14' 6"
13' 0"
34' 0"
UP TO 400 BBLS
... 10' 0" FOR BASEMENT STORY
OR 13' 0" FOR STORY ABOVE GROUND
36' 0"
400 TO 1000 BBLS
38' 0"
800 TO 1500 BBLS.
13' 0"
15' 0"
15' 0"
13' 0"
15' 0"
38' 0"
1000 TO 2500 BBLS.
44' 0"
1500 BBLS. AND UP.
SINGLE UNIT MILLS
48' 0"
500 BBLS. AND UP.
21' 0"
6' 0" MIN.
21' 0"
800 BBLS. AND UP.
21' 0"
14' 0"
21' 0"
800 TO 2000 BBLS.
21' 0"
22' 0"
21' 0"
1500 BBLS. AND UP
TWO UNIT MILLS
STANDARD WIDTHS AND STORY HEIGHTS FOR MILL BUILDINGS

PLATE XIII

The roof and wall construction were according to the climate. Most walls were of stone with a minimum thickness of not less than 12 inches. Glass areas were avoided in cold climates to minimize condensation. Roofs were insulated where necessary to avoid condensation. All inside and outside corners were beveled and the floors were finished at the walls with cove moulding. All ledges were eliminated if possible to avoid dust collection.

The following is a list of layout principles employed in the 1920's (18).

1. Roller mills and other high power consumption machines were placed on the lower floors.
2. The machine sequence down the mill was determined by the flow sheet.
3. Machines were placed as symetrically as possible with cross passages every twenty feet in roll lines.
4. Tall machines were kept away from windows to avoid obstructing light.
5. Elevators and conveyors were to be kept to a minimum.
6. Conveyors were easily accessible.
7. Elevators, conveyors, spouts, drives, etc., were kept clear of stairs, exits, etc.
8. Ample headroom was allowed beneath overhead shafting, pulleys, etc.
9. All main drives were carefully planned and had a margin of strength.
10. All floors were to have generous natural and artifical lighting.
11. Each mill was to have a well planned exhaust system.

The frequency of fires years ago caused insurance companies to demand that new mills be built to certain specifications. The mill at one time had to be separated from the cleaning house by a six foot wide fireproof compartment with double fire doors in the compartment. The stairs and manlift were often housed in these compartments. The lighting in the flour mill had to be electrical and enclosed. The power generating plants had to be in separated areas. Dust collection systems were required as well as automatic sprinkler systems.

Modern Mill Design and Layout. The mill buildings today are almost all of fireproof construction and the interior is partially air conditioned to provide the proper temperature and humidity for good milling results. Swan (26) states that the trend today is to the use of individual motor drives instead of lineshafts. The individual drives used with modern pneumatic conveying opens up completely new concepts of mill arrangement. Whereas old mills were four or five stories high, the new ones are one, two or three stories high. A comparison of a bucket elevator mill and a pneumatic mill is shown in Plate XIV. Scott (24) stated, "The sense of roominess and rightness imparted by these innovations has to be felt to be properly appreciated." This is especially true in older mills which have been remodeled using pneumatic conveying.

The Molinstar Mill. A recent innovation in flour mill design is shown in Plate XV. This is the Molinstar Mill which is marketed by a Swiss firm. It is a complete flour mill mounted in a rigid frame. This flour mill has no purifiers and comes in one size only, 84 cwt. per hour. If a larger capacity is desired, several of the basic units are used. A concrete foundation or basement floor is built with another floor above it and supported on pillars. The basement contains certain auxilliary equipment and pickups for the pneumatic units. The mill is built on the main floor. Youdale (30) states that the layout uses 28 percent less space and has one third of the spouting of a conventional mill of the same capacity.

PLATE XIV

**Comparison of Bucket Elevator and Pneumatically Conveyed Flour Mills**

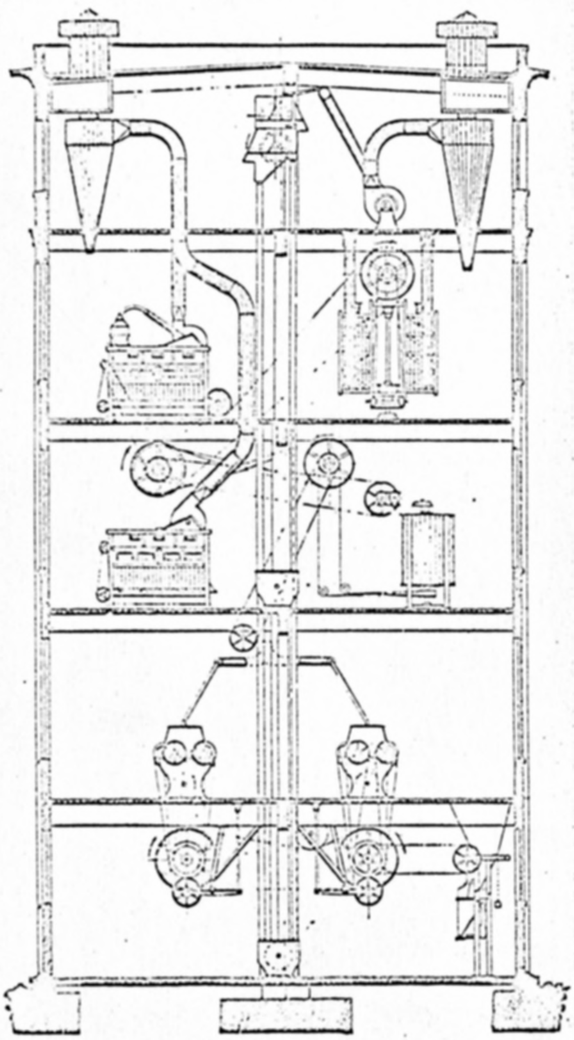


Fig. 1

Bucket Elevator Flour Mill

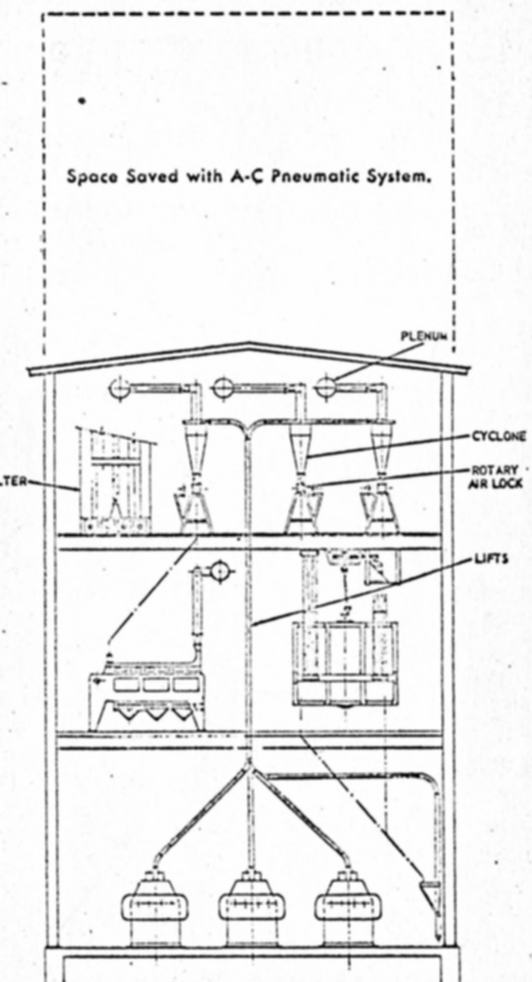
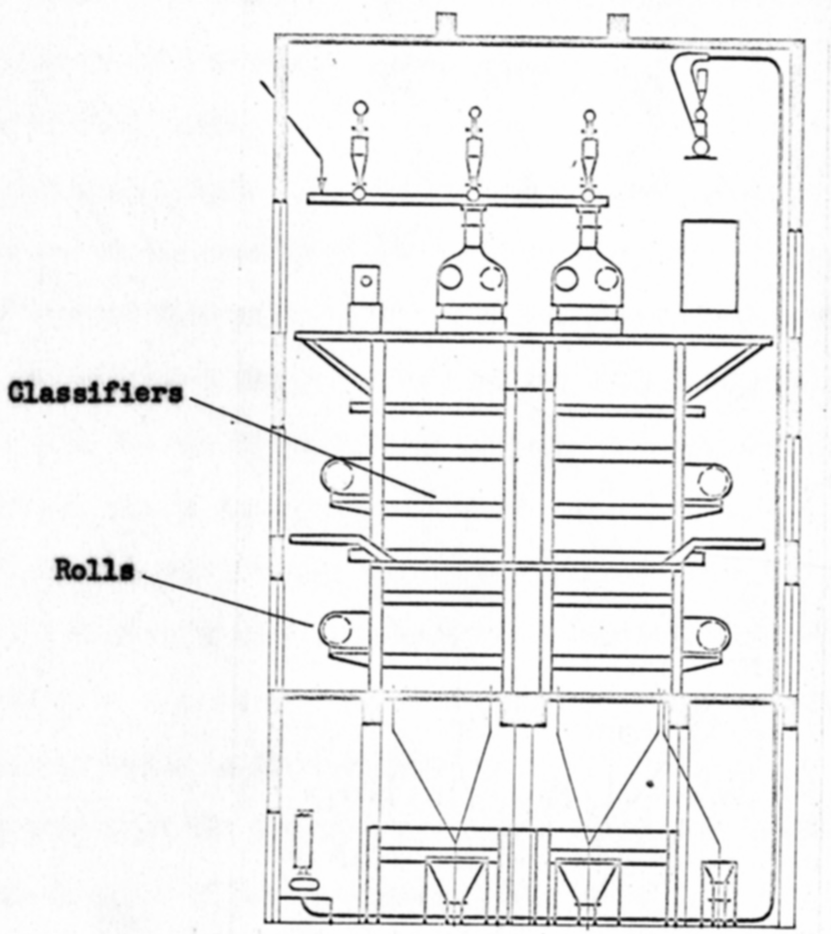



Fig. 2

Pneumatic Flour Mill

PLATE XV

Molinstar Flour Mill



The machinery of the Molinstar Mill is as follows:

6 forty inch four-roller mills
12 forty inch two-roller mills
36 double tier classifier sieves
3 bran finishers
1 eight section plansifter
auxiliary fans and dust collectors

The total power required for the 84 cwt. per hour mill was 227 horsepower. This is .37 horsepower per cwt. (30).

The whole mill frame is enclosed by a prefabricated building which serves to keep out weather elements. The total erection time of the mill is three to four weeks.

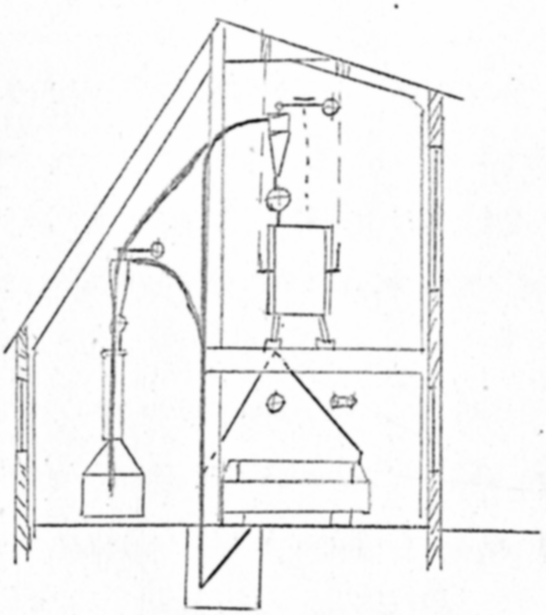
Future Mill Design. "A single-floor mill is possible in which all machines are at the same level, states Youdale (29). A single man could feasibly operate this mill. The use of the direct lift system makes it possible to eliminate the floor beneath the roll floor. This is also possible with the use of individual drives. A large number of horizontal conveyors are needed in a single-floor layout.

Future mills will become more beautiful and still basically functional. Much of the operation will be by automatic controls so that only a few men are required to operate the mill. A new mill design conceived by the Hungarians is shown in Plate XVI.

Regardless of the innovations to come management wants building and installation costs as low as possible (3).

PLATE XVI

Concept of a Future Flour Mill



# METHODS AND PROCEDURES

In the design of the single-floor mill it was necessary to secure some experimental data. The data pertained to the layout of the mill and the pneumatic pickups to be used with the machinery.

## Pneumatic Pickups for Milling Machine

Up until now it has been customary to spout material from a machine through the floor to a pickup. This isn't possible with a single story mill on a slab floor.

Roller Mill Pickups. As described in the review of types of pneumatic systems a roller mill (Figure 1, Plate VIII) has been designed with a self contained pneumatic pickup. This type of roller mill is used in the direct-lift type of system. A further discussion of roller mills will be undertaken later.

Purifier Pickups. The purifier presented no particular problem. It could be mounted on blocks thus giving enough room for the normal pneumatic lift fittings. The lower parts of the pickup could be attached to the frame of the machine.

Sifter Pickups. The sifter presented a problem when designing a pickup to fit underneath it, since it is constantly gyrating. It was felt that the pickup should be compact enough that the sifter could be hung at the normal distance from the floor. Two alternatives were possible in the design. The first is shown in Figure 1, Plate XVII. It is a rigid pickup that must be supported in some manner from the floor or a frame beside the sifter. If the sifter was suspended from a frame that rested on the floor it would be possible to attach the tubing to the frame.

PLATE XVII

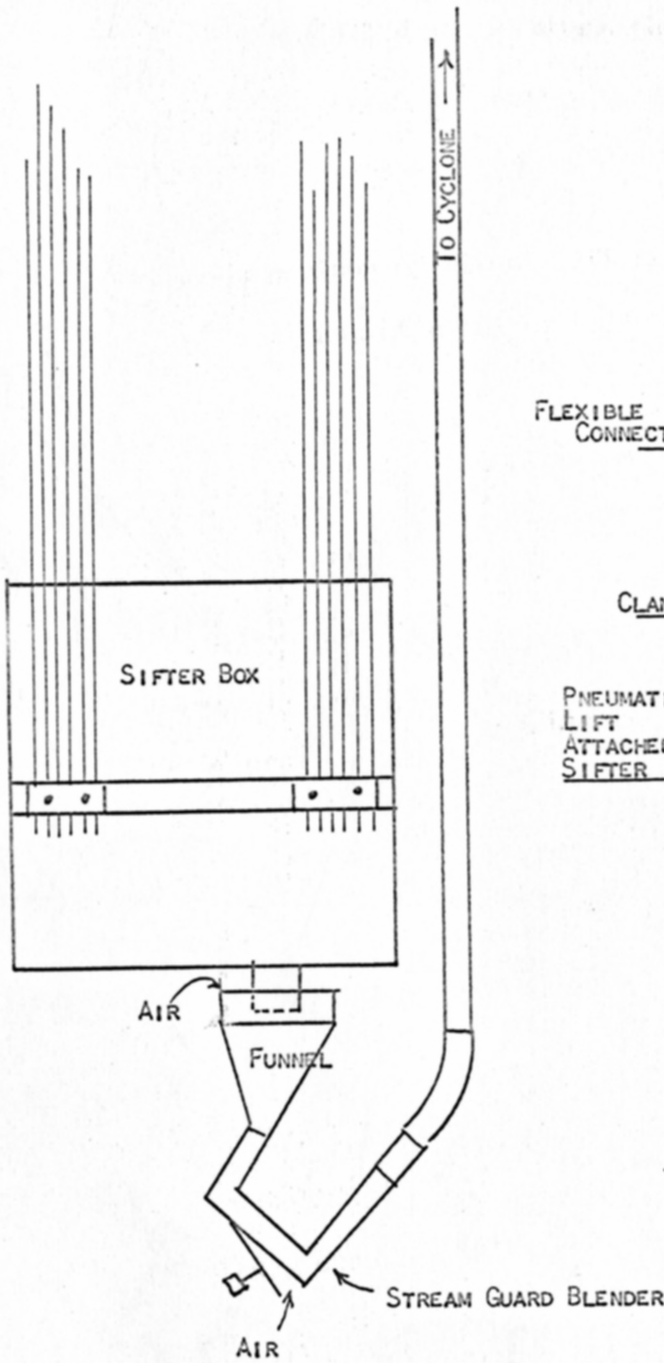



**Fig. 1**

**Rigid Sifter Pickup**

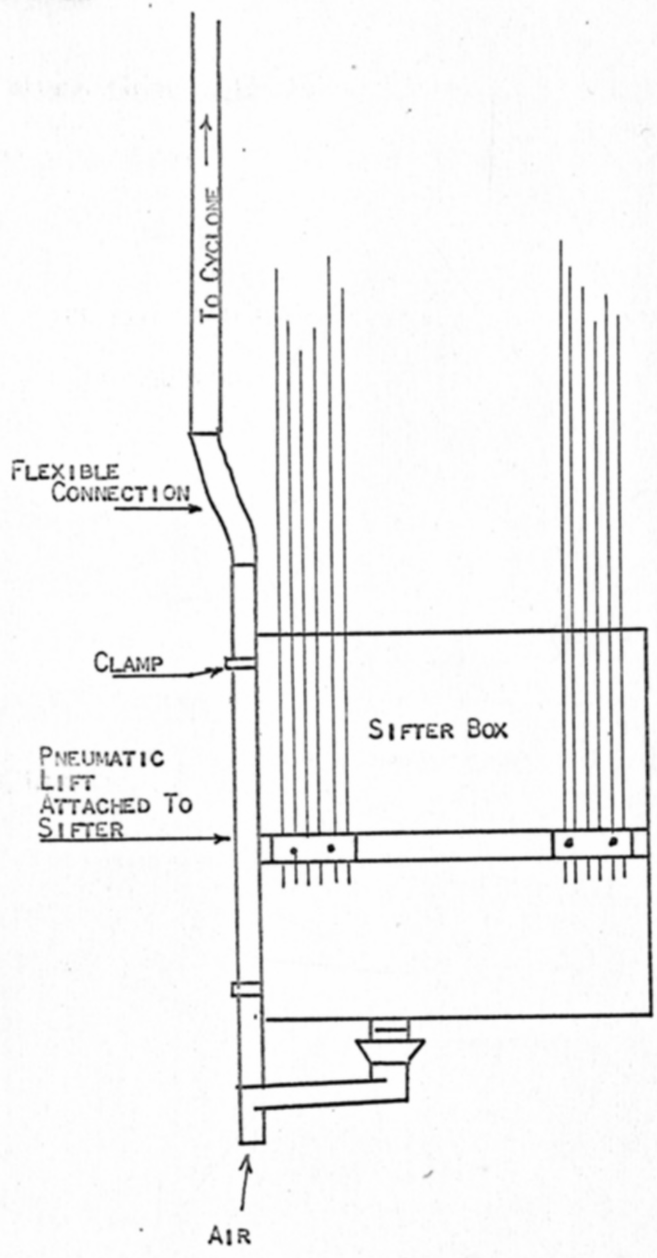


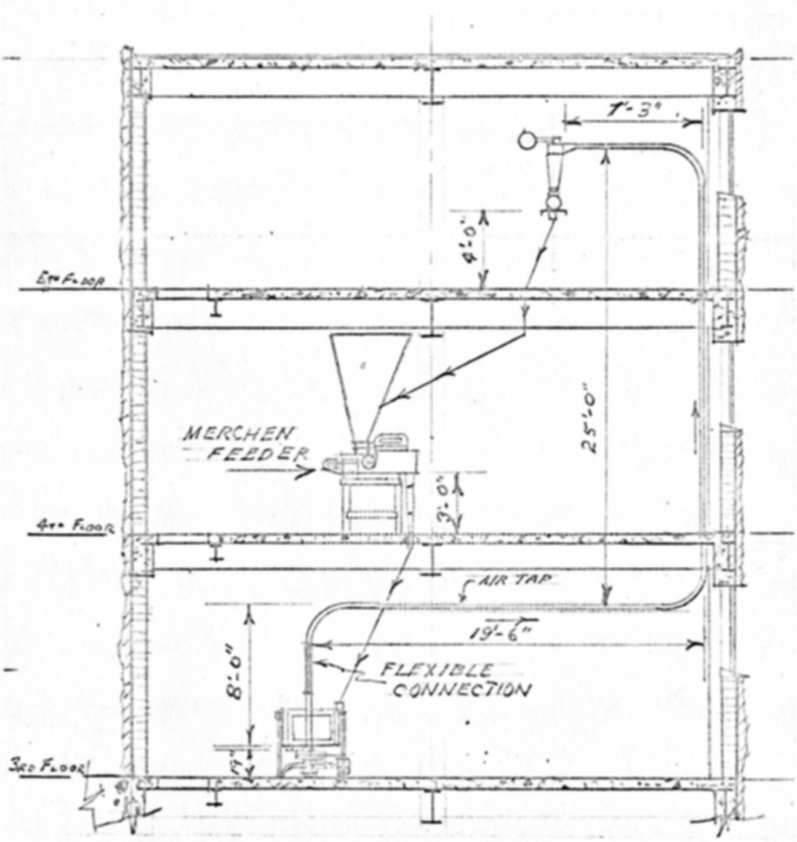

**Fig. 2**

**Gyrating Sifter Pickup**

PLATE XVIII

Cross-section of the Experimental

Pneumatic Conveying System



It was also desirable to use a sifter pickup that would discharge stock onto the floor if a choke up occurred in the pneumatic line. The use of the rigid pickup made this difficult because there was very little room left under the sifter for discharged stock. The rigid pickup method also made it difficult to sweep around the sifter.

The second alternative is shown in Figure 2, Plate XVII. This was a pickup rigidly attached to the sifter box itself. The gyrating motion of the lift was transferred to the rigid part through a flexible connection. Since no information was available for a gyrating sifter stock pickup, the author made experimental trials. It was desirable to know if there was any difference in the power requirements of a gyrating and stationary pickup.

A complete run around pneumatic system was constructed in the Kansas State University flour mill. A section of the mill showing the layout of the pneumatic system is shown in Plate XVIII. The vertical section of the lift and cyclone and airlock were part of an unused pneumatic lift in the flour mill. From the air lock, spouting carried the stock to a belt feeder which fed the spouting to the experimental sifter. The sifter used in the experiments was a single section floor-mounted fixed throw type. It had a motor with reversing switch for changing directions. All pneumatic tubing was 2 inch outside diameter (O.D.).

The pickup designed for experimental tests is shown in Plate XIX. It was designed so that it could receive and discharge stock whether the sifter was gyrating or stationary. The almost horizontal portion of the tubing was used to break the vertical fall of material entering the high angle stock inlet. The vertical part of the pickup is the passage for the air.

The plate at the bottom of the vertical section was attached after the initial construction. It was necessary to create high enough velocities to overcome a vortex action which was causing a small loss of stock out of the bottom.

The pickup was attached to the sifter as shown in Plate XX. A flexible connection for the pneumatic lift can be seen at the top of the picture. In the right center of the picture is a flexible connection so that stock can be introduced to the lift whether it is moving or not.

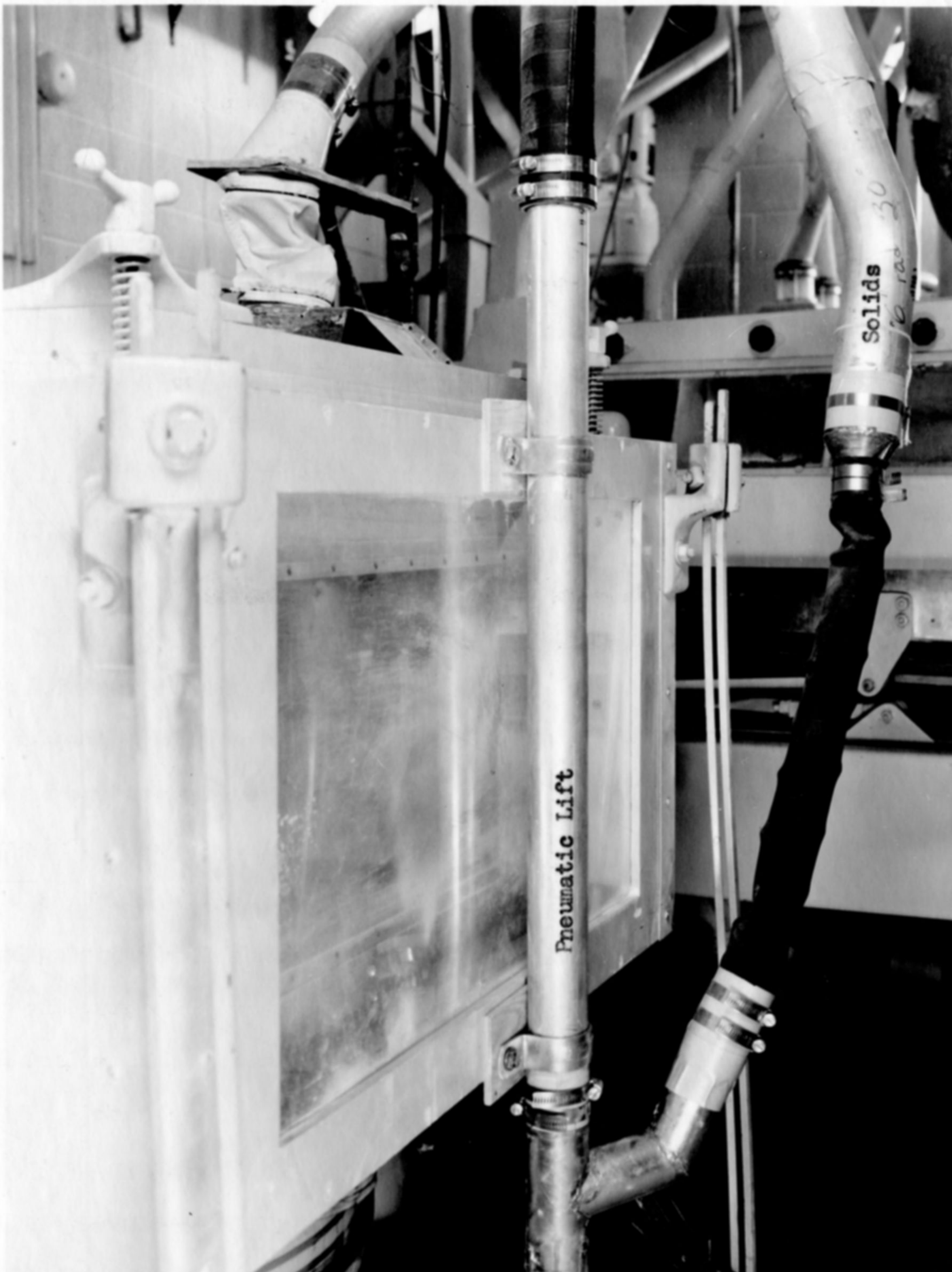
A series of air measurements were conducted with the system using no material. It was desirable to find out if the motion of the pickup and flexible pneumatic connection made an appreciable difference in power requirements. The measurements were made with a pitot tube and manometer. Both velocity and static pressures were taken. A 12 point traverse was used in securing an average velocity pressure. Two readings were taken from the center of the tube to determine average static pressures. The static pressures were negative readings because the lift was a suction type. The data secured is shown in Table 9, Appendix A. The stock inlet was taped for part of the trials to determine how much air was entering the system through the feed inlet. The cyclone damper was half closed for part of the trials in order to change the pressure and velocity of the system.

The air measurements were taken at the point marked air tap in Plate XVIII. Although this point wouldn't give power requirements for the whole system, it would give representative indications. The system was the same beyond the air tap and thus the tap measurements showed differences in air requirements for the gyrating and stationary pickups.

EXPLANATION OF PLATE XX

Attachment of Experimental Pneumatic Sifter Pickup.

PLATE XX



Velocity was derived from the velocity pressures by the following formula:

$$V = 4008 \sqrt{H} \qquad (2)$$

V = velocity in feet per minute

H = velocity head in inches of water

With the static pressures and velocities it was possible to determine horsepower requirements by the following formula:

$$\text{Fan Horsepower} = \frac{.000157 \times \text{CFM} \times \text{total head, inches water}}{\text{total efficiency}} \qquad (10)$$

CFM = velocity in feet per minute × cross-sectional area of the tube in square feet.

Total efficiency was assumed to be .80 in all cases. A summary of the total, static and velocity pressures as well as air and horsepower requirements is shown in Table 4.

Table 4. Data calculated from air measurements.

| Trial No. | Average Velocity Head (inches water) | Average Static Head (inches water) | Average Total Head (inches water) | Average Velocity (f.p.m.) | Volume of air (CFM) | Fan Horsepower required |
|---|---|---|---|---|---|---|
| 1- 5 | 1.25 | -12.525 | -11.275 | 4497 | 86.3 | .197 |
| 6-10 | 1.23 | -12.500 | -11.270 | 4452 | 85.5 | .189 |
| 11-15 | 1.21 | -12.300 | -11.090 | 4420 | 84.9 | .185 |
| 16-20 | 0.85 | -8.600 | -7.750 | 3678 | 70.6 | .107 |
| 21-25 | 0.83 | -8.600 | -7.770 | 3646 | 70.0 | .107 |
| 26-30 | 0.83 | -8.550 | -7.720 | 3649 | 70.1 | .106 |
| 31-35 | 1.90 | -7.500 | -5.600 | 5528 | 107.2 | .118 |
| 41-45 | 1.88 | -7.500 | -5.620 | 5486 | 105.3 | .116 |
| 46-50 | 1.14 | -4.550 | -3.410 | 4292 | 82.4 | .055 |
| 51-55 | 1.16 | -4.550 | -3.390 | 4306 | 82.7 | .055 |
| 56-60 | 1.11 | -4.600 | -3.490 | 4224 | 81.1 | .056 |

After performing the air measurements the calibrated belt feeder was used to introduce stock to the system. Second break stock and Purifier-1 stock were used to conduct experiments to find choke up points. The tests were run to compare feed capacities of the stationary and gyrating pickups under various conditions. A summary of the choke up points is found in Table 5.

Table 5. Summary of choke up points for gyrating and stationary pickups.

| Stock Used | Motion of Sifter | Choke up feed rate (lb/min.) |
|---|---|---|
| Purifier-1 Stock | Stationary | 23.06 |
| Purifier-1 Stock | 180 R.P.M., 4" Throw CW Rotation | 15.38 |
| Purifier-1 Stock | 180 R.P.M., 4" Throw CCW Rotation | 15.08 |
| 2 Bk. Stock | Stationary | 24.90 |
| 2 Bk. Stock | 180 R.P.M., 4" Throw CW Rotation | 13.94 |
| 2 Bk. Stock | 180 R.P.M., 4" Throw CCW Rotation | 13.90 |

The results of the air and stock trials will be explained in the discussion section of the thesis.

A second sifter stock pickup was also designed. It was the aim to make the pickup as simple and functional as possible. A picture of this pickup is shown in Plate XXI. It was actually a modification of the carrier used for many years on sifters to convey the product to a desired discharge point.

PLATE XXI


Carrier Type Pneumatic Sifter Pickup

It was mounted on the sifter as shown in Plate XXII making a very simple and neat installation. This pickup also possesses a unique discharge feature in case of choke up. The material just falls out the bottom of the air inlet onto the floor. This feature is illustrated in Plate XXIII. A discussion of this pickup will be found later in the thesis.

## Mill Layout and Machinery Arrangement

The Kansas State University flour mill was used for studies of mill layout. This mill has a capacity of 180 cwt daily. A flow sheet of the mill is shown in Plate XXIV. Comparisons were made of the mill as it exists and possible arrangements if it were laid out on one floor. The floor space and volumes occupied by the two arrangements were calculated. It was also necessary to compare pneumatic conveying requirements of the two arrangements.

In order to calculate the pneumatic conveying requirements it was necessary to secure a weighup of the entire flour mill so the flow rate of stock in each spout was known. The results of this weighup are also shown in Plate XXIV. It was also necessary to derive a series of terms and formulas to estimate pneumatic requirements. The first term used was called the "conveying value" for each lift. It was the length of the run in feet, vertical or horizontal, times the flow rate in pounds per minute of the stock in that lift. The conveying value was calculated for both the horizontal and vertical runs of each lift by the above formula. This gave an answer in foot-pounds per minute, but it couldn't be used to estimate horsepower requirements because it didn't consider static power losses in the line.

EXPLANATION OF PLATE XXII

Attachment of Carrier Type Pneumatic Sifter Pickup.

PLATE XXII

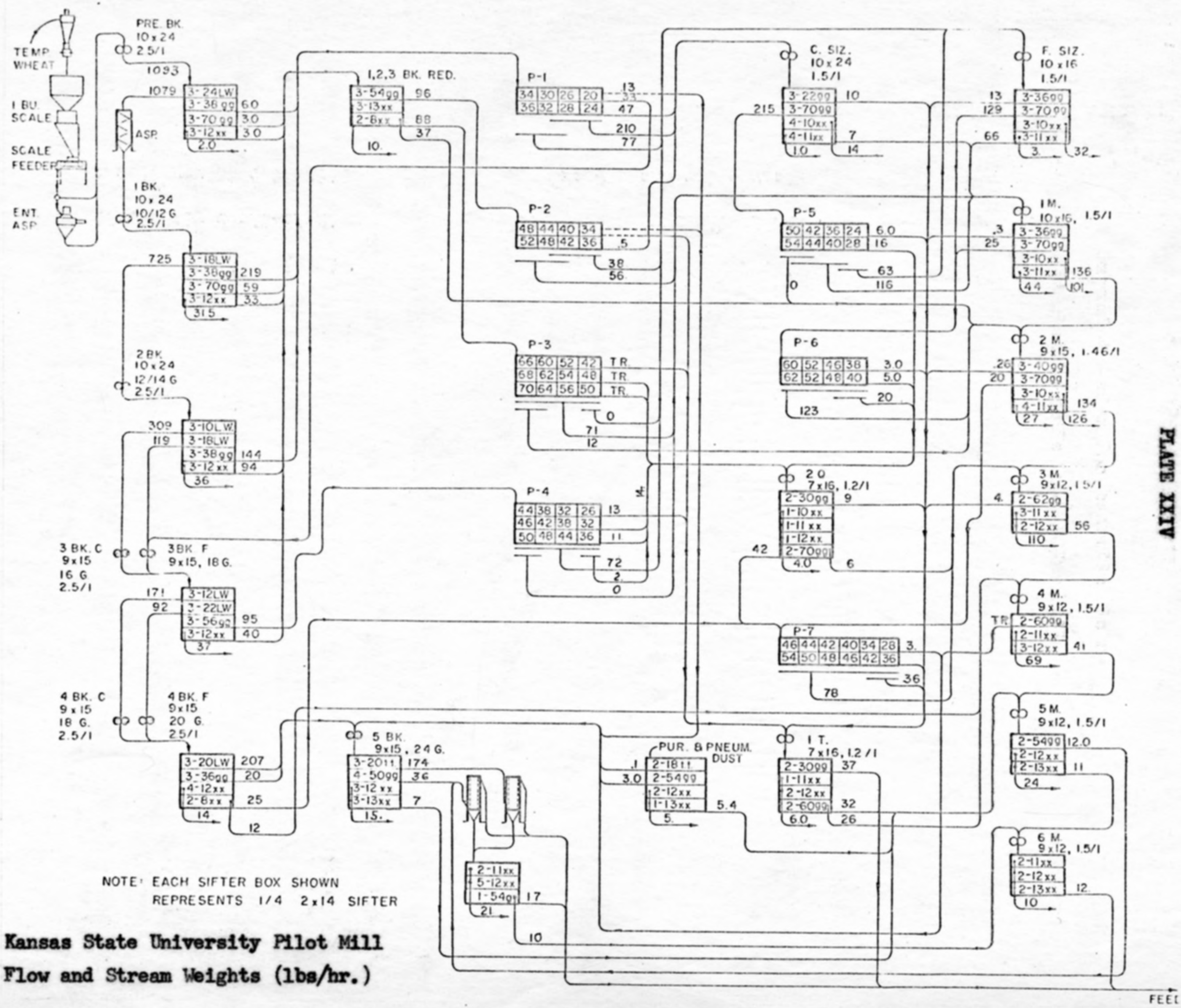
EXPLANATION OF PLATE XXIII

Discharge of Stock if

Pneumatic Lift Becomes Choked.

PLATE XXIII






**Kansas State University Pilot Mill**
**Flow and Stream Weights (lbs/hr.)**

PLATE XXIV

A second term used was the "vertical number index" (VNI). It was derived from the following formula:

$$VNI = \frac{\text{sum of vertical conveying values}}{\text{headweight to mill} \times \text{average vertical run}}$$

The headweight to the mill was determined by the rate of grain being fed to the prebreak rolls. In all cases in this study it was 18.16 pounds per minute. Another similar term was used for horizontal conveying lines. It was calculated from the following formula and was known as the "horizontal number index" (HNI).

$$HNI = \frac{\text{sum of horizontal conveying values}}{\text{headweight} \times \text{average horizontal run}}$$

Two other terms used in the presentation of the data were the number of pounds per minute conveyed vertically or horizontally per foot of vertical or horizontal run. These terms were derived by dividing the total stock conveyed per minute by the summation of the length of the horizontal or vertical runs.

The CFM and horsepower required for each mill arrangement were also needed for proper analysis. The data for estimating these requirements are shown in Table 6. This Table was prepared for use in this thesis by the Kice Metal Products Company. It is a lower extension of the estimating tables for negative pressure lifts as found in The Cereal Millers Handbook (7).

It was decided that the minimum size pneumatic tubing used would be 3/4 inch outside diameter. For conveyed rates of less than 1.0 pound per minute the lift is dampered in order that it requires the same power as it would for conveying 1.0 pound per minute.

Table 6. Estimating guide - Small diameter negative pneumatic conveying systems.

| Air Ratio 9 cfm per pound of stock | Pressure head required (inches water) | | | |
|---|---|---|---|---|
| Total run length | 20' | 30' | 40' | 50' |
| 100% Vertical | - | - | - | - |
| 50% Vertical - 50% Horizontal | 20.0 | 24.5 | 29.0 | - |
| 100% Horizontal | - | - | - | - |

| Tube dia. (inches) | Conveying Rate (lb/min.) | Air Rate (cfm) | Brake HP. at 50% Vert. - 50% Horiz. 20' | 30' | 40' | 50' |
|---|---|---|---|---|---|---|
| 3/4 | 1.0 | 9 | .056 | .070 | .082 | - |
| 1 | 1.9 | 17 | .108 | .131 | .155 | - |

| Air Ratio 6 cfm per pound of stock | Pressure head required (inches water) | | | |
|---|---|---|---|---|
| Total run length | 20' | 30' | 40' | 50' |
| 100% Vertical | - | - | - | - |
| 50% Vertical - 50% Horizontal | 22.6 | 28.1 | 33.6 | - |
| 100% Horizontal | - | - | - | - |

| Tube dia. (inches) | Conveying Rate (lb/min.) | Air Rate (cfm) | Brake HP. at 50% Vert. - 50% Horiz. 20' | 30' | 40' | 50' |
|---|---|---|---|---|---|---|
| 3/4 | 1.5 | 9 | .064 | .080 | .095 | - |
| 1 | 2.8 | 17 | .120 | .150 | .180 | - |

| Air Ratio 6 cfm per pound of stock | Pressure head required (inches water) | | | |
|---|---|---|---|---|
| Total run length | 20' | 30' | 40' | 50' |
| 100% Vertical | 17.5 | 19.5 | 21.5 | 23.5 |
| 50% Vertical - 50% Horizontal | 18.0 | 20.0 | 22.0 | 24.0 |
| 100% Horizontal | 18.5 | 20.5 | 22.5 | 24.5 |

| Tube dia. (inches) | Conveying Rate (lb/min.) | Air Rate (cfm) | Brake HP. at 50% Vert. - 50% Horiz. 20' | 30' | 40' | 50' |
|---|---|---|---|---|---|---|
| 1-1/4 | 4.5 | 27 | .17 | .19 | .21 | .23 |
| 1-1/2 | 6.7 | 40 | .25 | .27 | .30 | .34 |
| 2 | 12.5 | 75 | .46 | .51 | .56 | .61 |

| Air Ratio 5 cfm per pound of stock | Pressure head required (inches water) | | | |
|---|---|---|---|---|
| Total run length | 20' | 30' | 40' | 50' |
| 100% Vertical | 19.2 | 21.4 | 23.6 | 25.9 |
| 50% Vertical - 50% Horizontal | 19.8 | 22.0 | 24.2 | 26.5 |
| 100% Horizontal | 20.4 | 22.6 | 24.8 | 27.1 |

| Tube dia. (inches) | Conveying Rate (lb/min.) | Air Rate (cfm) | Brake HP. at 50% Vert. - 50% Horiz. 20' | 30' | 40' | 50' |
|---|---|---|---|---|---|---|
| 1-1/4 | 5.4 | 27 | .18 | .21 | .23 | .25 |
| 1-1/2 | 8.0 | 40 | .27 | .30 | .33 | .36 |
| 2 | 15.0 | 75 | .50 | .56 | .62 | .68 |

Table 6. (continued)

| Air Ratio 4 cfm per pound of stock | | | Pressure head required (inches water) | | | |
|---|---|---|---|---|---|---|
| Total run length | | | 20' | 30' | 40' | 50' |
| 100% Vertical | | | 21.8 | 24.3 | 26.7 | 29.0 |
| 50% Vertical - 50% Horizontal | | | 22.5 | 25.0 | 27.4 | 29.8 |
| 100% Horizontal | | | 23.2 | 25.7 | 28.1 | 30.0 |
| Tube dia. (inches) | Conveying Rate (lb/min.) | Air Rate (cfm) | Brake HP. at 50% Vert. - 50% Horiz. 20' | 30' | 40' | 50' |
| 1-1/4 | 6.7 | 27 | .21 | .23 | .25 | .27 |
| 1-1/2 | 10.8 | 40 | .30 | .34 | .37 | .40 |
| 2 | 18.7 | 75 | .58 | .64 | .70 | .75 |

| Air Ratio 3 cfm per pound of stock | | | Pressure head required (inches water) | | | |
|---|---|---|---|---|---|---|
| Total run length | | | 20' | 30' | 40' | 50' |
| 100% Vertical | | | 26.0 | 29.0 | 32.0 | 35.0 |
| 50% Vertical - 50% Horizontal | | | 27.0 | 30.0 | 33.0 | 36.0 |
| 100% Horizontal | | | 28.0 | 31.0 | 34.0 | 37.0 |
| Tube dia. (inches) | Conveying Rate (lb/min.) | Air Rate (cfm) | Brake HP. at 50% Vert. - 50% Horiz. 20' | 30' | 40' | 50' |
| 1-1/4 | 9.0 | 27 | .25 | .28 | .31 | .33 |
| 1-1/2 | 13.3 | 40 | .37 | .41 | .46 | .50 |
| 2 | 25.0 | 75 | .69 | .77 | .85 | .92 |

Basis of calculations:

1. Above figures are typical for average flour handling conditions where stock is conveyed at 4000 fpm air velocity.

2. Figures include allowances for 3 - 90 degree long-sweep ells (R = 24"), primary separator, smooth tube of size and length noted.

3. HP. estimates cover fan only and do not include drive loss.

4. Negative pressure estimates do not include secondary separator. Suction type filter assumed.

<u>The Existing Kansas State University Mill</u>. The mill layout is drawn as it is arranged in the four and one-half story structure. Floor plans for the mill are shown in Plates XXV through XXVIII. The first story is actually a half story and is used for the electric motors powering the roller mills and the pneumatic pickup under the rolls. The second story houses the roller mills and packing facilities. In the third story are the purifiers, entoleter, dusters, scales and blender. The sifters, agitator, belt feeder and enrichment equipment are found on the fourth floor. The fifth and top floor contains the fans, filters, entoleter, liberwork scales and air conditioner.

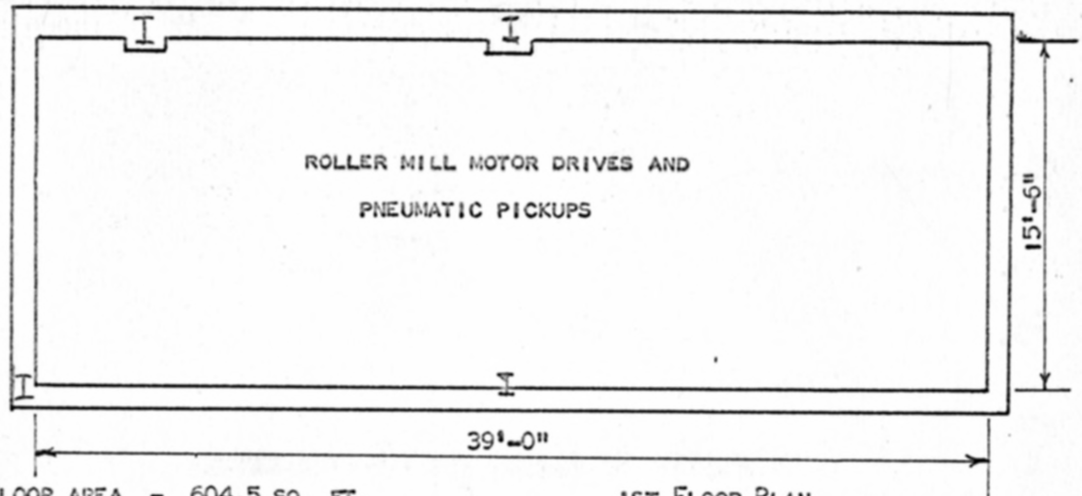
The building housing the existing mill is more than adequate. As shown in the floor plans, the actual floor space and that required to house the mill itself are quite different. The gross area of the building is 5440.5 sq. ft. The unused area is 858.5 sq. ft. giving a net floor area of 4582 sq. ft. for the mill, manlift, aisles and elevator. A volumetric study of the Kansas State University mill (Plate XXIX) shows a total used volume of 51,186.8 cubic feet.

The gravity and pneumatic conveying requirements are summarized in Table 7.

EXPLANATION OF PLATES XXV THROUGH XXVIII

Floor Plans and Equipment Location in Existing Kansas State University Mill.

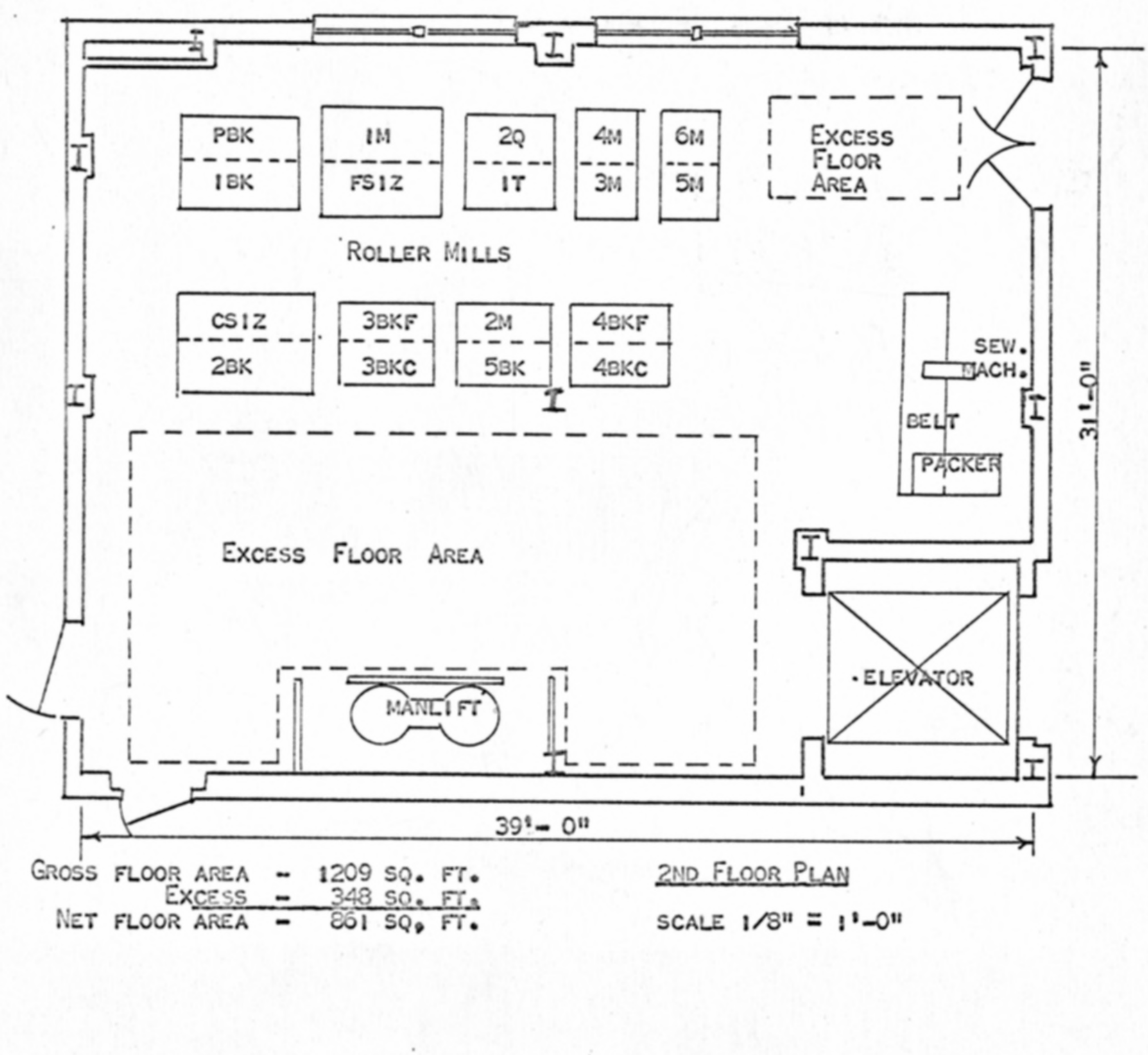
# PLATE XXV




FLOOR AREA - 604.5 SQ. FT.

1ST FLOOR PLAN

SCALE 1/8" = 1'-0"

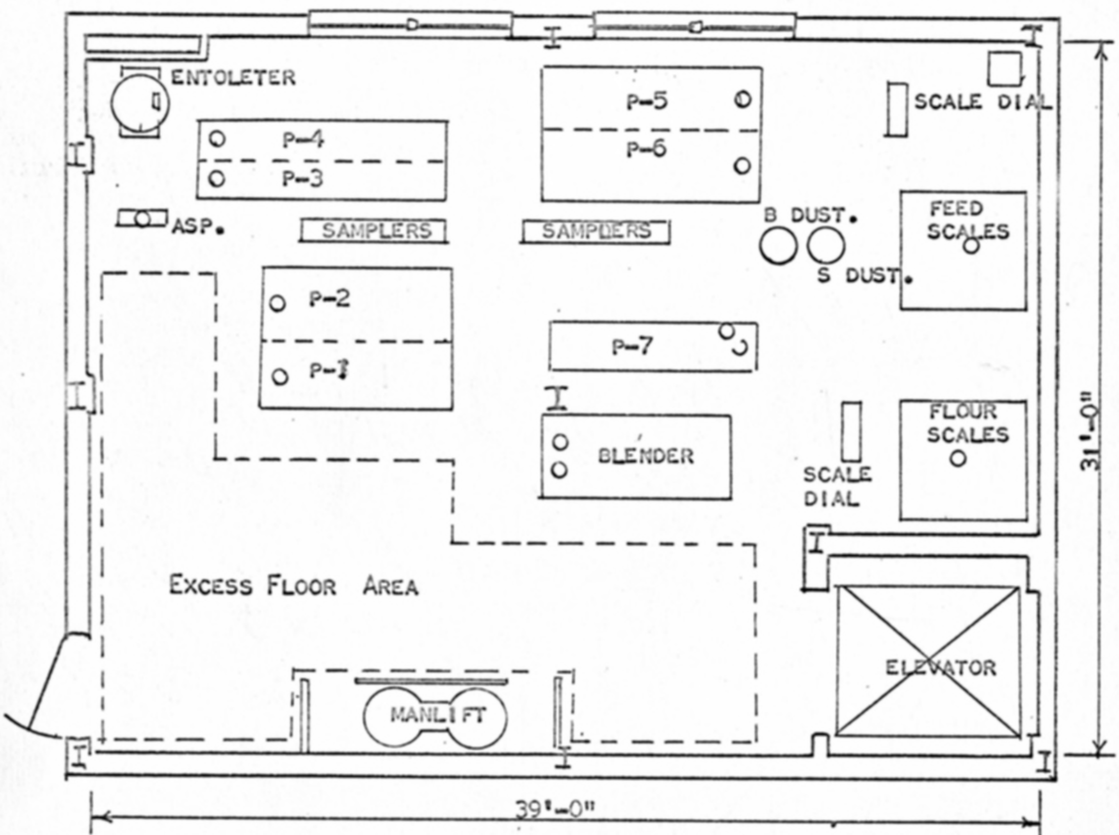



GROSS FLOOR AREA - 1209 SQ. FT.
EXCESS - 348 SQ. FT.
NET FLOOR AREA - 861 SQ. FT.

2ND FLOOR PLAN

SCALE 1/8" = 1'-0"

PLATE XXVI

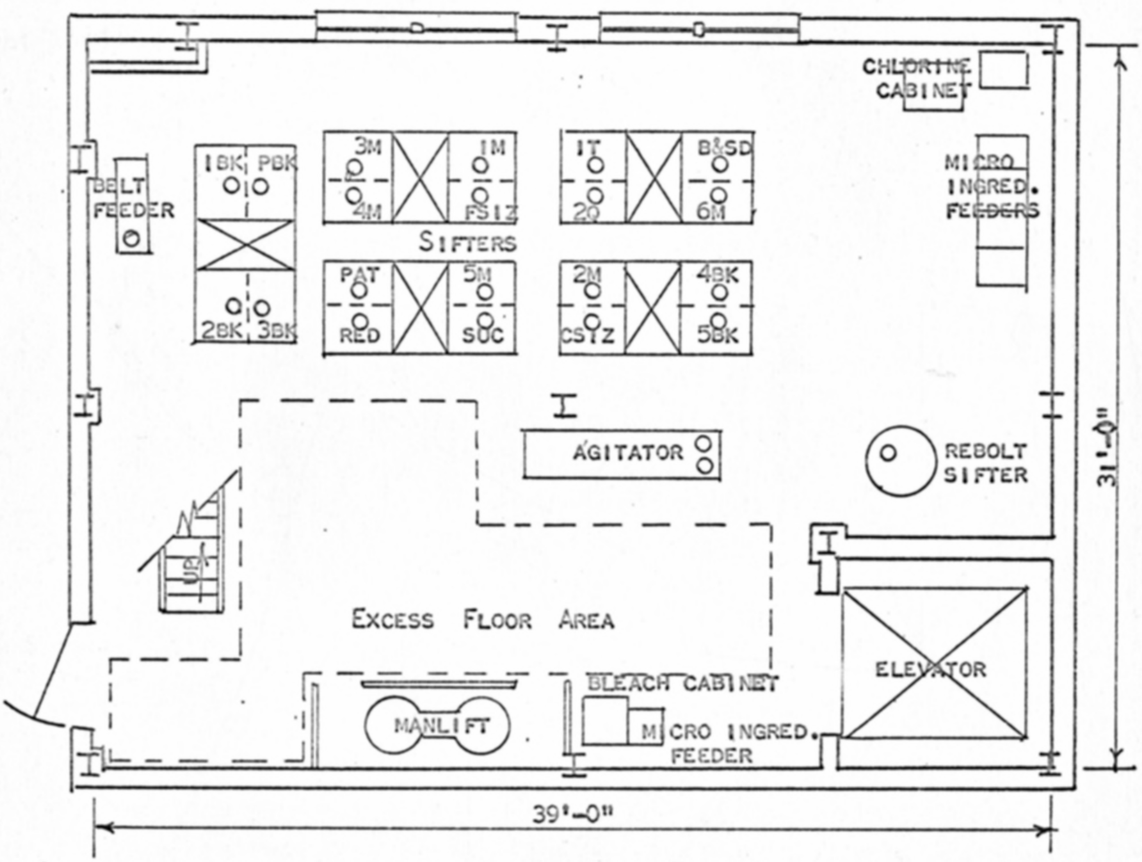



GROSS FLOOR AREA - 1209 SQ. FT.
EXCESS - 288 SQ. FT.
NET FLOOR AREA - 921 SQ. FT.

3RD FLOOR PLAN

SCALE 1/8" = 1'-0"

PLATE XXVII

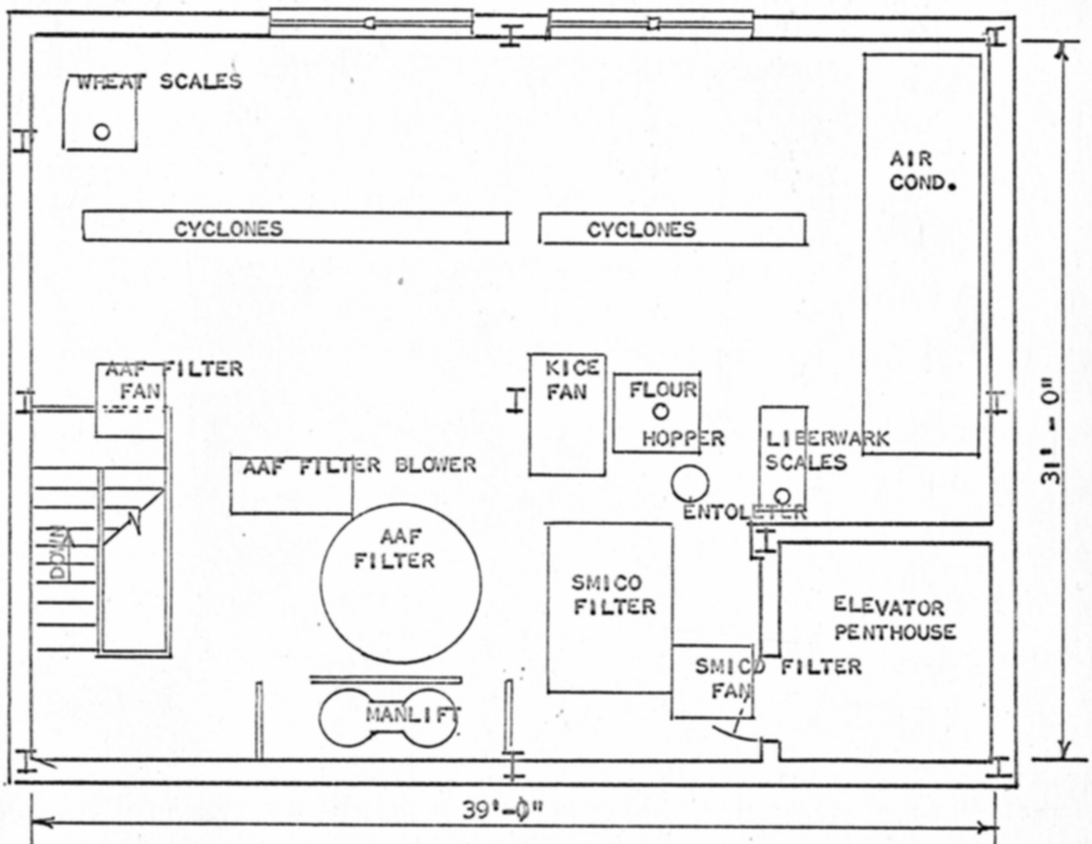



GROSS FLOOR AREA - 1209 SQ. FT.
EXCESS - 222 SQ. FT.
NET FLOOR AREA - 987 SQ. FT.

4TH FLOOR PLAN

SCALE 1/8" = 1'-0"

PLATE XXVIII

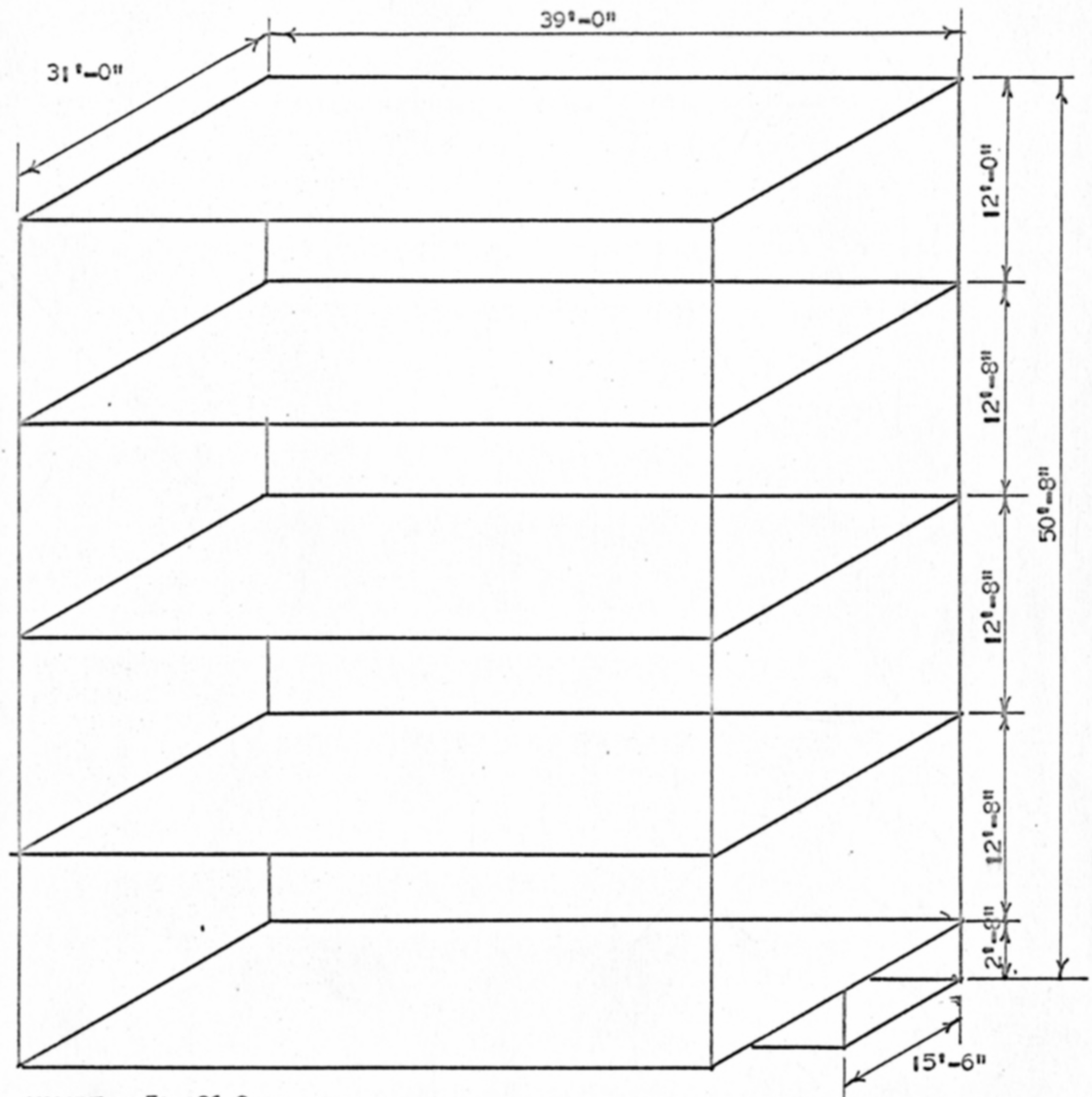



FLOOR AREA - 1209 SQ. FT.

5TH FLOOR PLAN

SCALE 1/8" = 1'-0"

PLATE XXIX




VOLUME - 51,186.8 CU. FT.

VOLUME STUDY OF EXISTING KANSAS STATE UNIVERSITY FLOUR MILL

Table 7. Gravity and pneumatic conveying requirements for

| Lift No. | Description from | Description to | Stock lb/min. | Pneumatic Conveying: Conveying Dist. (ft) Vertical | Conveying Dist. (ft) Horizontal | Tube Dia. (inches) | No. Elbows |
|---|---|---|---|---|---|---|---|
| - | Wheat Scales | Belt Feeder | 18.16 | - | - | - | - |
| - | Belt Feeder | Entoleter | 18.16 | - | - | - | - |
| - | Entoleter | PBk R | 18.16 | - | - | - | - |
| 1 | PBk R | PBk S | 18.16 | 48.0 | 9.5 | 2.5 | 2 |
| - | PBk S | 1Bk R | 18.00 | - | - | - | - |
| - | PBk S | Purifier-1 | .099 | - | - | - | - |
| - | PBk S | Red-a | .048 | - | - - | - | - |
| - | PBk S | Red-b | .057 | - | - | - | - |
| - | PBk S | Fl. Sam. | .033 | - | - | - | - |
| 2 | 1Bk R | 1 Bk S | 18.00 | 48.0 | 11.0 | 2.5 | 2 |
| - | 1Bk S | 2Bk R | 12.10 | - | - | - | - |
| - | 1Bk S | Purifier-1 | 3.66 | - | - | - | - |
| - | 1Bk S | Red-a | .99 | - | - | - | - |
| - | 1Bk S | Red-b | .54 | - | - | - | - |
| - | 1Bk S | Fl. Sam. | .52 | - | - | - | - |
| 3 | 2Bk R | 2Bk S | 12.10 | 48.0 | 13.0 | 2.5 | 2 |
| - | 2Bk S | 3Bk C R | 5.07 | - | - | - | - |
| - | 2Bk S | 3Bk F R | 1.99 | - | - | - | - |
| - | 2Bk S | Purifier-1 | 2.40 | - | - | - | - |
| - | 2Bk S | Redust | 1.56 | - | - | - | - |
| - | 2Bk S | Fl. Sam. | .60 | - | - | - | - |
| 4 | 3Bk Rs | 3Bk S | 7.06 | 48.0 | 18.5 | 2.0 | 2 |
| - | 3Bk S | 4Bk C R | 2.85 | - | - | - | - |
| - | 3Bk S | 4Bk F R | 1.54 | - | - | - | - |
| - | 3Bk S | Purifier-4 | 1.59 | - | - | - | - |
| - | 3Bk S | Redust | .67 | - | - | - | - |
| - | 3Bk S | Fl. Sam. | .63 | - | - | - | - |
| 5 | 4Bk Rs | 4Bk S | 4.39 | 48.0 | 10.0 | 2.0 | 2 |
| - | 4Bk S | 5Bk R-a | 3.48 | - | - | - | - |
| - | 4Bk S | 5Bk R-b | .33 | - | - | - | - |
| - | 4Bk S | Purifier-7 | .42 | - | - | - | - |
| - | 4Bk S | 4M R | .20 | - | - | - | - |
| - | 4Bk S | Fl. Sam. | .24 | - | - | - | - |
| 6 | 5Bk R | 5Bk S | 3.81 | 48.0 | 13.0 | 2.0 | 2 |
| - | 5Bk S | B Dust | 2.90 | - | - | - | - |
| - | 5Bk S | S Dust | .60 | - | - | - | - |
| - | 5Bk S | 5M R | .12 | - | - | - | - |
| - | 5Bk S | Fl. Sam. | .25 | - | - | - | - |

the multi-floor Kansas State University Mill.

| No. Cyclones | Gravity Spouting (ft) | Conveying Values (lb/min. × ft.) Horizontal | Vertical | Air Volume (CFM) | Required Power (H. P.) |
|---|---|---|---|---|---|
| - | 9.0 | - | - | - | - |
| - | 8.0 | - | - | - | - |
| - | 10.0 | - | - | - | - |
| 1 | 11.5 | 172.52 | 871.68 | 75 | .83 |
| - | 27.0 | - | — | - | - |
| - | 13.0 | - | - | - | - |
| - | 9.5 | - | - | - | - |
| - | 10.0 | - | - | - | - |
| - | 10.0 | - | - | - | - |
| 1 | 12.5 | 197.34 | 861.12 | 75 | .86 |
| - | 24.5 | - | - | - | - |
| - | 14.0 | - | - | - | - |
| - | 10.0 | - | - | - | - |
| - | 10.0 | - | - | - | - |
| - | 9.0 | - | - | - | - |
| 1 | 12.0 | 157.30 | 580.80 | 75 | .64 |
| - | 25.0 | - | - | - | - |
| - | 24.0 | - | - | - | - |
| - | 11.5 | - | - | - | - |
| - | 8.5 | - | - | - | - |
| - | 10.0 | - | - | - | - |
| 1 | 12.5 | 140.79 | 365.28 | 75 | .64 |
| - | 26.5 | - | - | - | - |
| - | 28.5 | - | - | - | - |
| - | 11.0 | - | - | - | - |
| - | 18.5 | - | - | - | - |
| - | 9.5 | - | - | - | - |
| 1 | 11.0 | 49.90 | 239.52 | 75 | .64 |
| - | 29.0 | - | - | - | - |
| - | | - | - | - | - |
| - | 39.0 | - | - | - | - |
| - | 16.0 | - | - | - | - |
| - | 16.0 | - | - | - | - |
| 1 | 13.5 | 50.83 | 189.64 | 75 | .64 |
| - | 13.0 | - | - | - | - |
| - | 13.0 | - | - | - | - |
| - | 23.0 | - | - | - | - |
| - | 10.5 | - | - | - | - |

Table 7. (continued)

| Lift No. | Description: from | Description: to | Stock lb/min. | Pneumatic Conveying: Conveying Dist. (ft): Vertical | Conveying Dist. (ft): Horizontal | Tube Dia. (inches) | No. Elbows |
|---|---|---|---|---|---|---|---|
| 7 | F Siz R | F Siz S | 4.17 | 48.5 | 12.5 | 2.0 | 2 |
| - | F Siz S | 1T R | .21 | - | - | - | - |
| - | F Siz S | Purifier-6 | 2.16 | - | - | - | - |
| - | F Siz S | 1M R | 1.10 | - | - | - | - |
| - | F Siz S | Fl. Sam.-t | .53 | - | - | - | - |
| - | F Siz S | Fl. Sam.-b | .06 | - | - | - | - |
| 8 | C Siz R | C Siz S | 4.28 | 48.5 | 22.5 | 2.0 | 2 |
| - | C Siz S | 1T R | .17 | - | - | - | - |
| - | C Siz S | Purifier-5 | 3.59 | - | - | - | - |
| - | C Siz S | 1M R | .12 | - | - | - | - |
| - | C Siz S | Fl. Sam.-t | .14 | - | - | - | - |
| - | C Siz S | Fl. Sam.-b | .01 | - | - | - | - |
| 9 | 1M R | 1M S | 5.27 | 48.5 | 13.0 | 2.0 | 2 |
| - | 1M S | 1T R | .004 | - | - | - | - |
| - | 1M S | Purifier-6 | .42 | - | - | - | - |
| - | 1M S | Fl. Sam.-t | 1.68 | - | - | - | - |
| - | 1M S | Fl. Sam.-b | .73 | - | - | - | - |
| - | 1M S | 2M R | 2.28 | - | - | - | - |
| 10 | 2M R | 2M S | 5.17 | 48.5 | 14.0 | 2.0 | 2 |
| - | 2M S | 1T R | .004 | - | - | - | - |
| - | 2M S | Purifier-7 | .34 | - | - | - | - |
| - | 2M S | 3M R | 2.24 | - | - | - | - |
| - | 2M S | Fl. Sam.-t | 2.11 | - | - | - | - |
| - | 2M S | Fl. Sam.-b | .44 | - | - | - | - |
| 11 | 3M R | 3M S | 2.86 | 48.5 | 20.0 | 2.0 | 0 |
| - | 3M S | 1T R | .07 | - | - | - | - |
| - | 3M S | 4M R | .93 | - | - | - | - |
| - | 3M S | Fl. Sam. | 1.84 | - | - | - | - |
| 12 | 4M R | 4M S | 2.06 | 48.5 | 20.0 | 2.0 | 2 |
| - | 4M S | 5Bk R | .0 | - | - | - | - |
| - | 4M S | 5M R | .69 | - | - | - | - |
| - | 4M S | Fl. Sam. | 1.15 | - | - | - | - |
| 13 | 5M R | 5M S | 1.00 | 48.5 | 17.0 | 2.0 | 2 |
| - | 5M S | S Dust | .20 | - | - | - | - |
| - | 5M S | 6M R | .19 | - | - | - | - |
| - | 5M S | Fl. Sam. | .40 | - | - | - | - |
| 14 | 6M R | 6M S | .37 | 48.5 | 13.5 | 2.0 | 2 |
| - | 6M S | Fd. Scale | .20 | (combined with lift No. 16) | | | |
| - | 6M S | Fl. Sam. | .17 | - | - | - | - |

| No. Cyclones | Gravity Spouting (ft) | Conveying Values (lb/min. × ft.) Horizontal | Vertical | Air Volume (CFM) | Required Power (H. P.) |
|---|---|---|---|---|---|
| 1 | 7.5 | 54.5 | 211.46 | 75 | .64 |
| - | 24.0 | - | - | - | - |
| - | 16.0 | - | - | - | - |
| - | 23.0 | - | - | - | - |
| - | 10.0 | - | - | - | - |
| - | 10.0 | - | - | - | - |
| 1 | 14.0 | 94.28 | 203.22 | 75 | .69 |
| - | 25.5 | - | - | - | - |
| - | 13.0 | - | - | - | - |
| - | 23.5 | - | - | - | - |
| - | 9 | - | - | - | - |
| - | 9 | - | - | - | - |
| 1 | 17.0 | 68.51 | 255.60 | 75 | .64 |
| - | 24.5 | - | - | - | - |
| - | 16.0 | - | - | - | - |
| - | 8.5 | - | - | - | - |
| - | 8.5 | - | - | - | - |
| - | 24.0 | - | - | - | - |
| 1 | 15.0 | 71.96 | 249.29 | 75 | .65 |
| - | 24.5 | - | - | - | - |
| - | 10.5 | - | - | - | - |
| - | 25.5 | - | - | - | - |
| - | 9.5 | - | - | - | - |
| - | 9.5 | - | - | - | - |
| 1 | 13.5 | 57.20 | 138.71 | 75 | .67 |
| - | 26.0 | - | - | - | - |
| - | 24.5 | - | - | - | - |
| - | 10.5 | - | - | - | - |
| 1 | 14.0 | 41.20 | 141.11 | 75 | .67 |
| - | 23.4 | - | - | - | - |
| - | 26.5 | - | - | - | - |
| - | 9.5 | - | - | - | - |
| 1 | 14.5 | 22.78 | 64.99 | 75 | .62 |
| - | 3.0 | - | - | - | - |
| - | 24.5 | - | - | - | - |
| - | 9.5 | - | - | - | - |
| 1 | 15.0 | 4.86 | 17.46 | 75 | .66 |
| - | 36.5 | - | - | - | - |
| - | 9.5 | - | - | - | - |

Table 7. (continued)

| Lift No. | Description from | Description to | Stock lb/min. | Pneumatic Conveying: Conveying Dist. (ft) Vertical | Conveying Dist. (ft) Horizontal | Tube Dia. (inches) | No. Elbows |
|---|---|---|---|---|---|---|---|
| 15 | B&S Dust | B&SD S | .85 | 38.5 | 18.0 | 2.0 | 2 |
| 16 | B&S Dust | Fd. Scales | 3.58 | 38.0 | 21.0 | 2.0 | 3 |
| - | B&SD S | 6M R | .17 | - | - | - | - |
| - | B&SD S | Fd. Scales | .28 | (Combined with Lift No. 16) | | | |
| - | B&SD S | Fl. Sam. | .35 | - | - | - | - |
| 17 | Red Coll. | Red. S | 3.86 | 27.0 | 15.5 | 2.0 | 2 |
| - | Red S | Purifier-2 | 1.60 | - | - | - | - |
| - | Red S | Purifier-3 | 1.48 | - | - | - | - |
| - | Red S | 2M R | .62 | - | - | - | - |
| - | Red S | Fl. Sam. | .17 | - | - | - | - |
| - | Fl. Sam. | A-Valve | 12.41 | - | - | - | - |
| 18 | Fl. Sam. | 1 Cl. Agit. | 0 | 50.5 | 18.0 | 2.0 | 2 |
| 19 | A-Valve | P Reb S | 0 | 28.5 | 21.0 | 2.0 | 2 |
| 20 | A-Valve | St. Gd. Agit. | 12.41 | 48.5 | 21.0 | 2.5 | 2 |
| - | Agit. | Blend (2) | 12.41 | - | - | - | - |
| - | Blender | By Pass (2) | 0 | - | - | - | - |
| 21 | Blend | Hop & Ent. | 12.41 | 31.5 | 11.0 | 2.5 | 2 |
| - | Reb | Packer | 12.41 | - | - | - | - |
| - | Reb | Purifier-7 | .06 | - | - | - | - |
| 22 | 2Q R | 2Q S | .95 | 48.5 | 13.0 | 2.0 | 2 |
| - | 2Q S | 1T R | .15 | - | - | - | - |
| - | 2Q S | Purifier-7 | .70 | - | - | - | - |
| - | 2Q S | 3M R | .10 | - | - | - | - |
| - | 2Q S | Fl. Sam. | .064 | - | - | - | - |
| 23 | 1T R | 1T S | 1.70 | 48.5 | 12.0 | 2.0 | 2 |
| - | 1T S | Fd. Scales | .62 | - | - | - | - |
| - | 1T S | 4M R | .45 | - | - | - | - |
| - | 1T S | 5M R | .53 | - | - | - | - |
| - | 1T S | Fl. Sam. | .099 | - | - | - | - |
| 24 | Suc | Suc S | .29 | 13.5 | 21.0 | 2.0 | 3 |
| - | Suc S | 5Bk R | .05 | - | - | - | - |
| - | Suc S | Fd. Scales | .09 | (Combined with Lift No. 16) | | | |
| - | Purifier-1 | 3Bk R | .55 | - | - | - | - |
| - | Purifier-1 | C Siz R | 4.28 | - | - | - | - |
| - | Purifier-1 | F Siz R | 1.29 | - | - | - | - |
| - | Purifier-1 | 5Bk (Asp.)* | tr | - | - | - | - |

*Asp. from Purifier-1 & Purifier-2 combined.

| No. Cyclones | Gravity Spouting (ft) | Conveying Values (lb/min. × ft.) Horizontal | Vertical | Air Volume (CFM) | Required Power (H. P.) |
|---|---|---|---|---|---|
| 1 | 19.5 | 15.30 | 32.73 | 75 | .63 |
| 1 | 6.0 | 84.00 | 192.00 | 75 | .64 |
| - | 25.0 | - | - | - | - |
| - | 36.0 | - | - | - | - |
| - | 9.5 | - | - | - | - |
| 1 | 11.5 | 10.42 | 59.83 | 75 | .57 |
| - | 10.5 | - | - | - | - |
| - | 12.0 | - | - | - | - |
| - | 26.0 | - | - | - | - |
| - | 9.5 | - | - | - | - |
| - | 25.0 | - | - | - | - |
| 1 | 37.0 | 0 | 0 | 0 | 0 |
| 1 | 12.0 | 0 | 0 | 0 | 0 |
| 1 | 17.0 | 260.61 | 601.89 | - | - |
| - | 16.0 | - | - | - | - |
| - | 10.0 | - | - | - | - |
| 1 | - | 136.51 | 390.92 | 75 | .57 |
| - | 12.0 | - | - | - | - |
| - | 2.0 | - | - | - | - |
| - | 10.0 | - | - | - | - |
| 1 | 14.0 | 12.35 | 46.08 | 75 | .65 |
| - | 28.5 | - | - | - | - |
| - | 12.5 | - | - | - | - |
| - | 24.0 | - | - | - | - |
| - | 9.0 | - | - | - | - |
| 1 | 15.0 | 20.4 | 82.45 | 75 | .64 |
| - | 43.5 | - | - | - | - |
| - | 25.0 | - | - | - | - |
| - | 23.5 | - | - | - | - |
| - | 9.0 | - | - | - | - |
| 1 | 14.0 | 3.92 | 6.09 | 75 | .54 |
| - | 23.0 | - | - | - | - |
| - | (Combined with B&SQ) | | | | |
| - | 10.0 | - | - | - | - |
| - | 10.0 | - | - | - | - |
| - | 25.5 | - | - | - | - |
| - | 14.0 | - | - | - | - |
| - | 8.0 | - | - | - | - |

Table 7. (concluded)

| Lift No. | Description from | Description to | Stock lb/min. | Pneumatic Conveying: Conveying Dist. (ft) Vertical | Pneumatic Conveying: Conveying Dist. (ft) Horizontal | Pneumatic Conveying: Tube Dia. (inches) | Pneumatic Conveying: No. Elbows |
|---|---|---|---|---|---|---|---|
| - | Purifier-2 | C Siz R | tr | - | - | - | - |
| - | Purifier-2 | F Siz R | .63 | - | - | - | - |
| - | Purifier-2 | 1M R | .93 | - | - | - | - |
| - | Purifier-2 | 1T R | tr | - | - | - | - |
| - | Purifier-3 | 1M R | 1.19 | - | - | - | - |
| - | Purifier-3 | 2Q R | tr | - | - | - | - |
| - | Purifier-3 | 1T R | tr | - | - | - | - |
| - | Purifier-3 | 2M R | .19 | - | - | - | - |
| - | Purifier-3 | F Siz R | 0 | - | - | - | - |
| - | Purifier-3 | 5Bk (Asp) | tr | (Asp. Purifier-2 and Purifier-3 combined) | | | |
| - | Purifier-4 | 1T R | .22 | - | - | - | - |
| - | Purifier-4 | 2Q R | .23 | - | - | - | - |
| - | Purifier-4 | F Siz R | 1.20 | - | - | - | - |
| - | Purifier-4 | C Siz R | 0 | - | - | - | - |
| - | Purifier-5 | 2M R | 0 | - | - | - | - |
| - | Purifier-5 | 2Q R | .28 | - | - | - | - |
| - | Purifier-5 | 1M R | 1.93 | - | - | - | - |
| - | Purifier-5 | 1T R | .097 | - | - | - | - |
| - | Purifier-5 | F Siz R | 1.05 | - | - | - | - |
| - | Purifier-6 | 1T R | .05 | - | - | - | - |
| - | Purifier-6 | 2Q R | .09 | - | - | - | - |
| - | Purifier-6 | 2M R | 2.05 | - | - | - | - |
| - | Purifier-6 | 3M R | 0 | - | - | - | - |
| - | Purifier-7 | 5Bk R | .05 | - | - | - | - |
| - | Purifier-7 | 3M R | 1.29 | - | - | - | - |
| - | Purifier-7 | 1T R | .61 | - | - | - | - |
| Totals | | | 790.97 | 1069.0 | 400.0 | - | 42 |

| No. Cyclones | Gravity Spouting (ft) | Conveying Values (lb/min. × ft.) Horizontal | Vertical | Air Volume (CFM) | Required Power (H. P.) |
|---|---|---|---|---|---|
| - | 11.0 | - | - | - | - |
| - | 12.5 | - | - | - | - |
| - | 10.5 | - | - | - | - |
| - | 12.5 | - | - | - | - |
| | | | | | |
| - | 9.0 | - | - | - | - |
| - | 9.5 | - | - | - | - |
| - | 9.5 | - | - | - | - |
| - | 13.5 | - | - | - | - |
| - | 8.5 | - | - | - | - |
| - | 13.0 | - | - | - | - |
| | | | | | |
| - | 12.5 | - | - | - | - |
| - | 10.5 | - | - | - | - |
| - | 12.5 | - | - | - | - |
| - | 12.0 | - | - | - | - |
| | | | | | |
| - | 16.0 | - | - | - | - |
| - | 18.5 | - | - | - | - |
| - | 12.0 | - | - | - | - |
| - | 10.0 | - | - | - | - |
| - | 12.0 | - | - | - | - |
| | | | | | |
| - | 9.6 | - | - | - | - |
| - | 11.0 | - | - | - | - |
| - | 15.0 | - | - | - | - |
| - | 9.0 | - | - | - | - |
| | | | | | |
| - | 9.5 | - | - | - | - |
| - | 22.0 | - | - | - | - |
| - | 12.0 | - | - | - | - |
| | | | | | |
| 24 Total | 2136.1 | 1727.66 | 5801.78 | 1575 | 13.73 |

<u>The Single-floor Kansas State University Mill</u>. An attempt was made to arrange all of the machinery on a single slab floor. The goal in the arrangement was to use as little power as possible for conveying the stock between the various machines. After several arrangements of the mill on paper the floor plan shown in Plate XXX was chosen. This arrangement was designed such that the heavily loaded tubes averaged the shortest conveying distance. The total floor area of this single-floor mill is 2365.4 sq. ft. The volume study shown in Plate XXXI reveals a total volume of 40,582.7 cubic feet in the mill.

The conveying requirements for the single-floor mill were figured using two different arrangements. The first arrangement involved using a separate lift between each machine and for each sifter, purifier, and duster (Plan B, Plate XXXII) separation. The layouts of the pneumatic runs for this system are shown in Appendix B. The conveying requirements are found in Table 10.

The second arrangement (Plan C, Plate XXXII) used a single lift for all common stocks combined coming from a machine. One sifter has the Pre Break, First Break, Second Break and Third Break sifter sections. There are seven streams going to Break Redust from this machine. In the first plan this would require seven pneumatic lifts, but in the second plan all seven were combined and carried to a central point and a single lift. The pneumatic tubing layout and conveying requirements for the second single-floor plan are shown in Appendix C.

A summary of the data gathered and values calculated for both the existing mill and the two single-floor arrangements are found in Table 8.

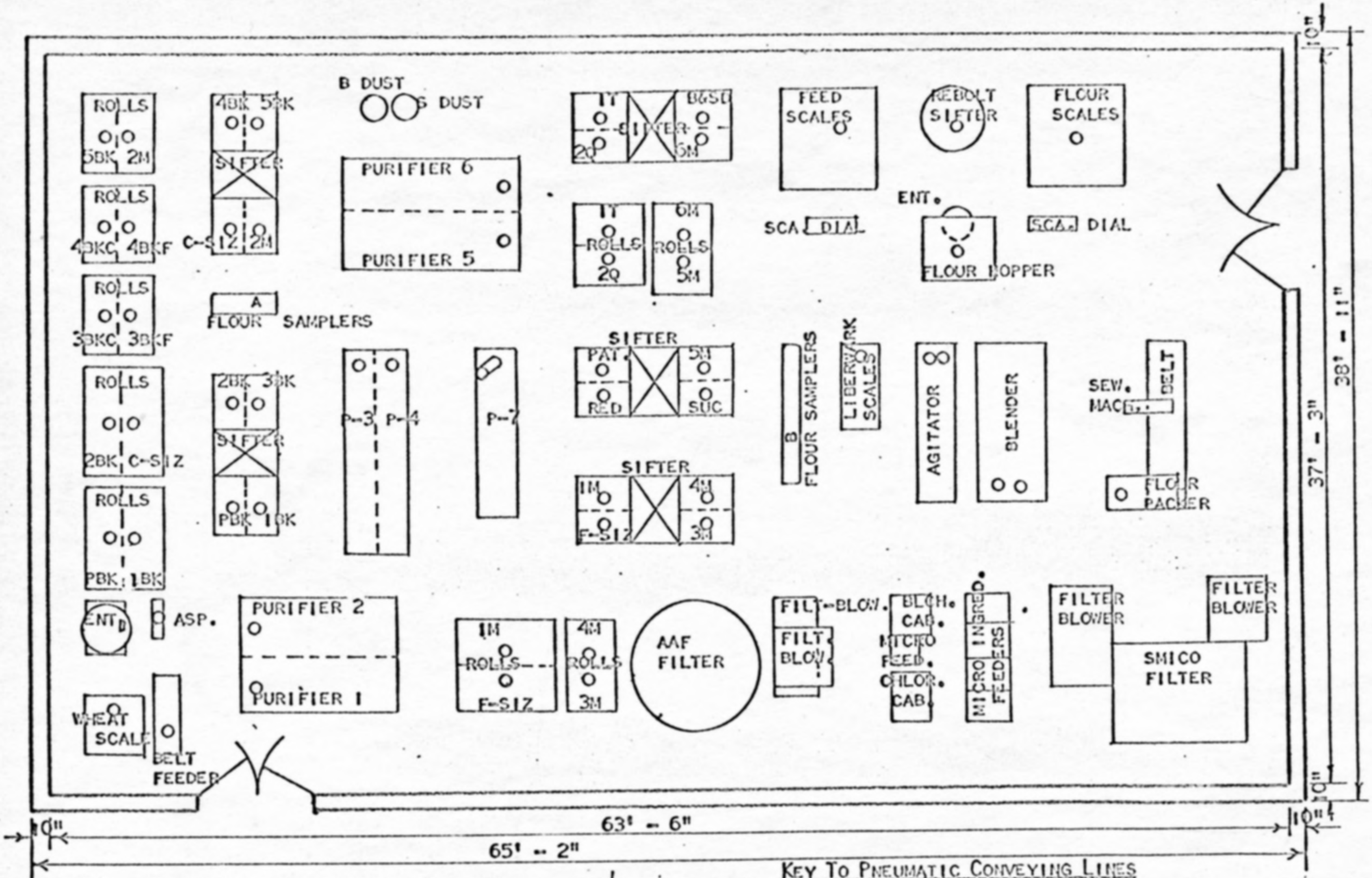



**PLATE XXX**

Single Floor Layout for Kansas State Univ.
Flour Mill

Scale 1/8" = 1' - 0"

Floor Area = 2365.4 Sq. Ft.

Key To Pneumatic Conveying Lines

Between machines (except sifter separations) ————

Sifter Separations

Bottom flour - - - - - - - -

Top flour ..................

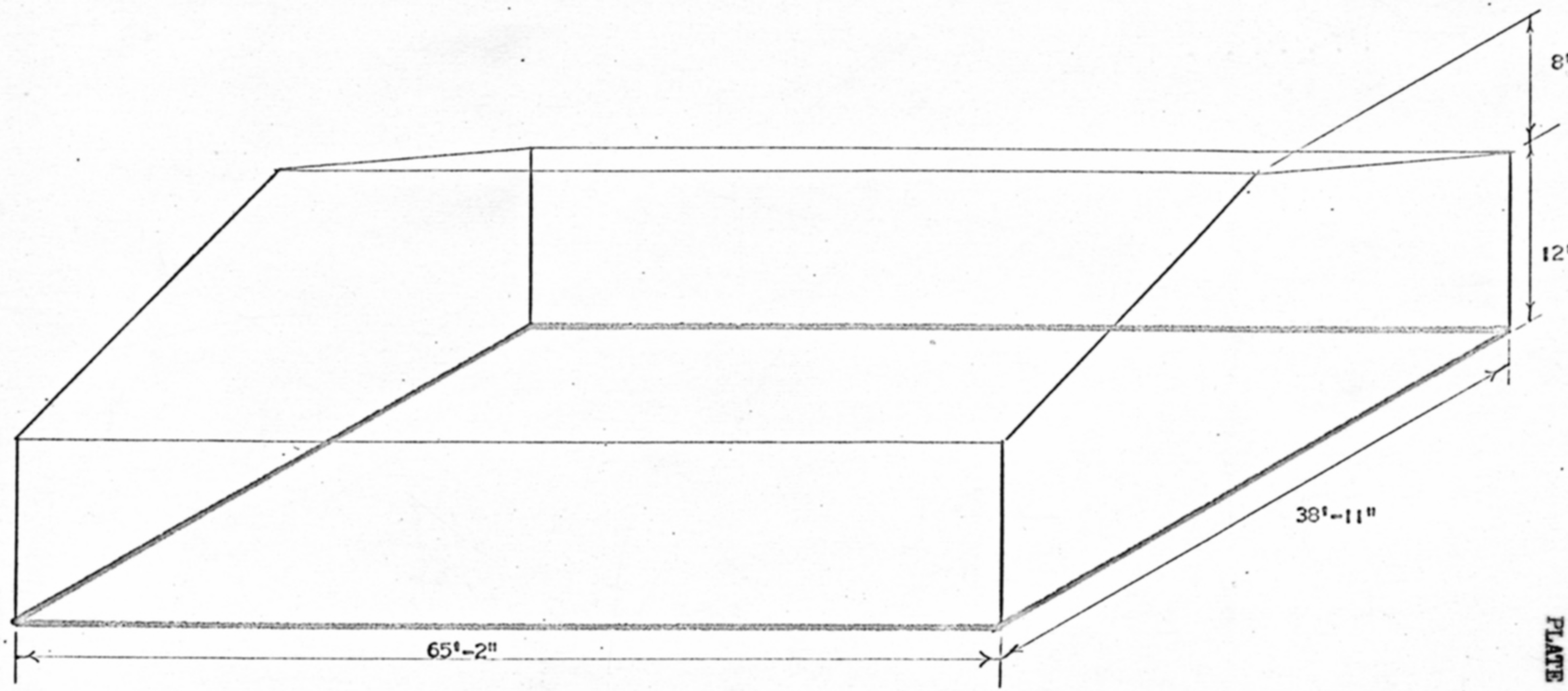
Thrus of grading or dusting cloth — ——

Bottom scalp —— - —— - ——

2nd from bottom scalp —— - - ——

3rd from bottom scalp —— - - - ——

4th from bottom scalp —— - - - - ——




VOLUME STUDY OF SINGLE FLOOR MILL BUILDING

TOTAL VOLUME - 40582.7 CU. FT.

PLATE XXXI

PLATE XXXII

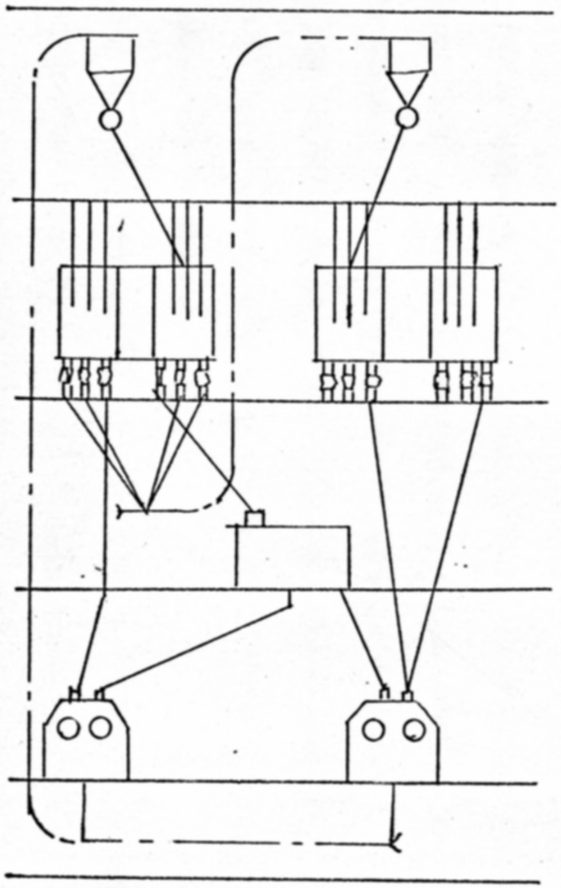


Fig. 1 Plan A

Existing K. S. U. Mill

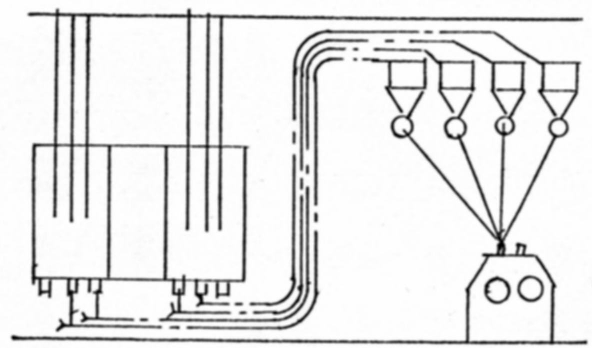


Fig. 2 Plan B

Single-floor with Separate

Pickups for Each Stock

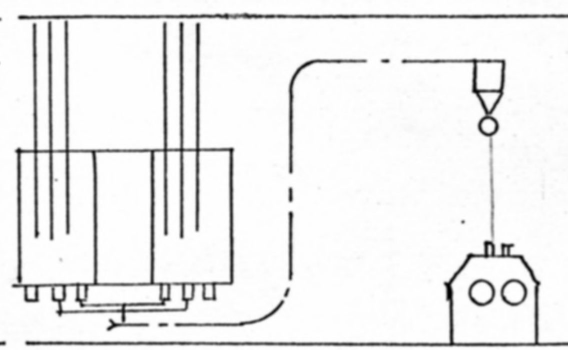


Fig. 3 Plan C

Single-floor with Combined

Lifts for Common Stocks

Table 8. Summary of conveying requirements.

| Item | Plan A Existing K.S.U. Mill | Single-floor Arrangements: Plan B Separate lift each stock | Plan C Combined common stock in single lift |
|---|---|---|---|
| Gravity Spouting | 2136.1 ft | 304.1 ft | 233.0 ft |
| No. Pneumatic Lifts | 24 | 157 | 122 |
| Total Vertical Pneumatic Tubing | 1069.0 ft | 1739.0 ft | 1350.0 ft |
| Total Horizontal Pneumatic Tubing | 400.0 ft | 2248.7 ft | 1676.4 ft |
| Elbows | 42 | 327 | 254 |
| Average Vertical Run | 44.54 ft | 11.08 ft | 11.07 ft |
| Average Horizontal Run | 16.67 ft | 14.32 ft | 13.74 ft |
| Conveying Valve, Vertical | 5801.78 | 4369.0 | 3985.7 |
| Conveying Valve, Horizontal | 1727.66 | 3269.53 | 3118.6 |
| Vertical Number Index (VNI) | 7.17 | 21.71 | 19.83 |
| Horizontal Number Index (HNI) | 5.88 | 11.13 | 12.50 |
| No. lb/min lifted per foot of vertical run | .17 | .20 | .26 |
| No. lb/min lifted per foot of horizontal run | .31 | .16 | .21 |
| CFM Required | 1575 | 2413 | 2257 |
| H. P. Required | 13.73 | 18.070 | 16.270 |

## RESULTS AND DISCUSSION

### Machinery Pneumatic Pickups and Drives

As stated before the mill worked with in this thesis was laid out on a single slab floor. This floor rested against the earth. Due to this all lifts had to be carried from each collection point at floor level to the cyclone over the next machine in the flow. This slab floor made it unwise to use a lineshaft to power the machinery since it would have to be mounted from the ceiling above the machinery.

Roller Mill Pickups and Drives. Most of the work on pickups was done with a sifter, but it would be wise to mention a little more about the roller mill. In the review of literature the direct-lift type of pickup was shown as applied to a European roller mill (Fig. 1, Plate VIII). The pickup used for one European roller mill could be modified and attached to the standard American Allis roller mill. The changes and attachment of the lift are shown in Plate XXXIII. The pickup is designed so that the air for the lift is pulled through the rolls. Some of this air is separated from the stock due to the low air velocities in the large hopper of the roller mill base. The separate air is collected high on the side of the hopper and piped through the base of the hopper to the vertical section of the lift. In the horizontal part of tubing passing through the roll stand the stock is reintroduced into the moving air stream via a venturi type of opening.

The air tight sealed outside opening serves only for the purpose of quick cleanout in case of a choke up in the system. The elbow and vertical section of the lift can be uncoupled from the stand. By removing the air seal cap at the other end, the horizontal pickup in the roller mill base can be easily cleaned out.

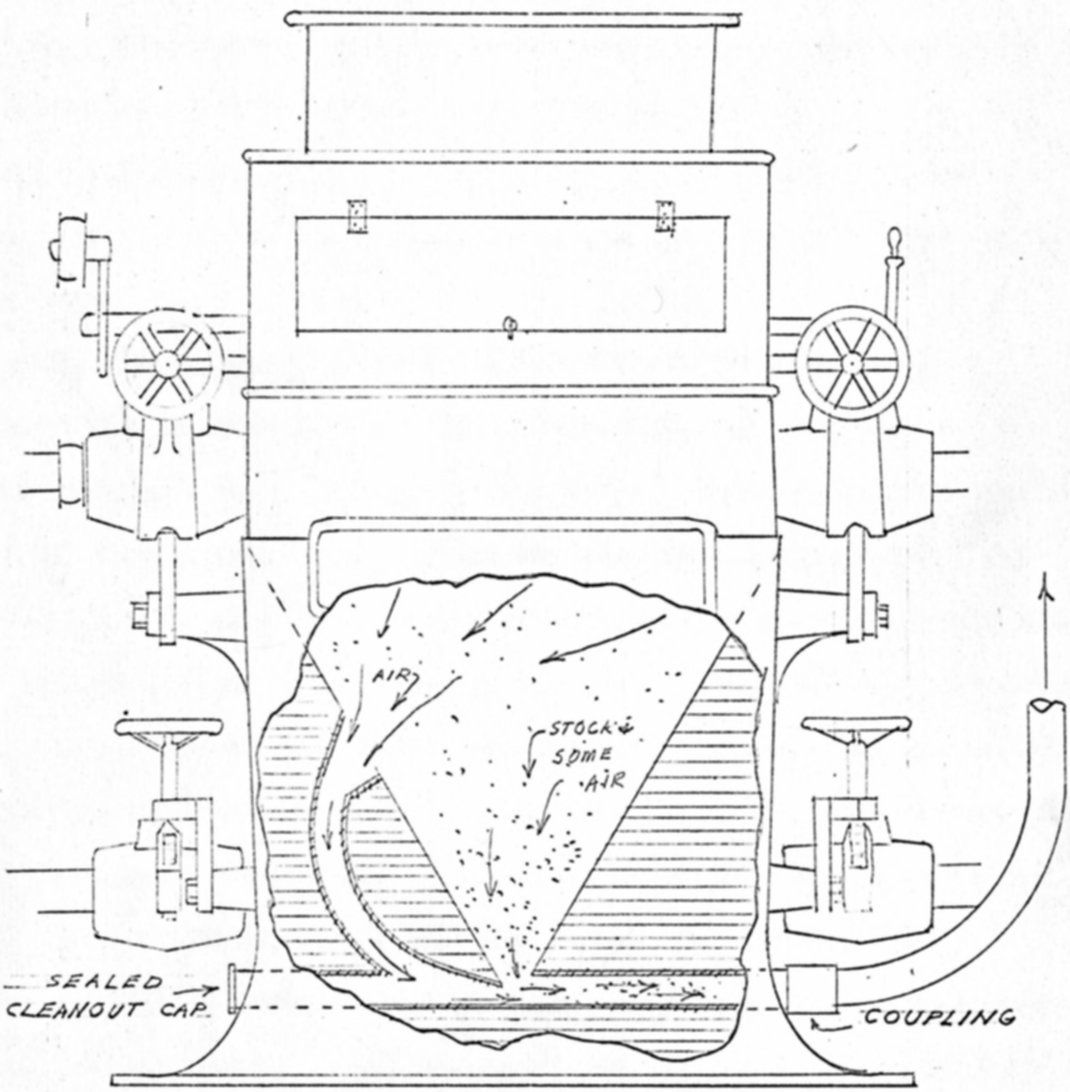
In regard to roller mill drives, with the use of individual drives, the roll doesn't have to be aligned with others but placed at any location where it is easiest to use. Most of the individual drives used are electric motors and V-belts. These motors have to be of the enclosed explosion proof type and are quite expensive. These motors have to be chosen and installed carefully for their jobs if they are to work properly. An electric motor can't take an overload for too long without heating and stopping.

The use of hydraulic motors to drive the roller mills is possible as a solution to the problems encountered with the motors. These motors are relatively small and yet transmit sufficient horsepower to drive a roller mill.

PLATE XXXIII

Suggested Design for Pneumatic Pickup

Attached to Allis Type Roller Mill



The piston type of pump is estimated to be around 85 percent efficient. The motors could be mounted directly on the ends of the rolls. All of the motors for the roller mills would be powered from a central pressurized oil reservoir and pump. The use of hydraulics could also lead to possible reductions in insurance rates due to the absence of most of the electrical motors, wiring, switchgear, etc. The hydraulic motor can't overheat because of built-in pressure relief valves in the systems.

Purifier and Sifter Drives. Hydraulic motors could easily be adopted for use on these machines. They could be mounted in a similar manner to the electric motor.

Sifter Pneumatic Pickups. From the data calculated in Table 4 it appeared that the gyrating sifter pickup couldn't convey quite as much air through the system as the stationary pickup could. Although the data showed only a slight difference between the two systems, it was evident that the velocity was a little higher in the stationary pickup with other things being equal for both conditions of pickup. At the same time it was also noted that the stationary pickup required about the same static pressure as the gyrating pickup. Horsepower requirements for the gyrating and stationary pickups were relatively the same. Thus it can be said that the difference in power requirements for the gyrating and stationary pickups was negligible.

As stated earlier, some air was entering the pickup through the stock inlet. With the cyclone wide open at the end of the system identical trials were run with the stock inlet taped and open. A similar set of trials was run with the cyclone being half open. With the cyclone wide open it was found that 19 percent of the air was entering with the stock. With the cyclone half open this figure was 14.4 percent. Since it isn't desirable to have much suction on the sifter some method of allowing outside air to enter the stock inlet is needed. This can be accomplished by using an open funnel rigidly attached between the nipple of the sifter and the carrier type of pickup.

Results of the data compiled showed the maximum capacity or choke up feed rate for the pickup was interesting (Table 5). Whether or not the pickup gyrates is a very important factor. Results show that the stationary pickup will take 51 percent more Purifier-1 stock than the gyrating pickup. About 79 percent more second break can be passed through the stationary pickup.

It is believed that the gyrating motion and design of the stock pickup accounts for the inability of the moving pickup to convey as much as the stationary pickup. The stock was introduced to the air stream in a horizontal direction parallel to the throw of the sifter. The motion of the sifter tends to throw the stock in the vertical air stream centrifugally against the walls of the tube. Thus it is probable that part of the stock just entering the air stream is forced back into the stock inlet and hinders other incoming stock from entering the air passage.

With the knowledge gained from the stock conveying abilities of the gyrating and stationary pickups certain improvements can be described. It might be possible to install a spiral along the inside diameter of the air pickup. This would probably add a little more resistance to the pneumatic system, but when the pickup was gyrating this spiral would help carry stock up and away from the inlet. Time didn't permit, but it would be interesting and helpful to construct the same pickup out of a transparent material and observe the action taking place when it was moving or stationary. A better way of introducing the stock to the air stream might also be devised.

## Mill Layout and Arrangement

**Floor Areas**. In the single-floor mill layout the manlift and elevator aren't needed. When the multi-floor and single-floor layout were compared it was found that the single-floor arrangement required 2365.4 sq. ft. of floor space. The multi-floor mill required 4582 sq. ft. to house the same equipment and the elevator and manlift. The single-floor layout required 48 percent less floor area.

**Pneumatic Conveying Comparisons**. For ease in comparing the multi-floor mill and two single-floor arrangements the arrangements will be designated as follows:

Plan A - The Kansas State University mill on multi-floors as it now exists.

Plan B - The Kansas State University mill on a single-floor with a separate lift for each stock.

Plan C - The Kansas State University mill on a single-floor with combined common stock from the same machine using one lift.

When the flour mill is arranged on one floor the gravity flow is drastically reduced. Plan B reduced the gravity spouting by 84 percent while plan C reduced it 90 percent. The gravity spouting in plans C and B is used only between the air lock below the cyclone and the inlet to the machine.

While plan A requires only 24 pneumatic lifts, plan B needs 157 lifts and plan C needs 122. The total vertical runs in the three plans shows some difference but it isn't as great as expected. Plan B requires 1.6 times as much as plan A and plan C needs 1.26 times as much. The horizontal total pneumatic conveying distances shows much greater variation between the three plans. Plan A uses only 400 ft. of horizontal tubing. Plan B uses 5.6 times more and plan C uses 4.2 times more horizontal tubing.

Since all machinery is on the single slab in plans B and C, the average vertical distance conveyed for each system is about 11 feet. This compares with 44.5 feet for plan A. Evidence shows that the average horizontal run is shorter in the single-floor arrangement.

The conveying values of the three plans shows appreciable differences. Plan A has a greater vertical conveying value than either of the other plans. In contrast, the horizontal conveying value is lowest for plan A. In comparison of plans B and C it is evident that the conveying values, both vertical and horizontal, are higher for the mill using separate lifts for each stock. Thus plan C begins to become more efficient in conveying. It must be stated now that the power requirements for vertical and horizontal conveying are related to the conveying values. In discussions with Jack Kice it was noted that horizontal conveying requires about 8 percent more power than a vertical conveying with the same amount of material. Thus it is necessary to correct the horizontal conveying values by a factor of 1.08.

The vertical number index (VNI) for plan A is considerably less than that for plans B and C. It is desirable to keep this factor as low as is possible. As can be seen in plan C the VNI is less than for plan B. This value dropped in plan C because the conveying value also dropped but the head weight and average vertical lift distance remained the same. The horizontal number index (HNI) shows a greater value for the single-floor arrangements, but shows that plan C has a higher HNI than plan B. This increase in the HNI was due to the decrease in the average horizontal distance conveyed. Although plan C has a lesser conveying value than plan B, the average horizontal distance conveyed decreases at a faster proportional rate for plan C and gives the HNI an increased value for plan C than plan B. Thus it is felt that the horizontal and vertical number indexes should be kept as low as possible, but in some cases the horizontal number index may increase slightly.

The amount of stock conveyed per foot of pneumatic run increases as the system becomes more efficient up to a point. This point is controlled by the ratio of the air being conveyed to the weight of stock being conveyed. This air ratio is usually set at a minimum of 4 cubic feet of air per pound of stock conveyed. This value differs a little for different types of stocks.

The air quantities needed for conveying the stocks increases for the single story layouts. The multi-floor layout requires only 1575 cfm while plan B needs 1.53 times as much and plan C needs 1.43 times as much. For the two single-floor layouts plan C requires 7 percent less air than plan B. These requirements could be lowered and the system made more efficient if small diameter pipes were used for many of the lifts. The smallest diameter tubing used in the layouts was 3/4" O.D. and was larger than needed for many of the lightly loaded streams.

The multi-floor plan requires 13.73 estimated horsepower to handle the pneumatic conveying of stocks. Single-floor plan B requires 18.070 horsepower for pneumatic conveying, an increase of 31 percent over the multi-floor plan A. Plan C requires less power than plan B, but does require 19 percent more power than plan A. Lower horsepower requirements also could be obtained with the use of smaller diameter tubes. For commercial installation it isn't considered feasible to use conveying lines much smaller than 1 1/4" outside diameter.

## CONCLUSIONS

It is firmly believed by the author that the successful operation of a single-floor flour mill is possible. The layout will have certain advantages over the multi-floor layout, but likewise will have some disadvantages.

The use of individual drives would make it possible to arrange the machinery in the order of the flow, situated so that the heaviest stocks are conveyed the shortest distances. With this arrangement and the use of a negative pneumatic conveying system the problem of pulling air through all the cyclones exists. In most installations the clean air sides of the cyclones are powered by a common fan through a system of air trunk lines. Since the machinery isn't lined up it might present some problems in supplying the air to the gathering trunk lines. This factor can have a definite effect on the location and alignment of the equipment. The development of a cyclone with its own built-in fan might alleviate this problem.

The floor area and building occupied by the single-floor mill can be easily constructed. It would be possible to use a prefabricated building erected over a concrete slab floor. This type of structure is very versatile and makes it possible to erect a single-floor mill quickly. The structure has particular advantages if the mill is considered out of location and needs to be moved. It would take a minimum of non-operating time to disassemble the mill and move it. The building, except for the slab, could also be moved along with the equipment. At the new location the only thing needed is a slab floor. After 14 days of curing time the machinery and building can be arranged on the slab and operations can begin just as soon as the equipment is installed. The cost of the single story structure would be less because it doesn't support any upper floors and actually requires about half the space needed for the same mill in a multi-story building.

The initial costs of conveying equipment would be higher for the single-floor mill since it requires more equipment. A separate cyclone and air lock feeder is necessary for each lift. The number of lifts can be cut down by combining similar stocks. It is also possible to arrange sifters with similar stocks side-by-side so that all the common stocks can be combined and conveyed in a single lift. Even though the pneumatic equipment costs are higher for the single-floor mill, the lesser costs for the building to house the single-floor mill should more than compensate for them.

The cost of power for this single-floor mill would be higher than for the multi-floor mill, but it is offset by the advantages of the single-floor mill. The single-floor mill requires no man lift or elevator. It is much easier to move about in the single-floor mill and very little lifting of machinery is necessary when installing or changing equipment. The single-floor mill could require less manpower to operate. All controls could be installed on a panel board located in such a position that the starting or stopping of all machinery could be observed.

It is possible to use used equipment in the single-floor mill with certain modifications to aid in pneumatic stock pickup. These modifications would normally require less than 40 percent of the value of the machine and could be written off as tax deductible expenses.

Thus a single-floor mill is definitely feasible. It could be built with all new equipment or could be built with the equipment formerly housed in a multi-floor mill. It would take less time to begin operations because of the small amount of time needed to construct the building housing the mill and to install the machinery. In the case of a mill that is remodeled or is being moved to a new location the single-floor mill will require a minimum of down time. The building housing the mill would be quite versatile and could be used for numerous other purposes if the mill were to cease operations for some reason. With improvements in the pneumatic pickups and machinery drives the power costs can be cut to a minimum. Thus it is quite possible that a single-floor flour mill will be common in future years. These mills could be small unit mills moved wherever needed.

## ACKNOWLEDGEMENTS

The author wishes to acknowledge his gratitude to his major professor, Professor A. B. Ward, and the other members of the advisory committee for guidance in the preparation of this manuscript. Grateful thanks is given to Dr. J. A. Shellenberger, Head of the Department of Flour and Feed Milling Industries, and other members of the faculty and staff who gave unceasingly of their time, efforts and facilities in this investigation. Appreciation is also given to Dr. L. W. Schruben and the Department of Economics and Sociology for services rendered.

Finally, the author expresses his appreciation to Kice Metal Products for financial support and counsel in this project.

## LITERATURE CITED

(1) Abbott, F. M.
Observation in pneumatic milling. Assoc. Oper. Millers Bull., August, 1954. pp. 2106-2108.

(2) Alden, J. L.
Design of industrial exhaust systems. New York: Industrial Press, 1948. p. 252.

(3) Alternative mill layouts. Consolidated Grain Milling Catalogs No. 12, Chicago: National Provisioner, 1960-1961. p. 140.

(4) Auer, Ernst.
Economic mill modernization. Assoc. Oper. Millers Bull., January, 1958. pp. 2363-2365.

(5) Basic types of air conveyors. Consolidated Grain Milling Catalogs No. 10, 1956-1957. pp. 342.

(6) Bogue, D. J. and Beale, C. L.
Economic areas of the United States. New York: Free Press of Glencoe, 1961. p. 1162.

(7) Cereal millers handbook. Kansas City: Assoc. Oper. Millers, 1963. p. 446.

(8) Dedrick, B. W.
Practical milling. Chicago: National Miller, 1924. p. 576.

(9) Donovan, H. L.
Individual motor drives in flour mills. Milling, April 25, 1959, 32 (10): pp. 428-430.

(10) Fan engineering. Buffalo: Buffalo Forge Co., 1949, p. 808.

(11) Gehrig, E. J. and Jun, F. G.
Pneumatic conveying as adapted to the milling industry. Paper 55-A-166 at ASME Meeting, Chicago, November 13-18, 1955, p. 8.

(12) General data on selecting and using screw conveyors. Consolidated Grain Milling Catalogs No. 11, 1958-1959. pp. 164-170.

(13) Grain in multiple-car shipments -- river crossings to the south. Investigation and Suspension Docket No. 7656, U. S. Interior Department, Interstate Commerce Commission, January 21, 1963, pp. 643-718.

(14) Grave consequences for mills from rates. Southwestern Miller, June 11, 1963, 42 (15).

(15) Heimovics, John
Power transmission. Assoc. Oper. Millers Bull. Book, Volume II, pp. 59-68.

(16) Kemeny, A.
Purification. Assoc. Oper. Millers Bull. Book, Volume II, pp. 172-184.

(17) Kozmin, P. A.
Flour milling, London: George Routledge and Sons, Ltd., 1921. p. 584.

(18) Lockwood, J. F.
Flour milling. Liverpool: Northern Publishing Co., Ltd., 2nd ed., 1949. p. 543.

(19) Materials handling handbook. New York: Ronald Press, 1958.

(20) Mill life or death in rates. Southwestern Miller, April 30, 1964, 42 (9).

(21) Miller, E. S.
Studies in practical milling. Minneapolis: Miller Publishing Co., 1941. p. 618.

(22) Production personnel directory. Minneapolis: Miller Publishing Co., 1959. p. 30.

(23) Rosza, T. A.
The cost of electric power for milling. Assoc. Oper. Millers Bull. Book, Volume II 1937-43. pp. 160-166.

(24) Scott, J. H.
Flour milling processes. New York: D. Van Nostrand, 1936. p. 415.

(25) Smith, Leslie
Flour milling technology. Liverpool: Northern Publishing Co., Ltd., 3rd ed., 1945. p. 571.

(26) Swan, H. K.
Our American milling system. Assoc. Oper. Millers Bull., July, 1954. pp. 2099-2102.

(27) Youdale, L. M.
Effects of developments in milling machinery on mill design and layout. -3. Milling, April 5, 1963, 140 (14): pp. 348-349.

(28) Youdale, L. M.
Effects of developments in milling machinery on mill design and layout -4. Milling, April 12, 1963, 140 (15): pp. 377-380.

(29) Youdale, L. M.
Effects of developments in milling machinery on mill design and layout -7. May 3, 1963, 134 (18): pp. 460-462.

(30) Youdale, L. M.
Effects of developments in milling machinery on mill design and layout -11. Milling, June 7, 1963, 140 (23): pp. 611-616.

# APPENDIX A

## Experimental Air Measurements

TABLE 9. Air Measurements for studies of pneumatic pickup at the sifter.

| Trial | Motion of Sifter | Cyclone Outlet | Stock Inlet | Velocity Heads (inches water) Vertical Traverse Points 1 | 2 | 3 | 4 | 5 | 6 | Horizontal Traverse Points 1 | 2 | 3 | 4 | 5 | 6 | Static Head (inches water) Vert. | Horiz. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Stationary | Open | Taped | 0.94 | 0.95 | 1.18 | 1.65 | 1.41 | 1.13 | 1.03 | 1.02 | 1.39 | 1.59 | 1.50 | 1.36 | -12.6 | -12.45 |
| 2 | Stationary | Open | Taped | 0.94 | 0.98 | 1.20 | 1.62 | 1.42 | 1.05 | 0.90 | 1.06 | 1.37 | 1.58 | 1.55 | 1.42 | | |
| 3 | Stationary | Open | Taped | 0.93 | 0.97 | 1.20 | 1.65 | 1.47 | 1.18 | 1.04 | 1.18 | 1.46 | 1.61 | 1.50 | 1.33 | | |
| 4 | Stationary | Open | Taped | 0.92 | 0.98 | 1.19 | 1.64 | 1.41 | 1.02 | 1.14 | 1.10 | 1.46 | 1.60 | 1.46 | 1.28 | | |
| 5 | Stationary | Open | Taped | 0.93 | 1.02 | 1.20 | 1.65 | 1.36 | 1.02 | 1.12 | 1.10 | 1.49 | 1.58 | 1.44 | 1.16 | | |
| 6 | Gyrating | Open | Taped | 0.89 | 0.91 | 1.18 | 1.64 | 1.42 | 1.14 | 1.12 | 1.23 | 1.50 | 1.56 | 1.46 | 1.18 | -12.6 | -12.4 |
| 7 | 180 R.P.M. | Open | Taped | 0.96 | 0.96 | 1.20 | 1.61 | 1.39 | 1.12 | 1.21 | 1.27 | 1.52 | 1.58 | 1.40 | 0.90 | | |
| 8 | 4" Throw | Open | Taped | 0.93 | 1.00 | 1.36 | 1.54 | 1.30 | 0.84 | 1.14 | 1.18 | 1.53 | 1.58 | 1.38 | 0.94 | | |
| 9 | Rot. CW | Open | Taped | 0.87 | 1.00 | 1.20 | 1.62 | 1.36 | 0.95 | 1.28 | 1.35 | 1.53 | 1.57 | 1.22 | 0.83 | | |
| 10 | | Open | Taped | 0.92 | 0.94 | 1.24 | 1.62 | 1.28 | 0.84 | 1.30 | 1.35 | 1.53 | 1.50 | 1.41 | 0.85 | | |
| 11 | Gyrating | Open | Taped | 0.91 | 0.98 | 1.27 | 1.58 | 1.22 | 0.82 | 1.18 | 1.23 | 1.54 | 1.57 | 1.39 | 1.02 | -12.4 | -12.2 |
| 12 | 180 R.P.M. | Open | Taped | 0.91 | 1.02 | 1.22 | 1.61 | 1.30 | 0.88 | 1.24 | 1.28 | 1.54 | 1.55 | 1.34 | 0.93 | | |
| 13 | 4" Throw | Open | Taped | 0.91 | 1.00 | 1.31 | 1.56 | 1.25 | 0.85 | 1.25 | 1.27 | 1.52 | 1.53 | 1.38 | 1.05 | | |
| 14 | Rot. CCW | Open | Taped | 0.90 | 1.03 | 1.26 | 1.59 | 1.26 | 0.82 | 1.16 | 1.26 | 1.53 | 1.56 | 1.36 | 0.95 | | |
| 15 | | Open | Taped | 0.92 | 1.00 | 1.20 | 1.61 | 1.32 | 0.93 | 1.11 | 1.34 | 1.48 | 1.48 | 1.20 | 0.98 | | |
| 16 | Stationary | 1/2 Open | Taped | 0.64 | 0.64 | 0.81 | 1.10 | 0.92 | 0.59 | 0.73 | 0.73 | 0.95 | 1.03 | 1.06 | 0.99 | -8.6 | -8.6 |
| 17 | Stationary | 1/2 Open | Taped | 0.64 | 0.69 | 0.84 | 1.10 | 0.91 | 0.66 | 0.58 | 0.75 | 1.00 | 1.05 | 0.98 | 0.84 | | |
| 18 | Stationary | 1/2 Open | Taped | 0.60 | 0.65 | 0.80 | 1.11 | 0.87 | 0.70 | 0.74 | 0.70 | 0.97 | 1.04 | 1.06 | 0.98 | | |
| 19 | Stationary | 1/2 Open | Taped | 0.66 | 0.68 | 0.81 | 1.12 | 0.90 | 0.64 | 0.66 | 0.80 | 1.00 | 1.03 | 1.03 | 0.86 | | |
| 20 | Stationary | 1/2 Open | Taped | 0.64 | 0.68 | 0.80 | 1.11 | 0.90 | 0.70 | 0.70 | 0.76 | 0.99 | 1.04 | 1.06 | 0.95 | | |
| 21 | Gyrating | 1/2 Open | Taped | 0.64 | 0.64 | 0.80 | 1.11 | 0.95 | 0.70 | 0.70 | 0.69 | 1.01 | 1.04 | 1.00 | 0.86 | -8.6 | -8.6 |
| 22 | 180 R.P.M. | 1/2 Open | Taped | 0.58 | 0.69 | 0.84 | 1.10 | 0.93 | 0.69 | 0.64 | 0.71 | 1.00 | 1.00 | 1.01 | 0.77 | | |
| 23 | 4" Throw | 1/2 Open | Taped | 0.63 | 0.65 | 0.80 | 1.11 | 0.95 | 0.73 | 0.72 | 0.77 | 1.01 | 1.00 | 1.00 | 0.70 | | |
| 24 | Rot. CW | 1/2 Open | Taped | 0.61 | 0.63 | 0.82 | 1.08 | 0.97 | 0.78 | 0.72 | 0.74 | 1.00 | 1.02 | 1.01 | 0.64 | | |
| 25 | | 1/2 Open | Taped | 0.62 | 0.66 | 0.82 | 1.11 | 0.92 | 0.63 | 0.76 | 0.69 | 0.97 | 1.00 | 1.01 | 0.74 | | |

Table 9. (continued)

| Trial | Motion of Sifter | Cyclone Outlet | Stock Inlet | Velocity Heads (inches water) Vertical Traverse Points | | | | | | Velocity Heads (inches water) Horizontal Traverse Points | | | | | | Static Head (inches water) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | 1 | 2 | 3 | 4 | 5 | 6 | 1 | 2 | 3 | 4 | 5 | 6 | Vert. | Horiz. |
| 26 | Gyrating | 1/2 Open | Taped | 0.65 | 0.72 | 0.85 | 1.10 | 0.88 | 0.57 | 0.77 | 0.75 | 1.02 | 1.10 | 0.96 | 0.66 | -8.5 | -8.6 |
| 27 | 180 R.P.M. | 1/2 Open | Taped | 0.63 | 0.65 | 0.80 | 1.10 | 0.85 | 0.58 | 0.86 | 0.90 | 1.03 | 1.08 | 1.05 | 0.79 | | |
| 28 | 4" Throw | 1/2 Open | Taped | 0.62 | 0.73 | 0.86 | 1.08 | 0.86 | 0.58 | 0.73 | 0.84 | 1.03 | 0.89 | 0.80 | 0.74 | | |
| 29 | Rot. CCW | 1/2 Open | Taped | 0.62 | 0.68 | 0.84 | 1.10 | 0.94 | 0.72 | 0.80 | 0.86 | 1.04 | 1.05 | 0.87 | 0.56 | | |
| 30 | | 1/2 Open | Taped | 0.66 | 0.67 | 0.83 | 1.07 | 0.87 | 0.68 | 0.80 | 0.85 | 1.06 | 1.07 | 0.96 | 0.71 | | |
| 31 | Stationary | Open | Open | 1.53 | 1.47 | 1.97 | 2.49 | 2.09 | 1.40 | 1.56 | 1.94 | 2.34 | 2.31 | 2.18 | 1.63 | -7.5 | -7.5 |
| 32 | Stationary | Open | Open | 1.51 | 1.55 | 1.84 | 2.52 | 2.10 | 1.44 | 1.62 | 1.40 | 2.20 | 2.32 | 2.37 | 2.07 | | |
| 33 | Stationary | Open | Open | 1.46 | 1.58 | 1.92 | 2.51 | 2.02 | 1.39 | 1.62 | 1.76 | 2.13 | 2.33 | 2.36 | 2.14 | | |
| 34 | Stationary | Open | Open | 1.48 | 1.60 | 1.98 | 2.54 | 2.04 | 1.35 | 1.70 | 1.31 | 2.14 | 2.28 | 2.35 | 2.21 | | |
| 35 | Stationary | Open | Open | 1.41 | 1.44 | 1.83 | 2.43 | 2.22 | 1.84 | 1.58 | 1.56 | 2.23 | 2.28 | 2.27 | 1.86 | | |
| 36 | Gyrating | Open | Open | 1.52 | 1.58 | 1.92 | 2.47 | 2.03 | 1.55 | 1.25 | 1.58 | 2.22 | 2.33 | 2.32 | 2.18 | -7.4 | -7.5 |
| 37 | 180 R.P.M. | Open | Open | 1.54 | 1.61 | 1.90 | 2.45 | 2.00 | 1.67 | 1.72 | 1.86 | 2.25 | 2.22 | 2.23 | 1.78 | | |
| 38 | 4" Throw | Open | Open | 1.44 | 1.60 | 1.90 | 2.46 | 2.08 | 1.68 | 1.60 | 1.73 | 2.28 | 2.25 | 2.22 | 1.90 | | |
| 39 | Rot. CW | Open | Open | 1.54 | 1.65 | 1.86 | 2.47 | 2.01 | 1.65 | 1.31 | 1.48 | 2.20 | 2.21 | 2.34 | 1.99 | | |
| 40 | | Open | Open | 1.56 | 1.70 | 1.94 | 2.44 | 2.00 | 1.58 | 1.30 | 1.53 | 2.18 | 2.21 | 2.25 | 1.84 | | |
| 41 | Gyrating | Open | Open | 1.60 | 1.61 | 1.92 | 2.45 | 2.02 | 1.32 | 1.30 | 1.75 | 2.24 | 2.26 | 1.98 | 1.54 | -7.4 | -7.6 |
| 42 | 180 R.P.M. | Open | Open | 1.55 | 1.70 | 1.95 | 2.33 | 1.94 | 1.30 | 1.54 | 1.72 | 2.25 | 2.26 | 2.06 | 1.39 | | |
| 43 | 4" Throw | Open | Open | 1.58 | 1.54 | 1.90 | 2.48 | 1.81 | 1.31 | 1.91 | 1.70 | 2.25 | 2.25 | 2.28 | 1.76 | | |
| 44 | Rot. CCW | Open | Open | 1.64 | 1.64 | 1.88 | 2.48 | 2.11 | 1.62 | 1.44 | 1.73 | 2.22 | 2.21 | 2.28 | 1.76 | | |
| 45 | | Open | Open | 1.49 | 1.70 | 2.00 | 2.47 | 2.03 | 1.27 | 1.75 | 1.65 | 2.24 | 2.30 | 2.28 | 1.84 | | |
| 46 | Stationary | 1/2 Open | Open | 0.93 | 0.93 | 1.14 | 1.53 | 1.27 | 0.95 | 1.03 | 1.06 | 1.38 | 1.40 | 1.39 | 0.95 | -4.5 | -4.6 |
| 47 | Stationary | 1/2 Open | Open | 0.85 | 0.98 | 1.12 | 1.53 | 1.24 | 0.81 | 1.04 | 1.03 | 1.28 | 1.47 | 1.45 | 1.32 | | |
| 48 | Stationary | 1/2 Open | Open | 0.90 | 0.89 | 1.10 | 1.50 | 1.33 | 1.04 | 1.04 | 1.01 | 1.38 | 1.41 | 1.34 | 0.84 | | |
| 49 | Stationary | 1/2 Open | Open | 0.85 | 0.87 | 1.14 | 1.53 | 1.31 | 0.96 | 1.00 | 0.96 | 1.31 | 1.35 | 1.30 | 1.12 | | |
| 50 | Stationary | 1/2 Open | Open | 0.89 | 0.90 | 1.07 | 1.54 | 1.33 | 1.07 | 0.79 | 0.84 | 1.32 | 1.36 | 1.39 | 1.28 | | |

Table 9. (concluded)

| Trial | Motion of Sifter | Cyclone Outlet | Stock Inlet | Velocity Heads (inches water): Vertical Traverse Points 1 | 2 | 3 | 4 | 5 | 6 | Horizontal Traverse Points 1 | 2 | 3 | 4 | 5 | 6 | Static Head (inches water): Vert. | Horiz. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 51 | Gyrating | 1/2 Open | Open | 0.90 | 0.95 | 1.14 | 1.51 | 1.24 | 0.83 | 0.80 | 0.89 | 1.30 | 1.46 | 1.38 | 1.18 | -4.5 | -4.6 |
| 52 | 180 R.P.M. | 1/2 Open | Open | 0.90 | 1.04 | 1.16 | 1.47 | 1.19 | 0.79 | 1.11 | 1.08 | 1.40 | 1.41 | 1.40 | 1.22 | | |
| 53 | 4" Throw | 1/2 Open | Open | 0.93 | 0.98 | 1.17 | 1.52 | 1.31 | 0.94 | 0.84 | 0.92 | 1.34 | 1.44 | 1.41 | 1.20 | | |
| 54 | Rot. CW | 1/2 Open | Open | 0.89 | 0.95 | 1.11 | 1.51 | 1.33 | 1.00 | 1.00 | 0.95 | 1.37 | 1.35 | 1.30 | 1.11 | | |
| 55 | | 1/2 Open | Open | 0.94 | 0.90 | 1.20 | 1.48 | 1.28 | 0.97 | 0.97 | 1.19 | 1.36 | 1.40 | 1.39 | 1.19 | | |
| 56 | Gyrating | 1/2 Open | Open | 0.93 | 0.97 | 1.23 | 1.48 | 1.16 | 0.88 | 0.88 | 0.76 | 1.20 | 1.32 | 1.20 | 0.93 | -4.6 | -4.6 |
| 57 | 180 R.P.M. | 1/2 Open | Open | 0.94 | 1.00 | 1.14 | 1.51 | 1.33 | 1.11 | 0.94 | 0.77 | 1.34 | 1.25 | 1.22 | 0.90 | | |
| 58 | 4" Throw | 1/2 Open | Open | 0.90 | 0.82 | 1.14 | 1.50 | 1.25 | 0.97 | 1.03 | 1.00 | 1.34 | 1.38 | 1.36 | 1.18 | | |
| 59 | Rot. CCW | 1/2 Open | Open | 0.93 | 0.97 | 1.14 | 1.49 | 1.15 | 0.88 | 0.93 | 0.80 | 1.31 | 1.37 | 1.38 | 1.17 | | |
| 60 | | 1/2 Open | Open | 0.94 | 0.86 | 1.17 | 1.48 | 1.21 | 0.87 | 0.88 | 1.00 | 1.30 | 1.36 | 1.34 | 1.04 | | |

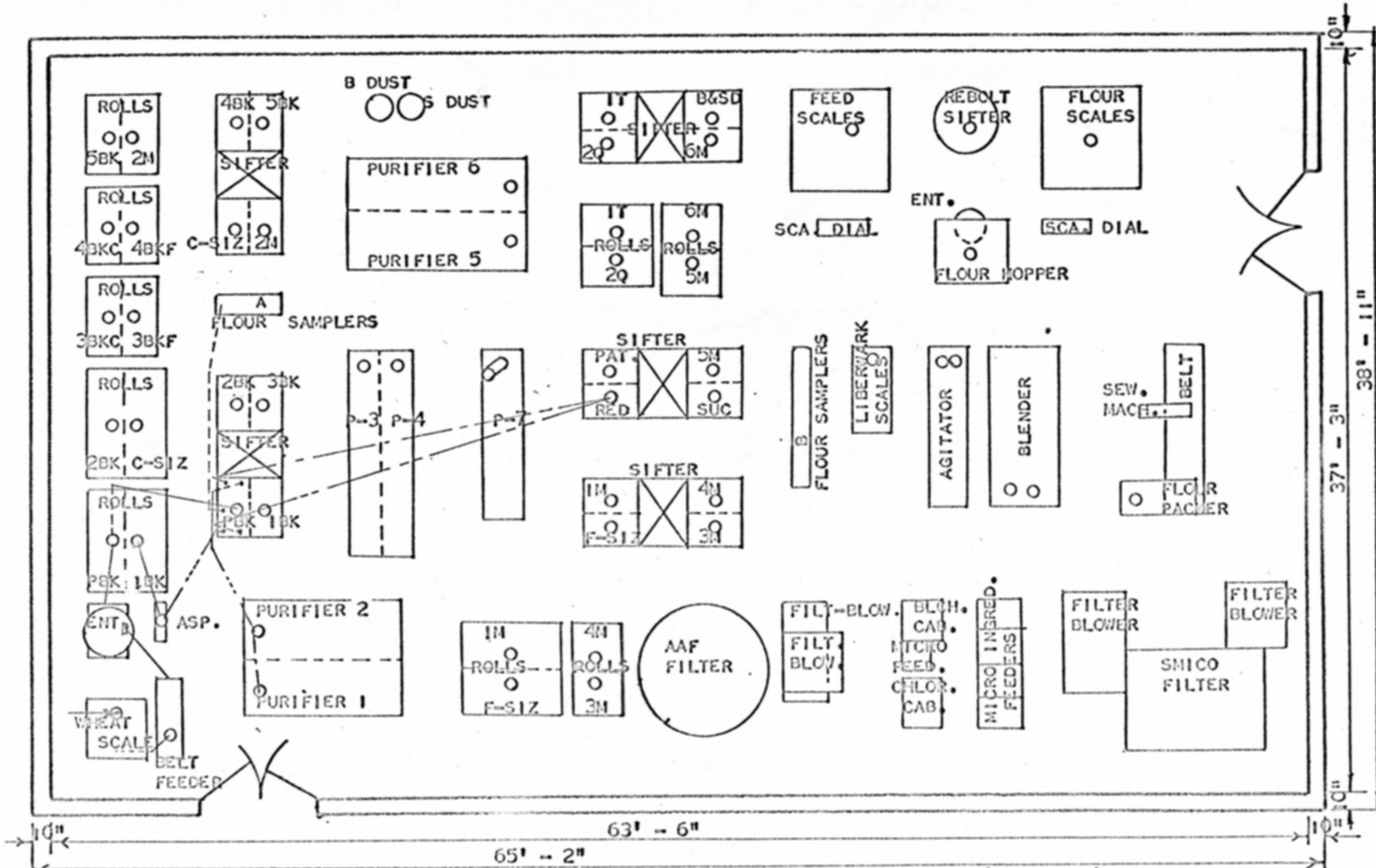
Date: March 25, 1964
Average Temperature: 74° F.
Relative Humidity: 30 percent

# APPENDIX B

Conveying Diagrams and Requirements for

Single-floor Mill Using a Separate Lift for Each Stock.

PLATE XXXIV




SINGLE FLOOR LAYOUT FOR KANSAS STATE UNIV. FLOUR MILL

SCALE 1/8" = 1' - 0"

RECEIVING AND PREBREAK CONVEYING SYSTEMS USING SEPARATE LIFT FOR EACH STOCK

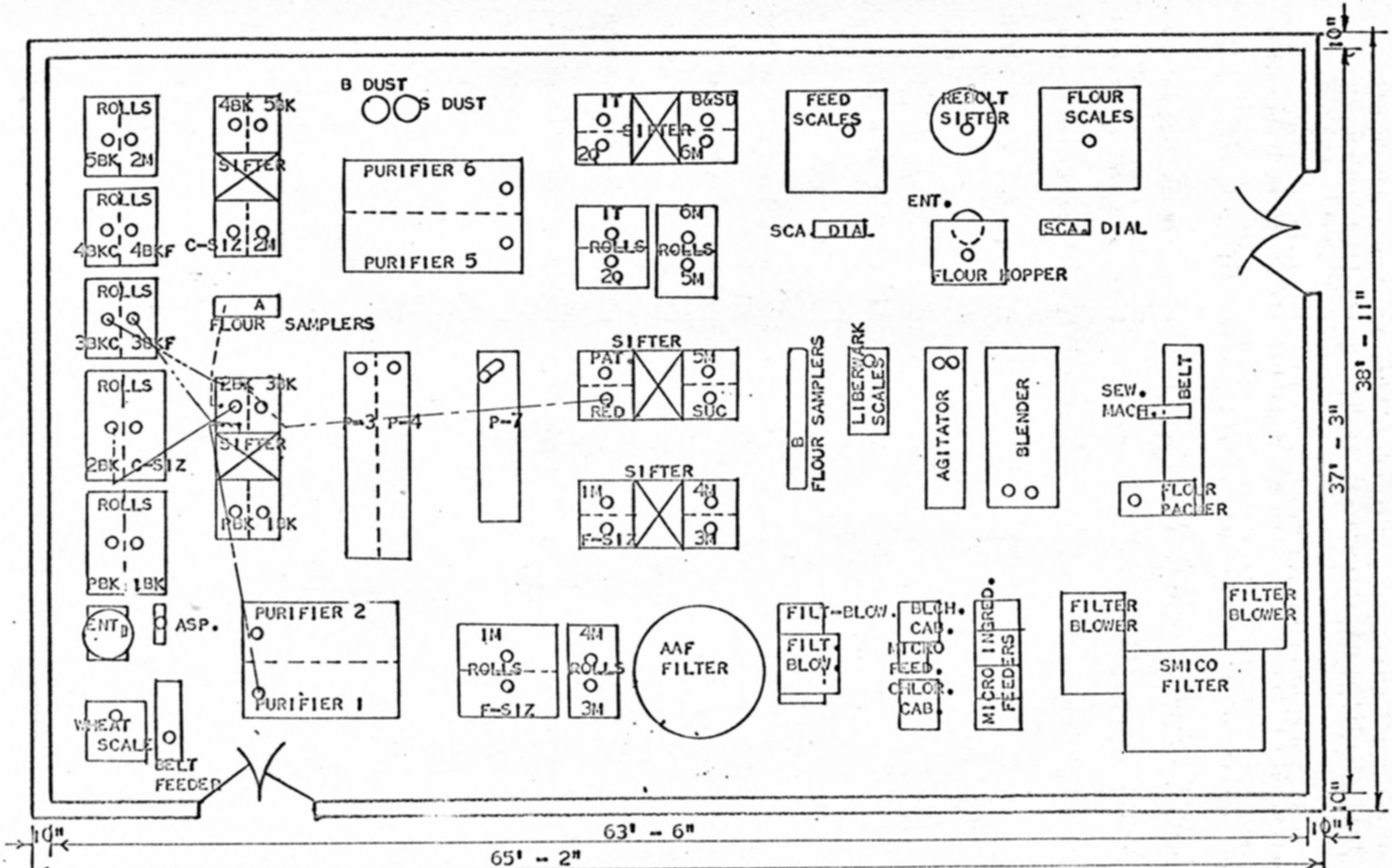
KEY TO PNEUMATIC CONVEYING LINES

BETWEEN MACHINES (EXCEPT SIFTER SEPARATIONS) ————

SIFTER SEPARATIONS

| | |
|---|---|
| BOTTOM FLOUR - - - - - - - - | BOTTOM SCALP ——— - - ——— |
| TOP FLOUR ················ | 2ND FROM BOTTOM SCALP —— - - —— |
| THRUS OF GRADING OR DUSTING CLOTH —— —— | 3RD FROM BOTTOM SCALP —— - - - —— |
| | 4TH FROM BOTTOM SCALP —— - - - - —— |

PLATE XXXVI




Single Floor Layout for Kansas State Univ. Flour Mill

Scale 1/8" = 1' - 0"

2nd Break Conveying System Using Separate Lift for Each Stock

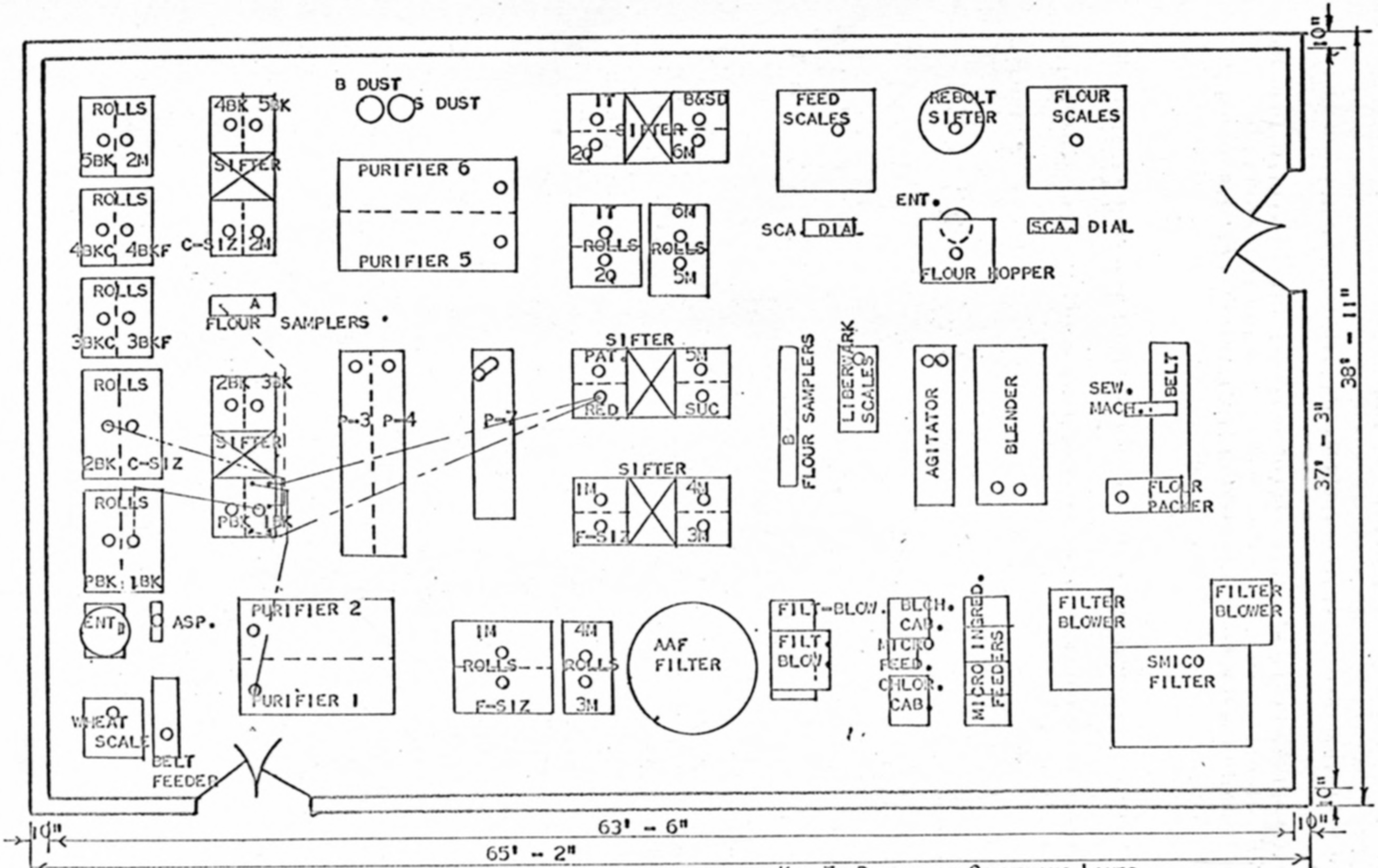
Key To Pneumatic Conveying Lines

Between machines (except sifter separations) ————

Sifter separations

| | | | |
|---|---|---|---|
| Bottom flour | - - - - - - - | Bottom scalp | —— - —— - |
| Top flour | ·················· | 2nd from bottom scalp | —— - - —— |
| Thrus of grading or dusting cloth | —— —— | 3rd from bottom scalp | —— - - - —— |
| | | 4th from bottom scalp | —— - - - - —— |

PLATE XXXV




Single Floor Layout for Kansas State Univ. Flour Mill

Scale 1/8" :: 1' - 0"

1st Break Conveying System Using Separate Lift for Each Stock

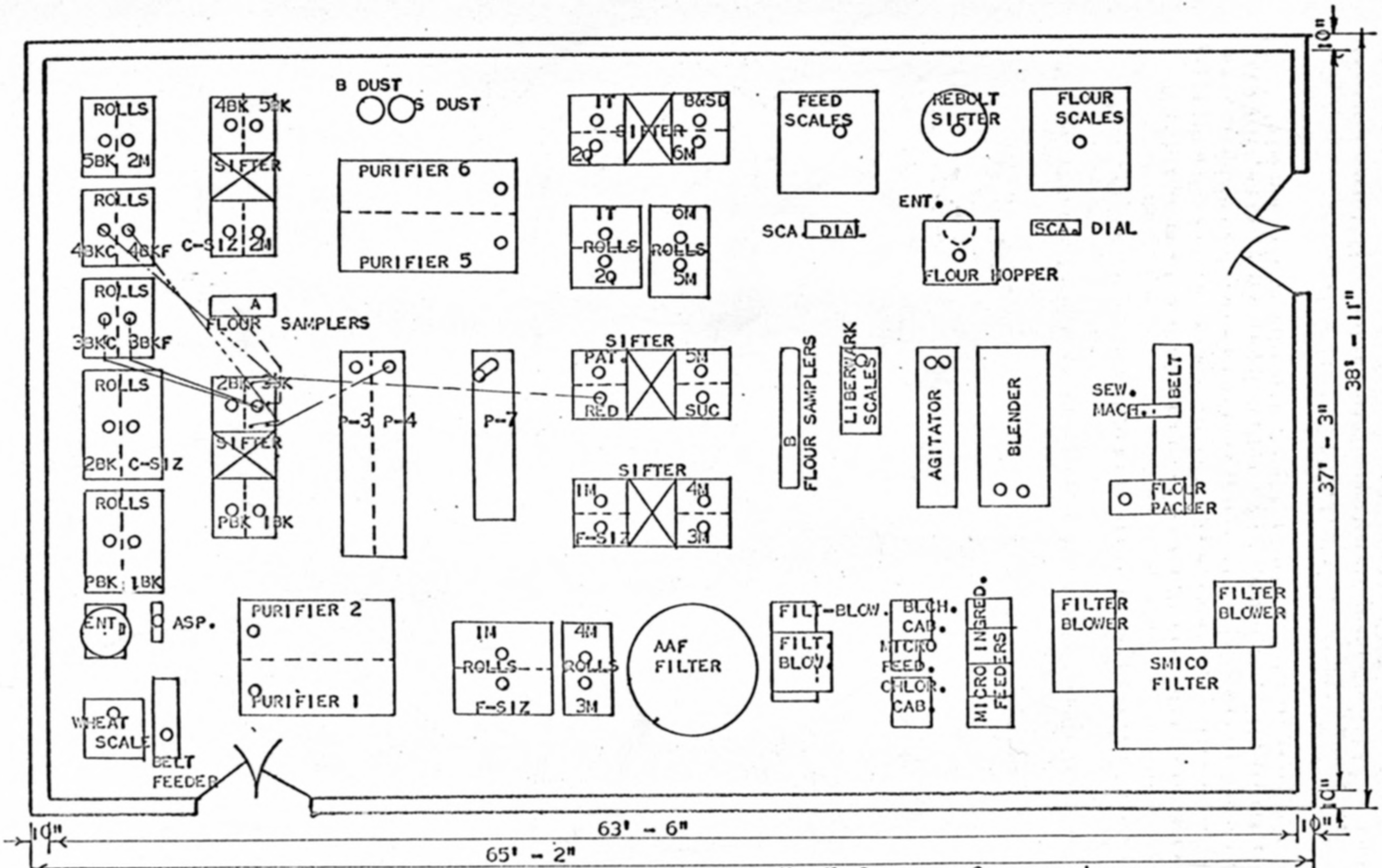
<u>Key To Pneumatic Conveying Lines</u>

Between machines (except sifter separations) ————

Sifter separations

| | | | |
|---|---|---|---|
| Bottom flour | - - - - - - - - | Bottom scalp | —— - —— - —— |
| Top flour | ················ | 2nd from bottom scalp | —— - - —— |
| Thrus of grading or dusting cloth | —— —— | 3rd from bottom scalp | —— - - - —— |
| | | 4th from bottom scalp | —— - - - - —— |

PLATE XXXVII




SINGLE FLOOR LAYOUT FOR KANSAS STATE UNIV.
FLOUR MILL

SCALE 1/8" :: 1' - 0"

3RD BREAK CONVEYING SYSTEM USING SEPARATE LIFT FOR EACH STOCK

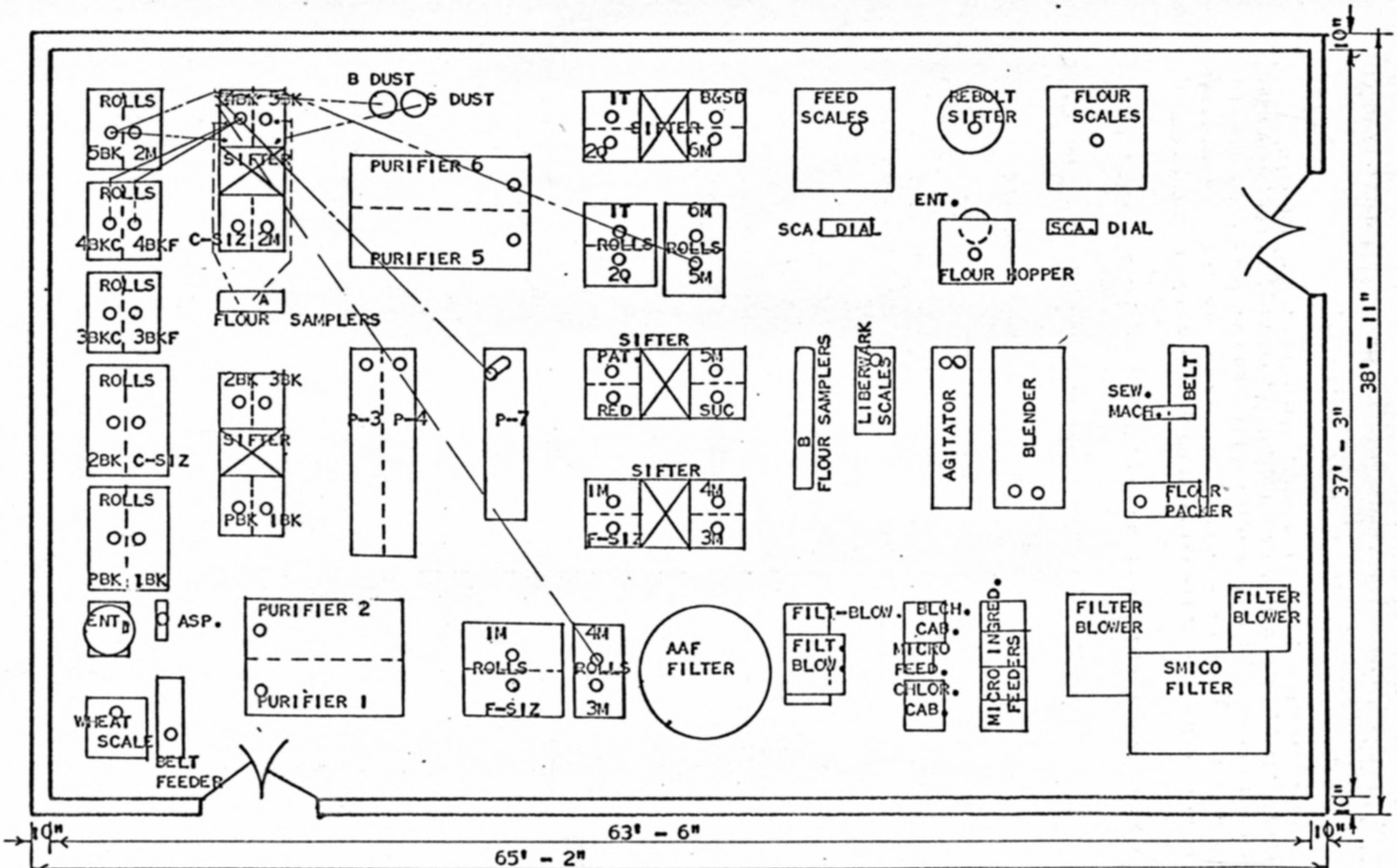
KEY TO PNEUMATIC CONVEYING LINES

BETWEEN MACHINES (EXCEPT SIFTER SEPARATIONS) ————————

SIFTER SEPARATIONS

| | |
|---|---|
| BOTTOM FLOUR – – – – – – – – | BOTTOM SCALP ——— - ———— |
| TOP FLOUR ··················· | 2ND FROM BOTTOM SCALP ——— - - ——— |
| THRUS OF GRADING OR DUSTING CLOTH ——— ——— | 3RD FROM BOTTOM SCALP ——— - - - ——— |
| | 4TH FROM BOTTOM SCALP ——— - - - - ——— |

PLATE XXXVIII




SINGLE FLOOR LAYOUT FOR KANSAS STATE UNIV. FLOUR MILL

SCALE 1/8" = 1' - 0"

4TH & 5TH BREAK CONVEYING SYSTEMS USING SEPARATE LIFT FOR EACH STOCK

KEY TO PNEUMATIC CONVEYING LINES

BETWEEN MACHINES (EXCEPT SIFTER SEPARATIONS) ————

SIFTER SEPARATIONS

BOTTOM FLOUR — — — — — —

TOP FLOUR ··················

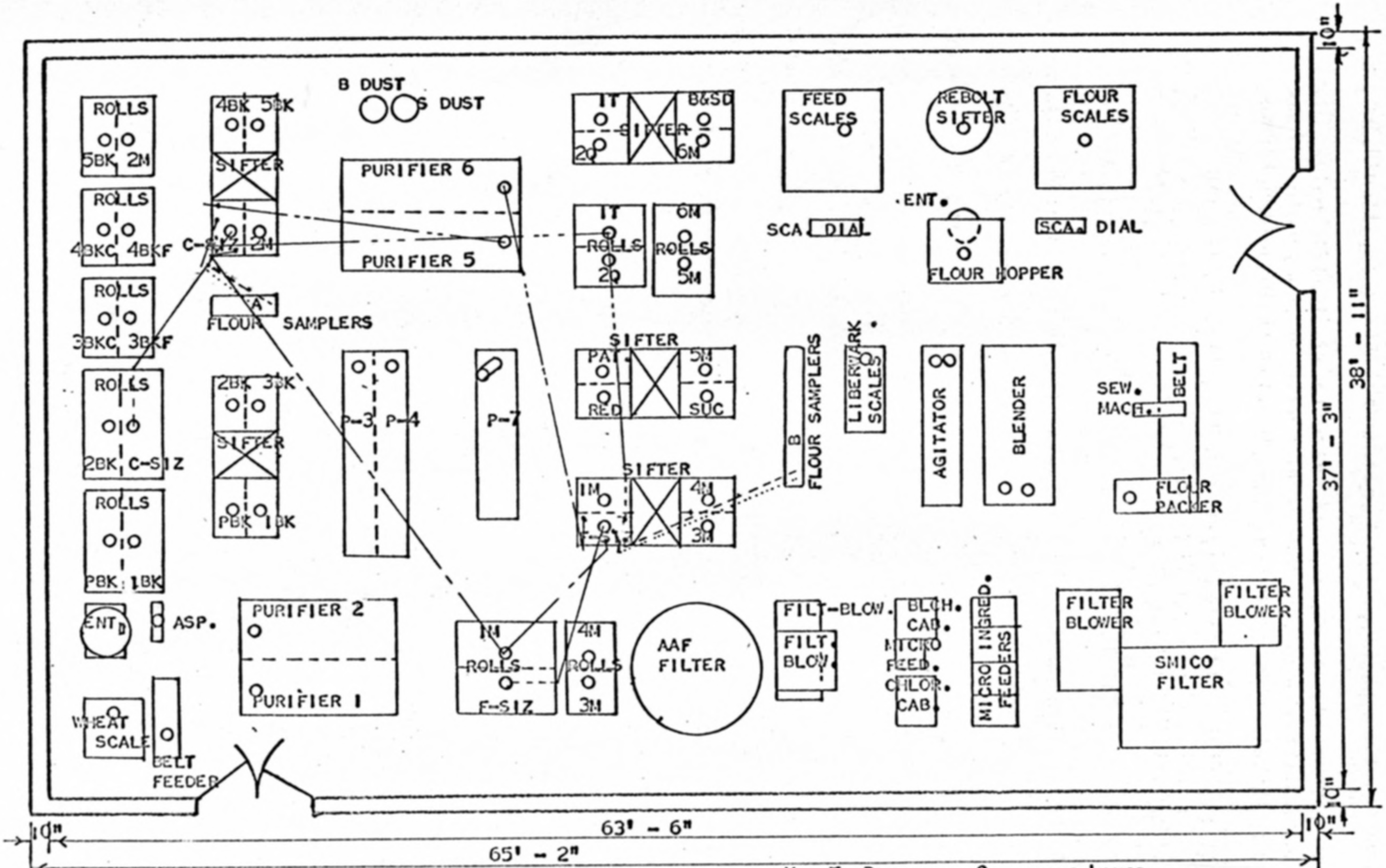
THRUS OF GRADING OR DUSTING CLOTH —— ——

BOTTOM SCALP —— - ——

2ND FROM BOTTOM SCALP —— - - ——

3RD FROM BOTTOM SCALP —— - - - ——

4TH FROM BOTTOM SCALP —— - - - - ——




Single Floor Layout for Kansas State Univ.
Flour Mill

Scale 1/8" = 1' - 0"

CSiz & FSiz Conveying Systems Using
Separate Lift for Each Stock

Key To Pneumatic Conveying Lines

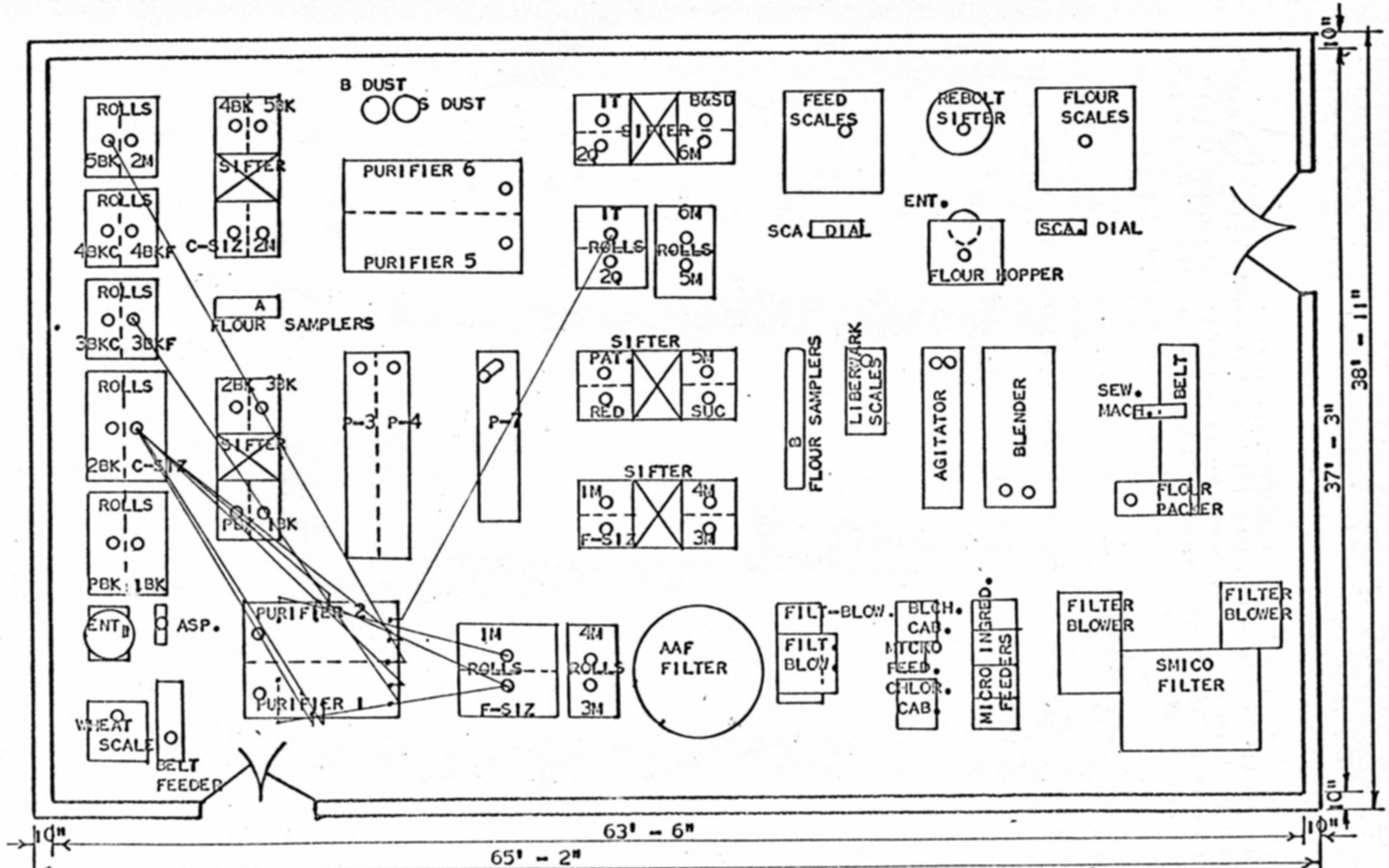
Between machines (except sifter separations)

Sifter separations

Bottom flour
Top flour
Thrus of grading or dusting cloth
Bottom scalp
2nd from bottom scalp
3rd from bottom scalp
4th from bottom scalp

PLATE XXXIX

PLATE XI




Single Floor Layout for Kansas State Univ.
Flour Mill

Scale 1/8" = 1' - 0"

P-1 & P-2 Conveying Systems Using Separate Lift for Each Stock

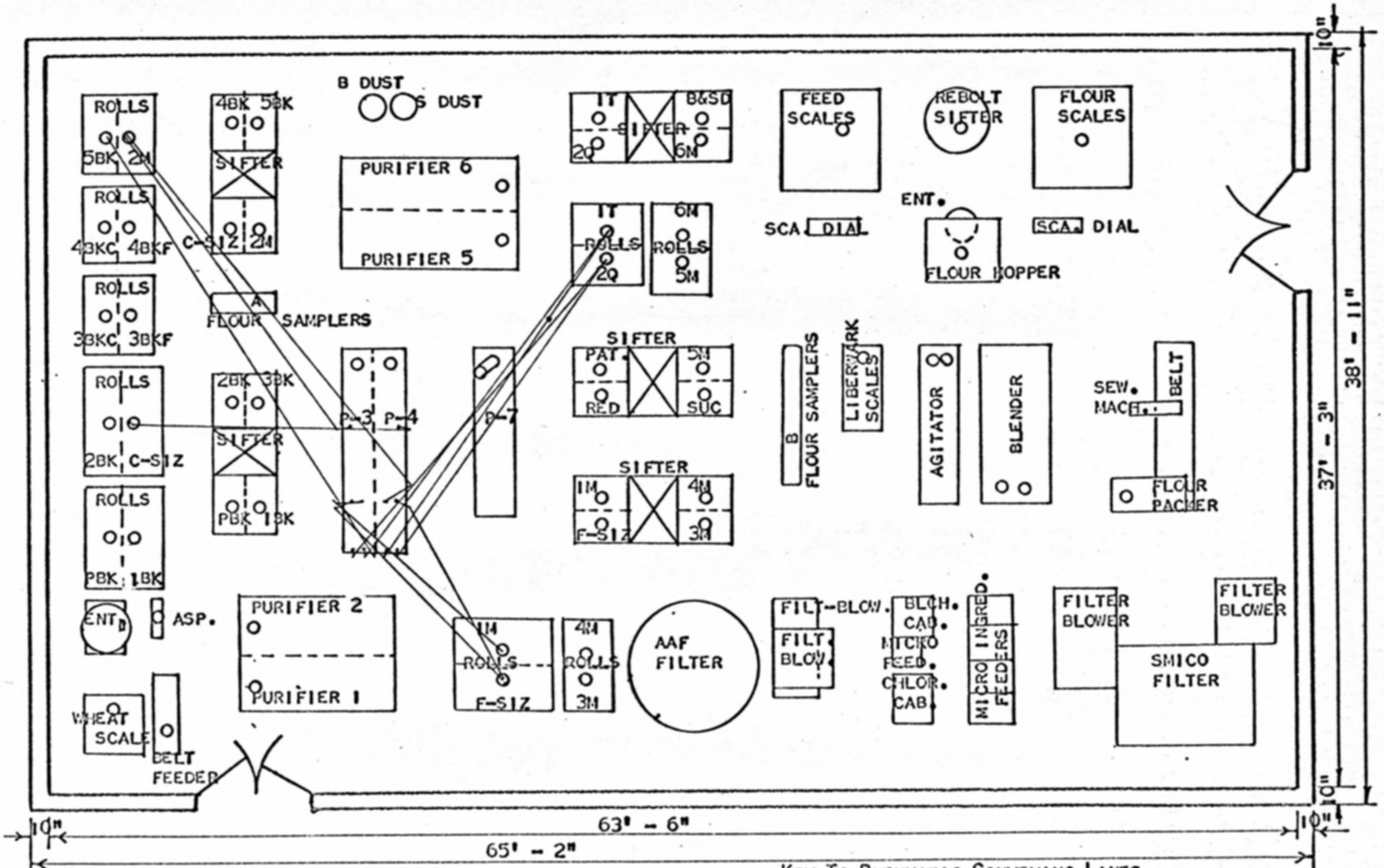
**Key To Pneumatic Conveying Lines**

Between machines (except sifter separations) ————

Sifter Separations

| | |
|---|---|
| Bottom flour – – – – – – – | Bottom scalp ——— – ——— |
| Top flour · · · · · · · · · · · · · | 2nd from bottom scalp —— – – —— |
| Thrus of grading or dusting cloth —— —— | 3rd from bottom scalp —— – – – —— |
| | 4th from bottom scalp —— - - - - —— |

PLATE XLI




Single Floor Layout for Kansas State Univ. Flour Mill

Scale 1/8" = 1' - 0"

P-3 & P-4 Conveying Systems Using Separate Lift for Each Stock

Key To Pneumatic Conveying Lines

Between machines (except sifter separations) ————

Sifter Separations

Bottom flour - - - - - - - -

Top flour ·················

Thrus of grading or dusting cloth —— ——

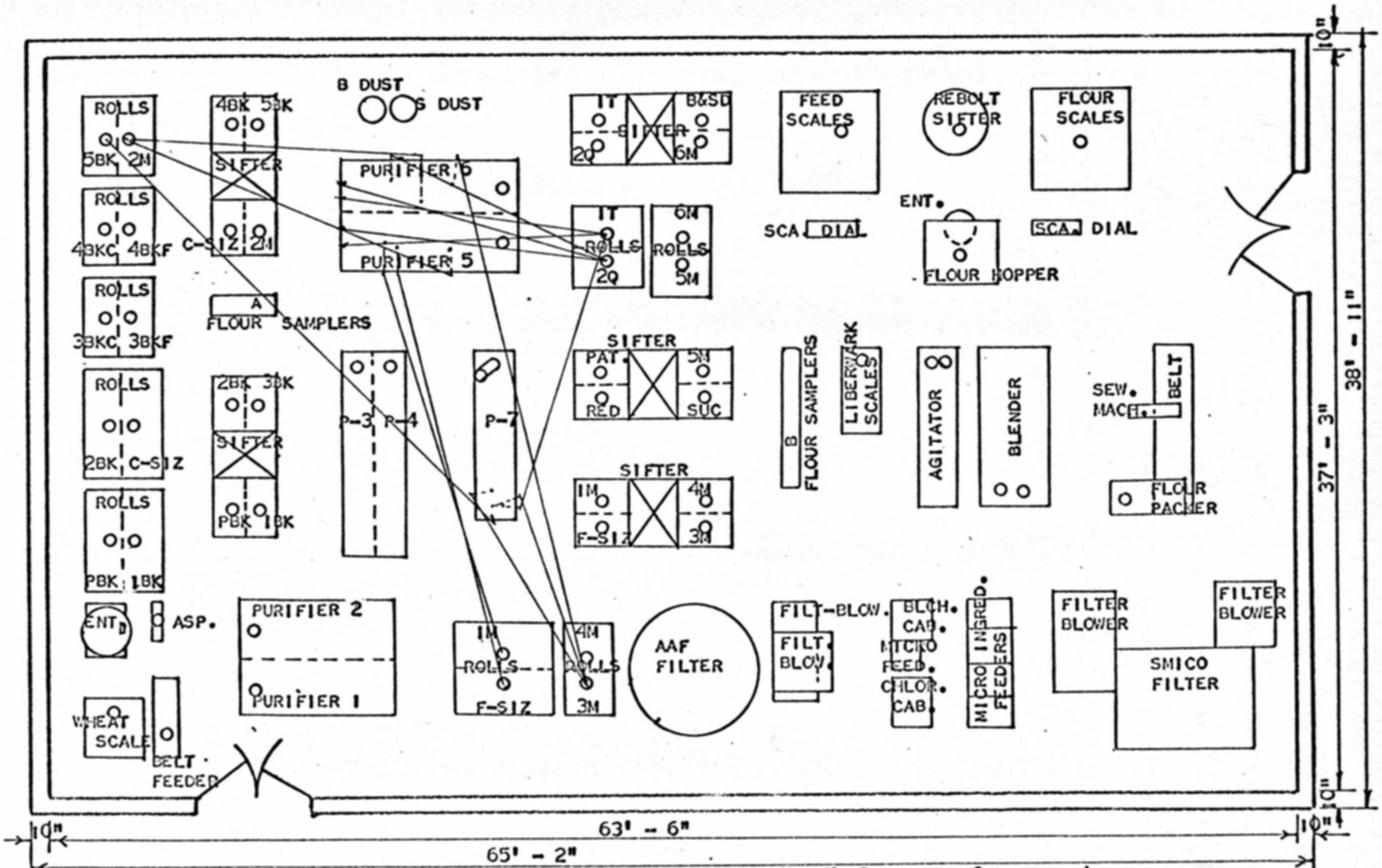
Bottom scalp ——— - ——— -

2nd from bottom scalp —— - - ——

3rd from bottom scalp —— - - - ——

4th from bottom scalp —— - - - - ——

PLATE XLII




Single Floor Layout for Kansas State Univ. Flour Mill

SCALE 1/8" = 1' - 0"

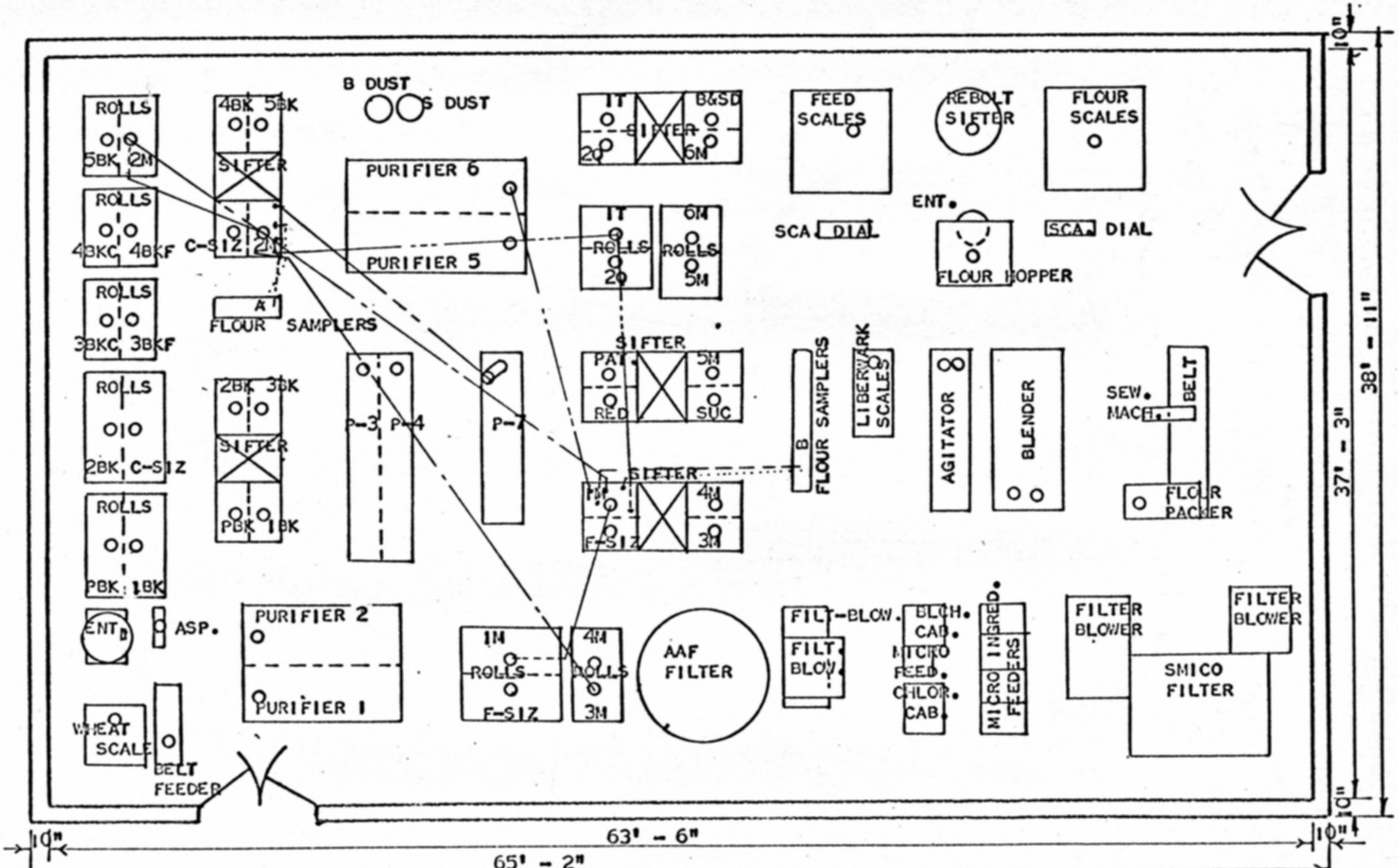
P-5, P-6 & P-7 Conveying Systems Using Separate Lift for Each Stock

Key To Pneumatic Conveying Lines

Between machines (except sifter separations) ————

Sifter separations

| | |
|---|---|
| Bottom flour – – – – – – – – | Bottom scalp —— – —— |
| Top flour ················ | 2nd from bottom scalp —— – – —— |
| Thrus of grading or dusting cloth —— —— | 3rd from bottom scalp —— – – – —— |
| | 4th from bottom scalp —— – · – · – —— |




Single Floor Layout for Kansas State Univ. Flour Mill

Scale 1/8" = 1' - 0"

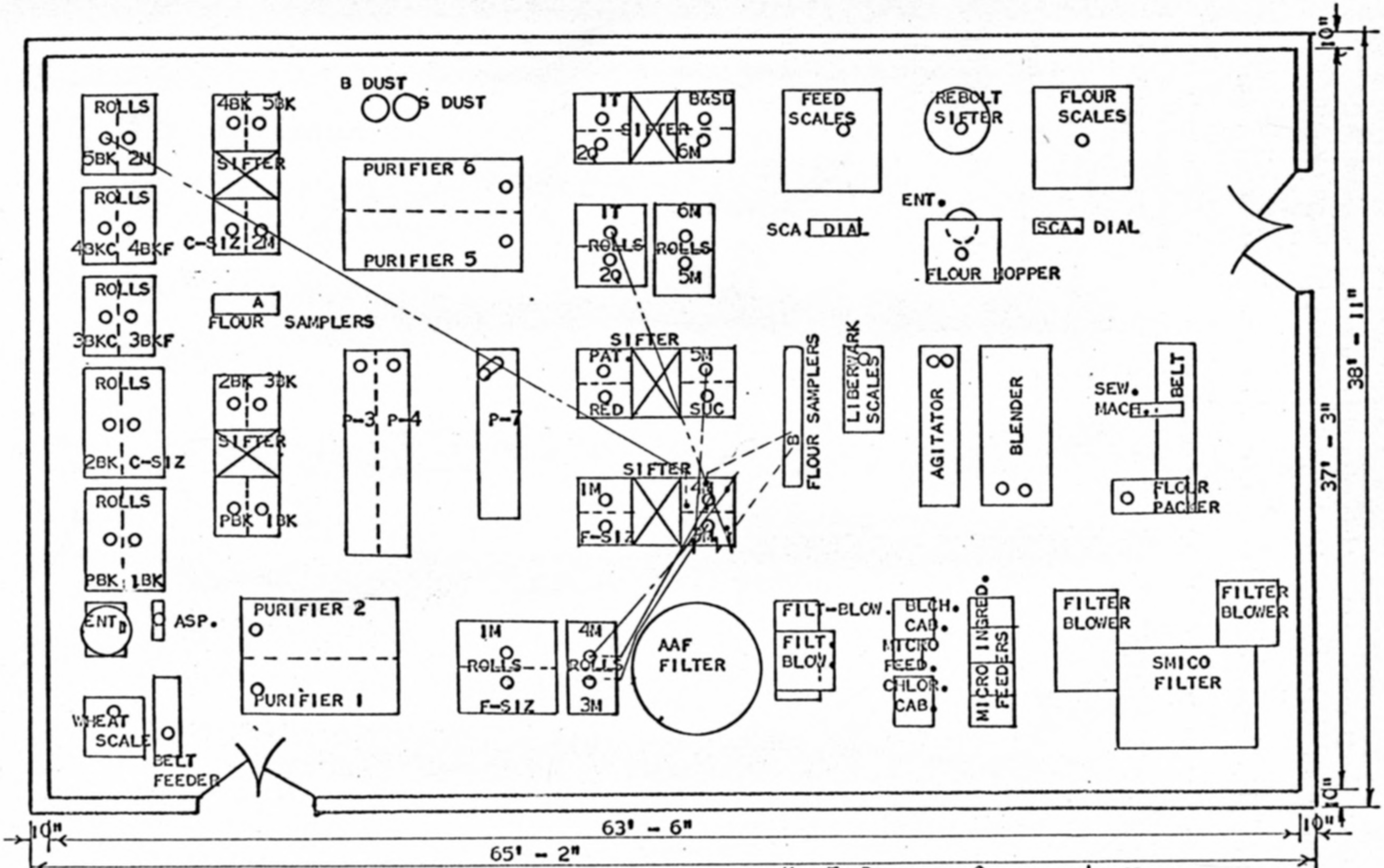
1st Midd & 2nd Midd Conveying Systems Using Separate Lift for Each Stock

Key To Pneumatic Conveying Lines

Between machines (except sifter separations) ————

Sifter Separations

| | |
|---|---|
| Bottom flour - - - - - - - - | Bottom scalp —— - —— - —— |
| Top flour ................ | 2nd from bottom scalp —— - - —— |
| Thrus of grading or dusting cloth —— —— | 3rd from bottom scalp —— - - - —— |
| | 4th from bottom scalp —— - - - - —— |




Single Floor Layout for Kansas State Univ. Flour Mill

Scale 1/8" = 1' - 0"

3rd Midd & 4th Midd Conveying Systems Using Separate Lift for Each Stock

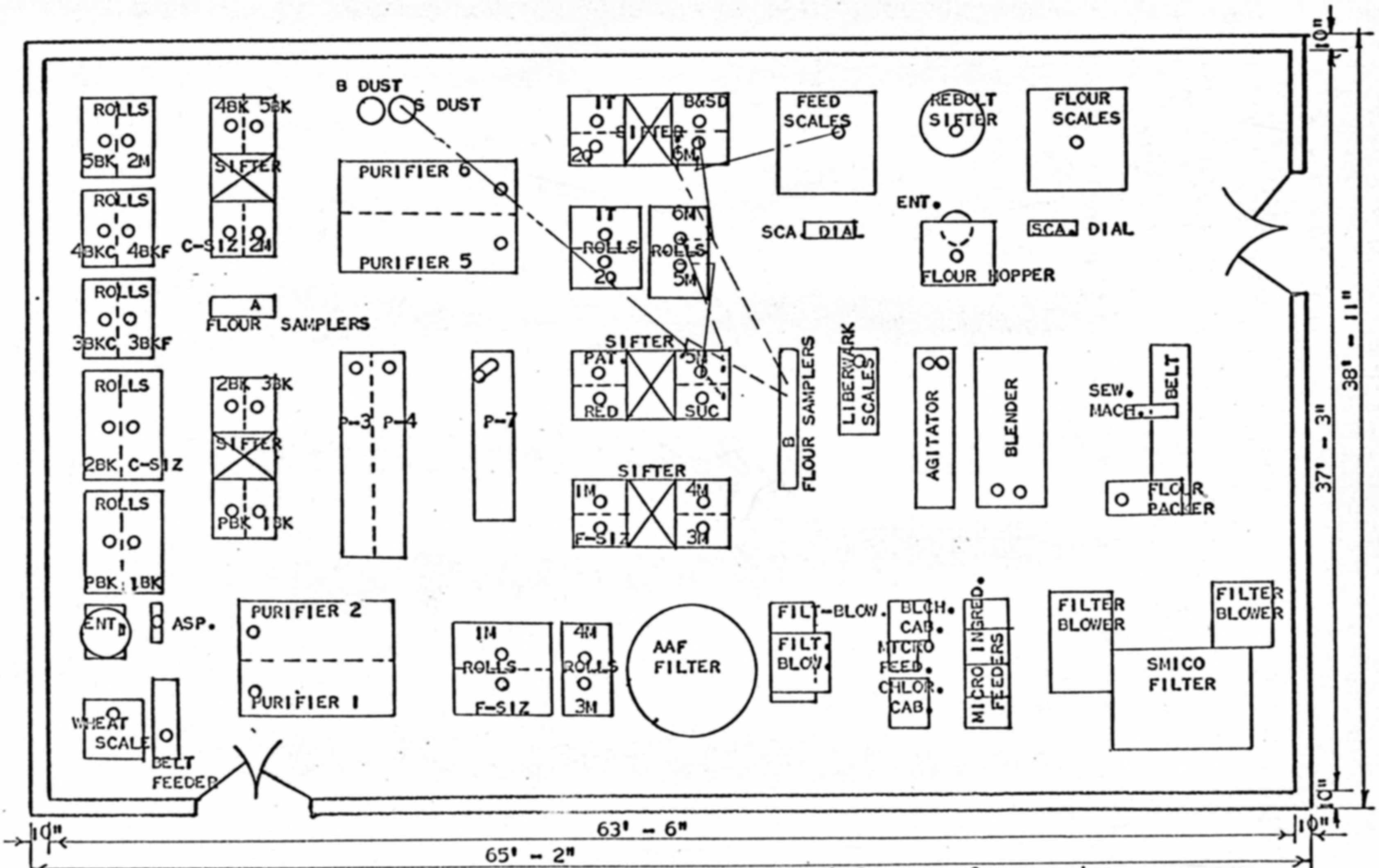
Key To Pneumatic Conveying Lines

Between machines (except sifter separations) ————

Sifter Separations

| | |
|---|---|
| Bottom flour - - - - - - - - | Bottom scalp ——— - ——— - ——— |
| Top flour ..................... | 2nd from bottom scalp —— - - —— |
| Thrus of grading or dusting cloth —— —— | 3rd from bottom scalp —— - - - —— |
| | 4th from bottom scalp —— - - - - —— |

PLATE XLV




Single Floor Layout for Kansas State Univ. Flour Mill

Scale 1/8" = 1' - 0"

5th Midd & 6th Midd Conveying Systems Using Separate Lift for Each Stock

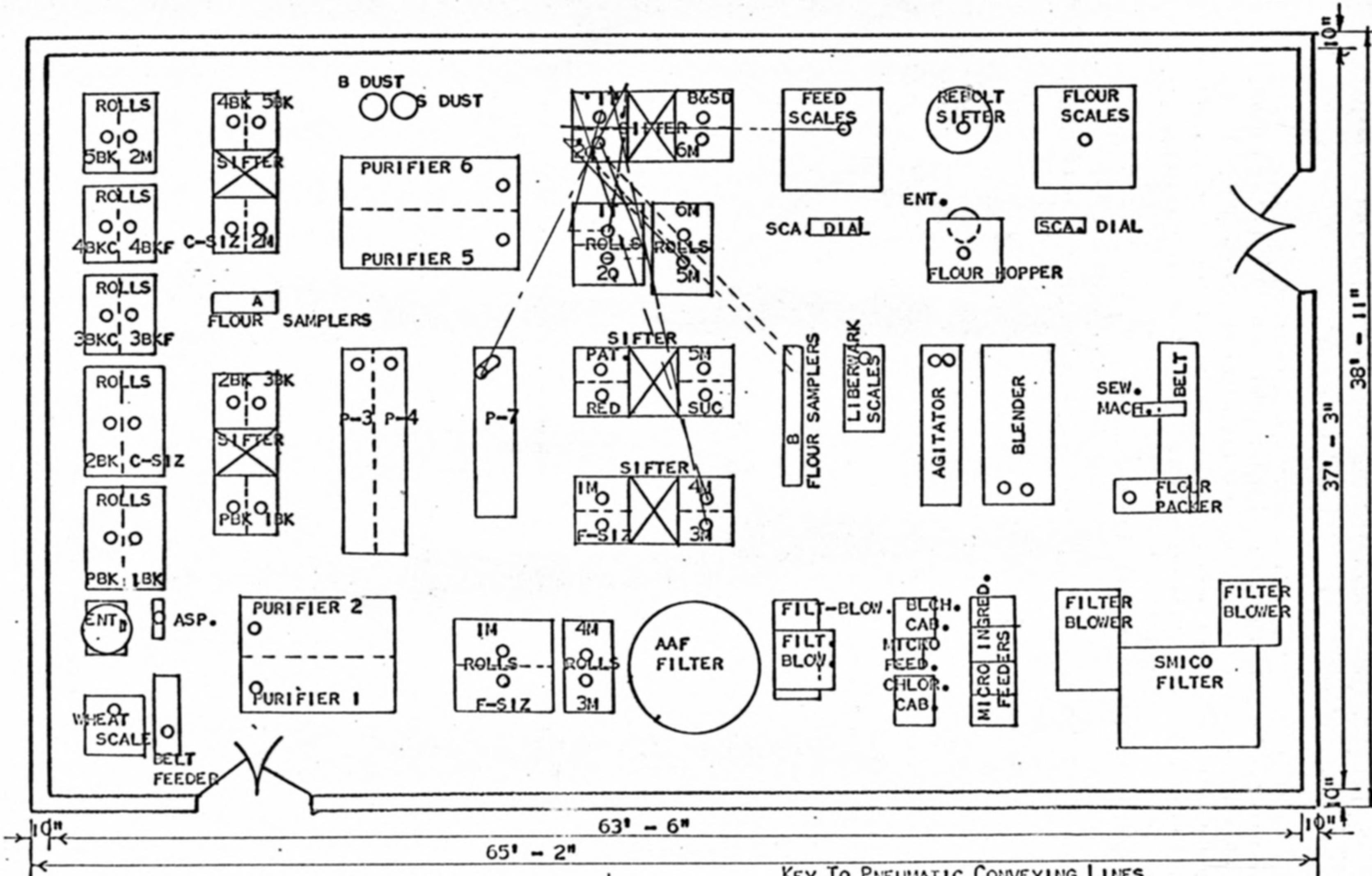
Key To Pneumatic Conveying Lines

Between machines (except sifter separations) ————

Sifter Separations

Bottom flour - - - - - - - -
Top flour . . . . . . . . . . . . . . .
Thrus of grading or dusting cloth —— ——
Bottom scalp
2nd from bottom scalp
3rd from bottom scalp
4th from bottom scalp

PLATE XLVI




Single Floor Layout for Kansas State Univ. Flour Mill

Scale 1/8" = 1' - 0"

1st Tail & 2nd Qual. Conveying Systems Using Separate Lift for Each Stock

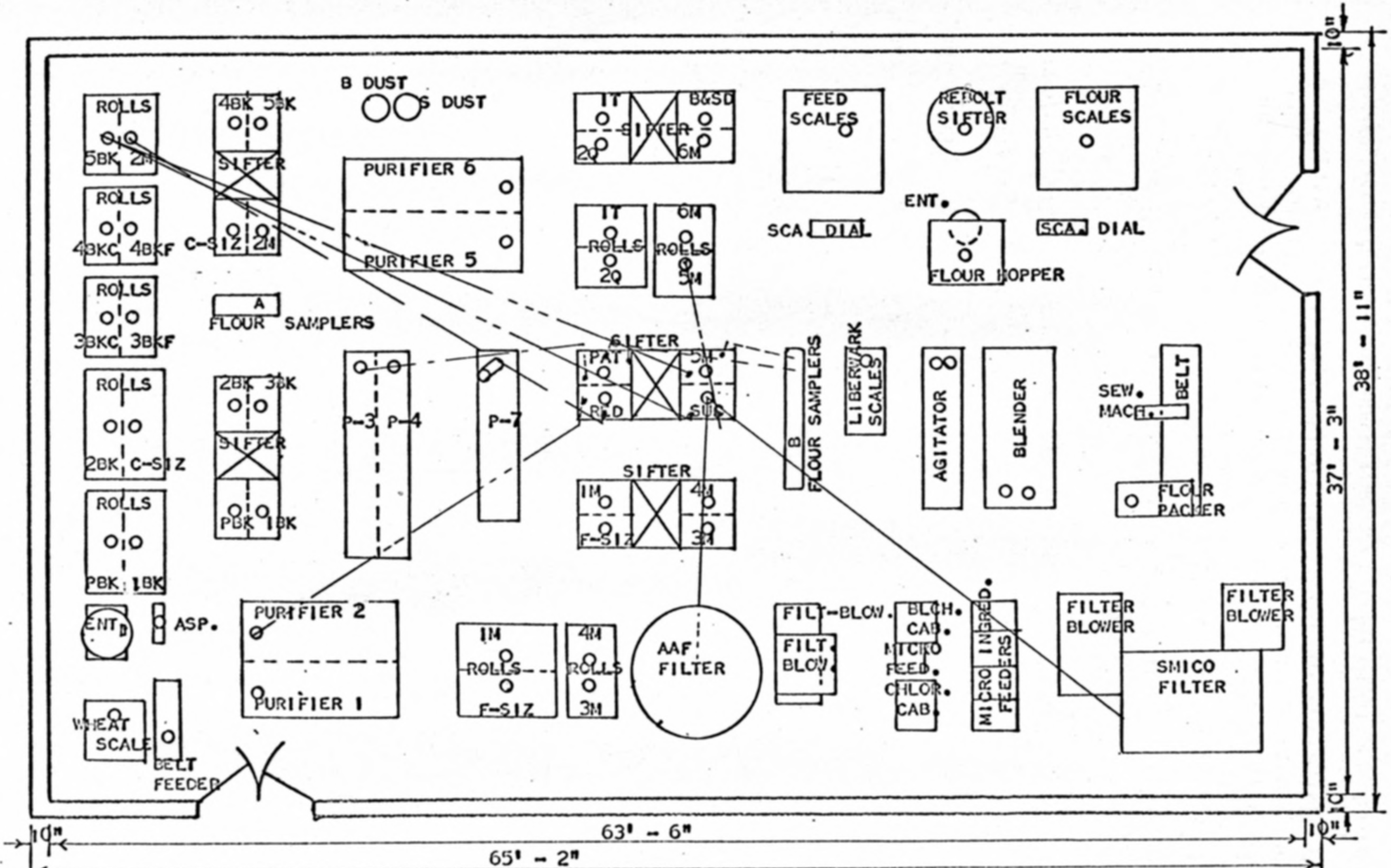
Key To Pneumatic Conveying Lines

Between machines (except sifter separations) ————

Sifter separations

| | |
|---|---|
| Bottom flour – – – – – – – – | Bottom scalp ——— - ——— - ——— |
| Top flour ·················· | 2nd from bottom scalp ——— - - ——— |
| Thrus of grading or dusting cloth ——— ——— | 3rd from bottom scalp ——— - - - ——— |
| | 4th from bottom scalp ——— - - - - ——— |

PLATE XLVII




SINGLE FLOOR LAYOUT FOR KANSAS STATE UNIV. FLOUR MILL

SCALE 1/8" = 1' - 0"

BREAK REDUST & SUCTION CONVEYING SYSTEMS USING SEPARATE LIFT FOR EACH STOCK

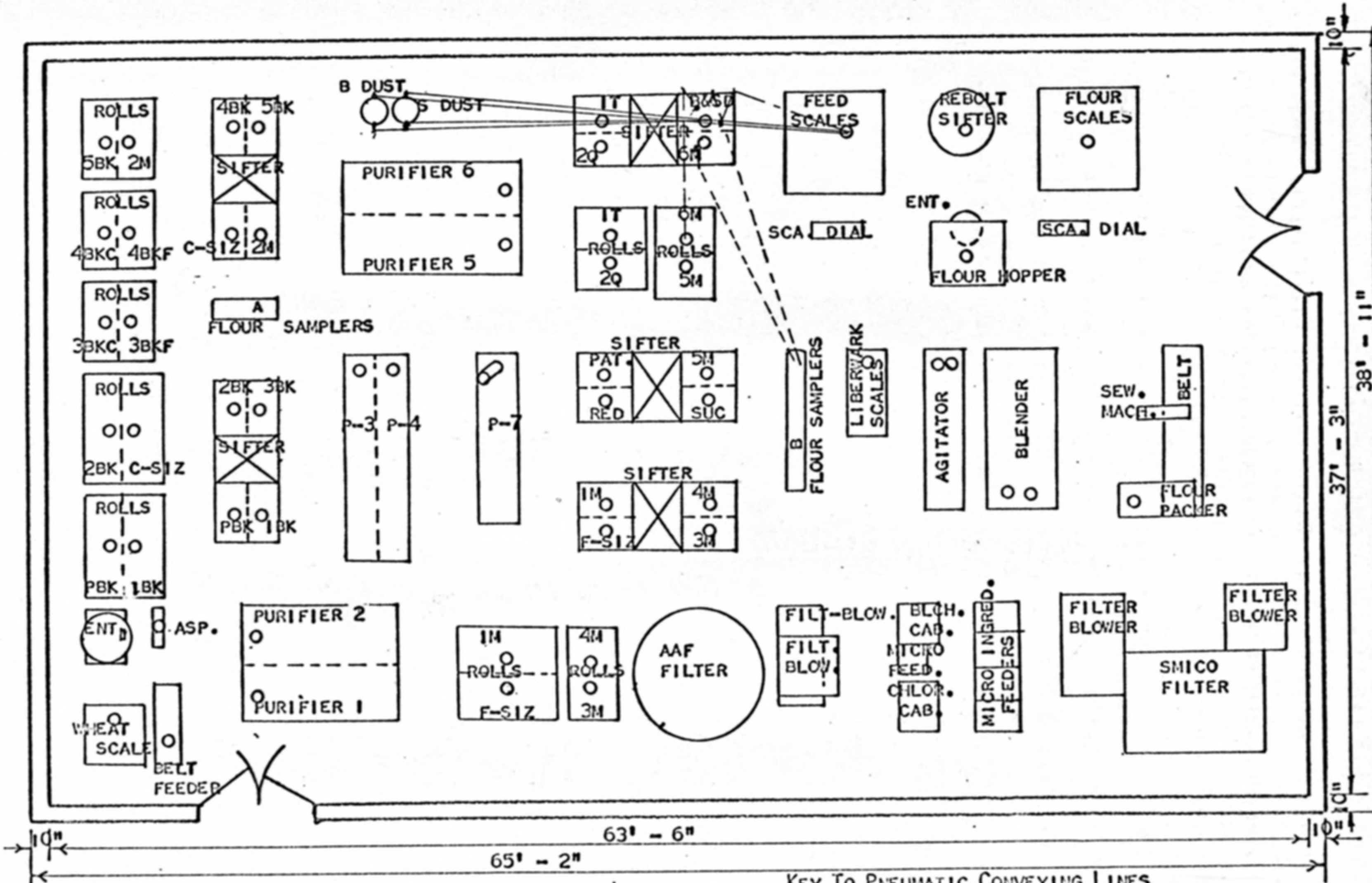
KEY TO PNEUMATIC CONVEYING LINES

BETWEEN MACHINES (EXCEPT SIFTER SEPARATIONS) ————————

SIFTER SEPARATIONS

| | |
|---|---|
| BOTTOM FLOUR - - - - - - - - | BOTTOM SCALP —— - —— - —— |
| TOP FLOUR ················ | 2ND FROM BOTTOM SCALP —— - - —— |
| THRUS OF GRADING OR DUSTING CLOTH —— —— | 3RD FROM BOTTOM SCALP —— - - - —— |
| | 4TH FROM BOTTOM SCALP —— - - - - —— |

PLATE XLVIII




Single Floor Layout for Kansas State Univ. Flour Mill

Scale 1/8" = 1' - 0"

B Dust, S Dust & B&SD Sift. Conveying Systems Using Separate Lift for Each Stock

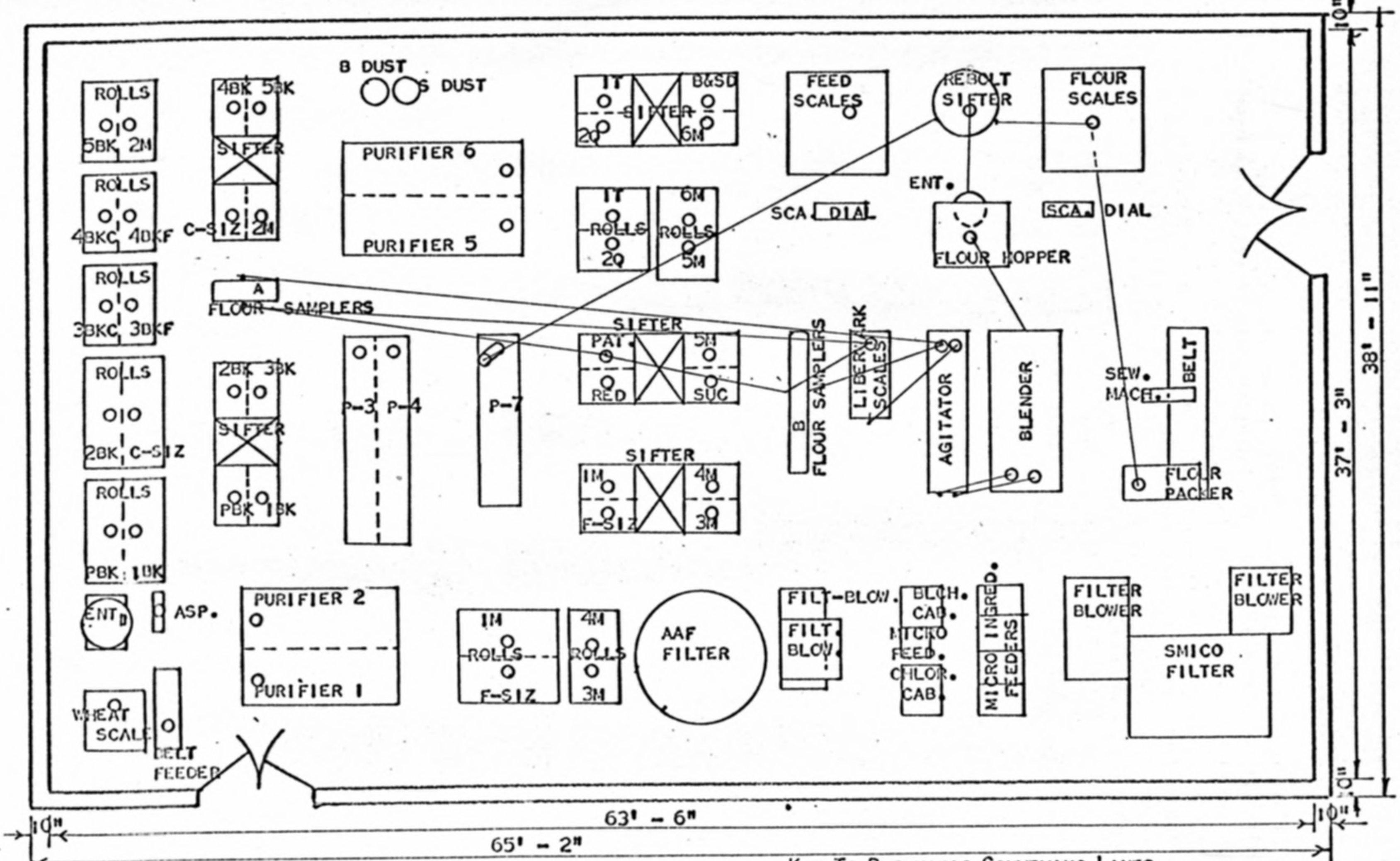
Key To Pneumatic Conveying Lines

Between machines (except sifter separations) ————

Sifter separations

| | |
|---|---|
| Bottom flour - - - - - - - - | Bottom scalp —— - —— - —— |
| Top flour ··················· | 2nd from bottom scalp —— - - —— |
| Thrus of grading or dusting cloth —— - —— | 3rd from bottom scalp —— - - - —— |
| | 4th from bottom scalp —— - ··· - —— |

PLATE XLIX




Single Floor Layout for Kansas State Univ.
Flour Mill

Scale 1/8" = 1' - 0"

Flour Finishing Systems Conveying Systems
Using Separate Lift foe Each Stock

Key To Pneumatic Conveying Lines

Between machines (except sifter separations) ————

Sifter separations

Bottom flour - - - - - - - -
Top flour ..................
Thrus of grading or dusting cloth —— ——
Bottom scalp —— - —— - ——
2nd from bottom scalp —— - - ——
3rd from bottom scalp —— - - - ——
4th from bottom scalp —— - - - - ——

Table 10. Gravity and pneumatic conveying requirements for

| Lift No. | Description: from | Description: to | Stock lb/min. | Pneumatic Conveying: Conveying Dist. (ft): Vertical | Pneumatic Conveying: Conveying Dist. (ft): Horizontal | Pneumatic Conveying: Tube Dia. (inches) | Pneumatic Conveying: No. Elbows |
|---|---|---|---|---|---|---|---|
| 1 | Wheat Scales | Belt Feeder | 18.16 | 11.0 | 3.0 | 2.0 | 2 |
| 2 | Belt Feeder | Entoleter | 18.16 | 11.0 | 3.3 | 2.0 | 2 |
| 3 | Entoleter | PBk R | 18.16 | 11.0 | 3.0 | 2.0 | 2 |
| 4 | PBk R | PBk S | 18.16 | 11.0 | 8.5 | 2.0 | 2 |
| 5 | PBk S | Asp. | 18.00 | 11.0 | 5.4 | 2.0 | 2 |
| 6 | Asp. | 1Bk R | 18.00 | 11.0 | 4.5 | 2.0 | 2 |
| 7 | PBk S | Purifier-1 | .099 | 11.0 | 12.0 | .75 | 3 |
| 8 | PBk S | Red-a | .048 | 11.0 | 23.7 | .75 | 2 |
| 9 | PBk S | Red-b | .057 | 11.0 | 21.0 | .75 | 2 |
| 10 | PBk S | Fl. Sam. | .033 | 11.0 | 11.0 | .75 | 3 |
| 11 | 1Bk R | 1Bk S | 18.00 | 11.0 | 10.3 | 2.0 | 3 |
| 12 | 1Bk S | 2Bk R | 12.10 | 11.0 | 11.0 | 2.0 | 3 |
| 13 | 1Bk S | Purifier-1 | 3.66 | 11.0 | 11.3 | 1.25 | 3 |
| 14 | 1Bk S | Red-a | .99 | 11.0 | 19.2 | .75 | 2 |
| 15 | 1Bk S | Red-b | .54 | 11.0 | 17.5 | .75 | 2 |
| 16 | 1Bk S | Fl. Sam. | .52 | 11.0 | 11.0 | .75 | 3 |
| 17 | 2Bk R | 2Bk S | 12.10 | 11.0 | 10.3 | 2.0 | 2 |
| 18 | 2Bk S | 3Bk C R | 5.07 | 11.0 | 8.5 | 1.25 | 2 |
| 19 | 2Bk S | 3Bk F R | 1.99 | 11.0 | 6.9 | 1.00 | 2 |
| 20 | 2Bk S | Purifier-1 | 2.40 | 11.0 | 13.5 | 1.25 | 2 |
| 21 | 2Bk S | Red | 1.56 | 11.0 | 19.1 | .75 | 2 |
| 22 | 2Bk S | Fl. Sam. | .60 | 11.0 | 6.0 | .75 | 3 |
| 23 | 3Bk C R | 3Bk S | 5.07 | 11.0 | 10.0 | 1.25 | 2 |
| 24 | 3Bk F R | 3Bk S | 1.99 | 11.0 | 9.0 | 1.00 | 2 |
| 25 | 3Bk S | 4Bk F | 2.85 | 11.0 | 12.5 | 1.00 | 2 |
| 26 | 3Bk S | 4Bk C | 1.54 | 11.0 | 14.3 | .75 | 2 |
| 27 | 3Bk S | Purifier-4 | 1.59 | 11.0 | 6.9 | .75 | 2 |
| 28 | 3Bk S | Red | .67 | 11.0 | 18.0 | .75 | 2 |
| 29 | 3Bk S | Fl. Sam. | .63 | 11.0 | 7.0 | .75 | 3 |
| 30 | 4Bk C R | 4Bk S | 2.85 | 11.0 | 9.0 | 1.00 | 2 |
| 31 | 4Bk F R | 4Bk S | 1.54 | 11.0 | 8.3 | .75 | 2 |
| 32 | 4Bk S | 4M R | .20 | 11.0 | 34.5 | .75 | 2 |
| 33 | 4Bk S | Purifier-7 | .42 | 11.0 | 21.0 | .75 | 2 |
| 34 | 4Bk S | 5Bk Ra | 3.48 | 11.0 | 6.4 | 1.25 | 2 |
| 35 | 4Bk S | 5Bk Rb | .33 | 11.0 | 5.5 | .75 | 2 |
| 36 | 4Bk S | Fl. Sam. | .24 | 11.0 | 9.8 | .75 | 2 |
| 37 | 5Bk R | 5Bk S | 3.81 | 11.0 | 10.0 | 1.25 | 2 |
| 38 | 5Bk S | B Dust | 2.90 | 11.0 | 5.0 | 1.25 | 2 |
| 39 | 5Bk S | S Dust | .60 | 11.0 | 7.0 | .75 | 2 |

K. S. U. mill on one floor - separate lift for each stock.

| No. Cyclones | Gravity Spouting (ft) | Conveying Values (lb/min. × ft.) Horizontal | Vertical | Air Volume (CFM) | Required Power (H. P.) |
|---|---|---|---|---|---|
| 1 | 1.0 | 54.0 | 198.0 | 75 | .50 |
| | | | | | |
| 1 | 0 | 54.0 | 198.0 | 75 | .50 |
| 1 | 1.0 | 54.0 | 198.0 | 75 | .50 |
| | | | | | |
| 1 | - | 153.0 | 198.0 | 75 | .60 |
| 1 | - | 97.2 | 198.0 | 75 | .50 |
| 1 | 3.0 | 81.0 | 198.0 | 75 | .50 |
| 1 | 3.0 | 1.2 | 1.1 | 9 | .056 |
| 1 | - | 1.1 | .5 | 9 | .076 |
| 1 | - | 1.2 | .6 | 9 | .073 |
| 1 | 2.0 | .4 | .4 | 9 | .059 |
| | | | | | |
| 1 | - | 185.4 | 198.0 | 75 | .70 |
| 1 | 3.0 | 133.1 | 133.1 | 75 | .50 |
| 1 | 3.0 | 41.4 | 40.3 | 27 | .17 |
| 1 | - | 19.0 | 10.9 | 9 | .07 |
| 1 | - | 9.4 | 5.9 | 9 | .068 |
| 1 | 2.0 | 5.7 | 5.7 | 9 | .059 |
| | | | | | |
| 1 | - | 124.6 | 133.1 | 75 | .50 |
| 1 | 2.3 | 43.1 | 55.8 | 27 | .17 |
| 1 | 2.3 | 13.7 | 21.9 | 17 | .12 |
| 1 | 3.0 | 32.4 | 26.4 | 27 | .17 |
| 1 | - | 29.8 | 17.2 | 9 | .08 |
| 1 | 2.0 | 3.6 | 6.6 | 9 | .054 |
| | | | | | |
| 1 | - | 50.7 | 55.8 | 27 | .18 |
| 1 | - | 17.9 | 21.9 | 17 | .108 |
| 1 | 2.3 | 35.6 | 31.4 | 17 | .132 |
| 1 | 2.3 | 22.0 | 16.9 | 9 | .072 |
| 1 | 2.2 | 11.0 | 17.5 | 9 | .075 |
| 1 | - | 12.1 | 7.4 | 9 | .068 |
| 1 | 2.0 | 4.4 | 6.9 | 9 | .055 |
| | | | | | |
| 1 | - | 25.7 | 31.4 | 17 | .120 |
| 1 | - | 12.8 | 16.9 | 9 | .064 |
| 1 | 3.0 | 6.9 | 22.2 | 9 | .086 |
| 1 | 2.0 | 8.8 | 4.6 | 9 | .072 |
| 1 | 2.3 | 22.3 | 38.3 | 27 | .17 |
| 1 | 2.3 | 1.8 | 3.6 | 9 | .052 |
| 1 | 2.0 | 2.4 | 2.6 | 9 | .056 |
| | | | | | |
| 1 | - | 38.1 | 41.9 | 27 | .17 |
| 1 | 3.2 | 14.5 | 31.9 | 27 | .17 |
| 1 | 3.2 | 4.2 | 6.6 | 9 | .055 |

Ta ble 10. (continued)

| Lift No. | Description from | Description to | Stock lb/min. | Pneumatic Conveying: Conveying Dist. (ft) Vertical | Conveying Dist. (ft) Horizontal | Tube Dia. (inches) | No. Elbows |
|---|---|---|---|---|---|---|---|
| 40 | 4Bk S | 5M R | .12 | 11.0 | 23.5 | .75 | 3 |
| 41 | 5Bk S | Fl. Sam. | .25 | 11.0 | 10.2 | .75 | 2 |
| 42 | C Siz R | C Siz S | 4.28 | 11.0 | 11.7 | 1.25 | 2 |
| 43 | C Siz S | 1M R | .12 | 11.0 | 27.0 | .75 | 2 |
| 44 | C Siz S | 1T R | .17 | 11.0 | 21.0 | .75 | 2 |
| 45 | C Siz S | Purifier-5 | 3.59 | 11.0 | 15.3 | 1.25 | 2 |
| 46 | C Siz S | Fl. Sam-t | .24 | 11.0 | 5.2 | .75 | 3 |
| 47 | C Siz S | Fl. Sam-b | .01 | 11.0 | 4.0 | .75 | 3 |
| 48 | F Siz R | F Siz R | 4.17 | 11.0 | 11.0 | 1.25 | 2 |
| 49 | F Siz S | 1M R | 1.10 | 11.0 | 7.9 | .75 | 2 |
| 50 | F Siz S | Purifier-6 | 2.16 | 11.0 | 20.8 | 1.00 | 2 |
| 51 | F Siz S | 1T R | .21 | 11.0 | 14.5 | .75 | 2 |
| 52 | F Siz S | Fl. Sam.-t | .53 | 11.0 | 11.0 | .75 | 2 |
| 53 | F Siz S | Fl. Sam.-b | .06 | 11.0 | 10.0 | .75 | 2 |
| 54 | 1M R | 1M S | 5.27 | 11.0 | 10.5 | 1.25 | 2 |
| 55 | 1M S | 1T R | .004 | 11.0 | 13.6 | .75 | 2 |
| 56 | 1M S | Purifier-6 | .42 | 11.0 | 15.8 | .75 | 2 |
| 57 | 1M S | Fl. Sam.-t | 1.68 | 11.0 | 9.3 | 1.00 | 2 |
| 58 | 1M S | Fl. Sam.-b | .73 | 11.0 | 11.5 | .75 | 2 |
| 59 | 1M S | 2M R | 2.28 | 11.0 | 30.4 | 1.00 | 3 |
| 60 | 2M R | 2M S | 5.17 | 11.0 | 9.0 | 1.25 | 2 |
| 61 | 2M S | 1T R | .004 | 11.0 | 17.5 | .75 | 2 |
| 62 | 2M S | Purifier-7 | .34 | 11.0 | 13.7 | .75 | 2 |
| 63 | 2M S | Fl. Sam.-t | 2.11 | 11.0 | 4.8 | 1.00 | 2 |
| 64 | 2M S | Fl. Sam.-b | .44 | 11.0 | 4.0 | .75 | 2 |
| 65 | 2M S | 3M R | 2.24 | 11.0 | 27.8 | 1.00 | 2 |
| 66 | 3M R | 3M S | 2.86 | 11.0 | 10.8 | 1.00 | 3 |
| 67 | 3M S | 1T R | .07 | 11.0 | 17.6 | .75 | 2 |
| 68 | 3M S | 4M R | .93 | 11.0 | 12.7 | .75 | 2 |
| 69 | 3M S | Fl. Sam. | 1.84 | 11.0 | 6.3 | 1.00 | 2 |
| 70 | 4M R | 4M S | 2.06 | 11.0 | 10.6 | 1.00 | 2 |
| 71 | 4M S | 5M R | .69 | 11.0 | 15.3 | .75 | 2 |
| 72 | 4M S | 5Bk R | .0 | 11.0 | 35.5 | .75 | 2 |
| 73 | 4M S | Fl. Sam. | 1.15 | 11.0 | 5.2 | .75 | 2 |
| 74 | 5M R | 5M S | 1.00 | 11.0 | 7.8 | .75 | 2 |
| 75 | 5M S | S Dust | .20 | 11.0 | 19.0 | .75 | 2 |
| 76 | 5M S | Fl. Sam. | .40 | 11.0 | 6.7 | .75 | 2 |
| 77 | 5M S | 6M R | .19 | 11.0 | 7.5 | .75 | 2 |

| No. Cyclones | Gravity Spouting (ft) | Conveying Values (lb/min. × ft.) Horizontal | Vertical | Air Volume (CFM) | Required Power (H. P.) |
|---|---|---|---|---|---|
| 1 | 3.0 | 2.8 | 4.1 | 9 | .076 |
| 1 | 2.0 | 2.6 | 5.4 | 9 | .058 |
| | | | | | |
| 1 | - | 49.6 | 96.7 | 27 | .17 |
| 1 | 2.6 | 3.2 | 4.5 | 9 | .079 |
| 1 | 3.5 | 3.6 | 5.5 | 9 | .072 |
| 1 | 4.5 | 54.9 | 94.4 | 27 | .18 |
| 1 | 2.0 | 1.2 | 3.8 | 9 | .052 |
| 1 | 2.0 | .04 | .14 | 9 | .052 |
| | | | | | |
| 1 | - | 45.9 | 9.18 | 27 | .170 |
| 1 | 2.6 | 8.7 | 20.8 | 9 | .060 |
| 1 | 4.5 | 44.9 | 68.7 | 17 | .152 |
| 1 | 3.5 | 3.0 | 5.3 | 9 | .059 |
| 1 | 2.0 | 5.8 | 11.6 | 9 | .062 |
| 1 | 2.0 | .7 | 1.4 | 9 | .057 |
| | | | | | |
| 1 | - | 55.3 | 113.3 | 27 | .18 |
| 1 | 3.5 | .05 | .09 | 9 | .062 |
| 1 | 4.5 | 6.6 | 11.2 | 9 | .064 |
| 1 | 2.0 | 15.6 | 34.1 | 17 | .108 |
| 1 | 2.0 | 8.4 | 16.4 | 9 | .059 |
| 1 | 2.3 | 69.3 | 94.4 | 17 | .182 |
| | | | | | |
| 1 | - | 46.5 | 56.8 | 27 | .18 |
| 1 | 3.5 | .07 | .05 | 9 | .069 |
| 1 | 2.0 | 4.7 | 3.7 | 9 | .076 |
| 1 | 2.0 | 10.1 | 23.2 | 17 | .100 |
| 1 | 2.0 | 1.8 | 4.8 | 9 | .052 |
| 1 | 3.0 | 62.3 | 24.6 | 17 | .175 |
| | | | | | |
| 1 | - | 30.9 | 31.5 | 17 | .126 |
| 1 | 3.5 | 1.2 | .8 | 9 | .069 |
| 1 | 2.0 | 11.8 | 10.2 | 9 | .062 |
| 1 | 2.0 | 11.6 | 20.2 | 17 | .10 |
| | | | | | |
| 1 | - | 21.8 | 22.7 | 17 | .126 |
| 1 | 2.0 | 10.6 | 7.6 | 9 | .064 |
| 1 | 2.3 | 0 | 0 | 9 | .086 |
| 1 | 2.0 | 6.0 | 12.7 | 9 | .060 |
| | | | | | |
| 1 | 0 | 7.8 | 11.0 | 9 | .054 |
| 1 | 3.2 | 7.3 | 2.2 | 9 | .070 |
| 1 | 2.0 | 2.7 | 4.4 | 9 | .052 |
| 1 | 2.0 | 1.4 | 2.1 | 9 | .054 |

Table 10. (continued)

| Lift No. | Description from | to | Stock lb/min. | Pneumatic Conveying: Conveying Dist. (ft) Vertical | Horizontal | Tube Dia. (inches) | No. Elbows |
|---|---|---|---|---|---|---|---|
| 78 | 6M R | 6M S | .37 | 11.0 | 6.0 | .75 | 2 |
| 79 | 6M S | Fd. Scales | .20 | 11.0 | 7.7 | .75 | 2 |
| 80 | 6M S | Fl. Sam. | .17 | 11.0 | 14.2 | .75 | 2 |
| 81 | 1T R | 1T S | 1.70 | 11.0 | 9.0 | 1.00 | 2 |
| 82 | 1T S | Fd. Scales | .62 | 11.0 | 14.0 | .75 | 2 |
| 83 | 1T S | 4M R | .45 | 11.0 | 22.6 | .75 | 2 |
| 84 | 1T S | 5M R | .53 | 11.0 | 8.0 | .75 | 2 |
| 85 | 1T S | Fl. Sam. | .099 | 11.0 | 13.5 | .75 | 2 |
| 86 | 2Q R | 2Q S | .97 | 11.0 | 8.0 | .75 | 2 |
| 87 | 2Q S | 1T R | .15 | 11.0 | 4.5 | .75 | 2 |
| 88 | 2Q S | Purifier-7 | .70 | 11.0 | 17.3 | .75 | 2 |
| 89 | 2Q S | 3M R | .10 | 11.0 | 17.3 | .75 | 2 |
| 90 | 2Q S | Fl. Sam. | .064 | 11.0 | 14.4 | .75 | 2 |
| 91 | Red S | Purifier-2 | 1.60 | 11.0 | 20.5 | 1.00 | 2 |
| 92 | Red S | Purifier-3 | 1.48 | 11.0 | 12.8 | .75 | 2 |
| 93 | Red S | 2M R | .62 | 11.0 | 28.3 | .75 | 2 |
| 94 | Red S | Fl. Sam. | .17 | 11.0 | 10.5 | .75 | 2 |
| 95 | Smico Filter | Suc S. | .19 | 12.0 | 13.0 | .75 | 2 |
| 96 | AAF Filter | Suc S | .10 | 12.0 | 25.3 | .75 | 2 |
| 97 | Suc S | 5Bk-a | .0 | 11.0 | 33.2 | .75 | 2 |
| 98 | Suc S | 5Bk R-b | .05 | 11.0 | 32.7 | .75 | 2 |
| 99 | Suc S | 5M R | .09 | 11.0 | 9.0 | .75 | 2 |
| 100 | Suc S | Fl. Sam. | .09 | 11.0 | 4.4 | .75 | 2 |
| 101 | B Dust | B&SD S | .18 | 11.0 | 17.0 | .75 | 2 |
| 102 | S Dust | B&SD S | .18 | 11.0 | 15.3 | .75 | 2 |
| 103 | B&SD S | Fd. Scales | .28 | 13.0 | 6.0 | .75 | 2 |
| 104 | B&SD S | 6M R | .17 | 11.0 | 18.2 | .75 | 2 |
| 105 | B&SD S | Fl. Sam. | .35 | 11.0 | 12.3 | .75 | 2 |
| 106 | B Dust | Fd. Scales | 2.80 | 12.0 | 24.2 | 1.00 | 2 |
| 107 | S Dust | Fd. Scales | .75 | 12.0 | 22.5 | .75 | 2 |
| Patent Flour System | | | | | | | |
| 108 | Fl. Sam.-a | Pat. Agit. | 5.07 | 11.0 | 36.1 | 1.25 | 2 |
| 109 | Fl. Sam.-b | Pat. Agit. | 7.33 | 11.0 | 7.7 | 1.25 | 2 |
| 110 | Agit. | Blender | 12.41 | 11.0 | 4.5 | 1.50 | 2 |

| No. Cyclones | Gravity Spouting (ft) | Conveying Values (lb/min. × ft.) Horizontal | Vertical | Air Volume (CFM) | Required Power (H. P.) |
|---|---|---|---|---|---|
| 1 | - | 2.2 | 4.1 | 9 | .054 |
| 1 | - | 1.5 | 2.2 | 9 | .055 |
| 1 | 2.0 | 2.4 | 1.9 | 9 | .063 |
| 1 | 0 | 15.3 | 18.7 | 17 | .108 |
| 1 | 0 | 8.7 | 6.8 | 9 | .063 |
| 1 | 2.0 | 10.1 | 15.0 | 9 | .075 |
| 1 | 2.0 | 4.2 | 5.8 | 9 | .055 |
| 1 | 2.0 | 1.3 | 1.1 | 9 | .063 |
| 1 | 0 | 7.8 | 10.7 | 9 | .055 |
| 1 | 3.5 | .7 | 1.7 | 9 | .052 |
| 1 | 2.0 | 12.1 | 7.7 | 9 | .067 |
| 1 | 2.0 | 2.2 | 1.1 | 9 | .074 |
| 1 | 2.0 | .9 | .7 | 9 | .067 |
| 1 | 3.0 | 32.8 | 17.6 | 17 | .11 |
| 1 | 2.3 | 18.9 | 16.3 | 9 | .060 |
| 1 | 2.3 | 17.5 | 6.8 | 9 | .081 |
| 1 | 2.0 | 1.8 | 1.9 | 9 | .057 |
| 1 | 0 | 2.5 | 2.3 | 9 | .063 |
| 1 | 0 | 2.5 | 1.2 | 9 | .078 |
| 1 | 2.3 | 0 | 0 | 9 | .090 |
| 1 | 2.3 | 1.6 | .6 | 9 | .090 |
| 1 | 2.0 | .8 | 1.0 | 9 | .056 |
| 1 | 2.0 | .4 | 1.0 | 9 | .050 |
| 1 | 0 | 3.1 | 2.0 | 9 | .067 |
| 1 | 0 | 2.8 | 2.0 | 9 | .064 |
| 1 | 0 | 1.7 | 3.6 | 9 | .056 |
| 1 | 2.0 | 3.1 | 1.9 | 9 | .069 |
| 1 | 2.0 | 4.3 | 3.9 | 9 | .063 |
| 1 | 0 | 67.8 | 33.6 | 17 | .168 |
| 1 | 0 | 16.9 | 9.0 | 9 | .076 |
| **Patent Flour System** | | | | | |
| 1 | 5.0 | 183.03 | 55.77 | 27 | .24 |
| 1 | 5.0 | 56.44 | 80.63 | 27 | .22 |
| 1 | 3.0 | 49.6 | 136.5 | 40 | .34 |

Table 10. (continued)

| Lift No. | Description from | Description to | Stock lb/min. | Pneumatic Conveying: Conveying Dist. (ft) Vertical | Horizontal | Tube Dia. (inches) | No. Elbows |
|---|---|---|---|---|---|---|---|
| **Fine Patent System** | | | | | | | |
| 111 | Fl. Sam.-a | Pat Reb S | .0 | 11.0 | 19.2 | 1.25 | 2 |
| 112 | Fl. Sam.-b | Pat Reb S | .0 | 11.0 | 9.6 | 1.25 | 2 |
| **Clear Flour System** | | | | | | | |
| 113 | Fl. Sam.-a | Lib Scale | .0 | 11.0 | 32.4 | 1.25 | 2 |
| 114 | Fl. Sam.-b | Lib Scale | .0 | 11.0 | 5.4 | 1.25 | 2 |
| 115 | Lib Scale | Agitator | .0 | 11.0 | 6.5 | 1.25 | 2 |
| 116 | Agitator | Blender | .0 | 11.0 | 4.0 | 1.25 | 2 |
| 117 | Blender | Hopper | 12.41 | 13.0 | 5.5 | 1.50 | 2 |
| 118 | Entoleter | Reb. Sift | 12.41 | 11.0 | 4.0 | 1.50 | 2 |
| 119 | Reb Sift | Fl. Scale | 12.35 | 15.0 | 4.8 | 1.50 | 2 |
| 120 | Reb S | Purifier-7 | .06 | 11.0 | 26.0 | 1.25 | 2 |
| 121 | Fl. Scale | Packer | 12.35 | 11.0 | 16.0 | 1.50 | 2 |
| 122 | Purifier-1 | F Siz R | 1.29 | 11.0 | 14.1 | .75 | 2 |
| 123 | Purifier-1 | C Siz Ra | .0 | 11.0 | 18.0 | 1.25 | 2 |
| 124 | Purifier-1 | C Siz Rb | 3.50 | 11.0 | 19.0 | 1.25 | 2 |
| 125 | Purifier-1 | C Siz Rt | .78 | 11.0 | 18.5 | .75 | 2 |
| 126 | Purifier-1 | 3Bk F R | .55 | 11.0 | 23.5 | .75 | 2 |
| 127 | Purifier-2 | 1M R | .93 | 11.0 | 13.3 | .75 | 2 |
| 128 | Purifier-2 | F Siz R | .63 | 11.0 | 11.7 | .75 | 2 |
| 129 | Purifier-2 | C Siz R | tr | 11.0 | 13.7 | 1.25 | 2 |
| 130 | Purifier-2 | C Siz Rt | .0 | 11.0 | 17.5 | 1.25 | 2 |
| 131 | Purifier-2 | 1T R | tr | 11.0 | 22.6 | 1.25 | 2 |
| 132 | Purifier-2 | 5Bk R(Asp. P-1 & P-2) | tr | 11.0 | 20.3 | 1.25 | 2 |
| 133 | Purifier-3 | 2M R | .19 | 11.0 | 19.5 | .75 | 2 |
| 134 | Purifier-3 | F Siz R | .0 | 11.0 | 12.6 | .75 | 2 |
| 135 | Purifier-3 | 1M R | 1.19 | 11.0 | 12.9 | .75 | 2 |
| 136 | Purifier-3 | 1T R | tr | 11.0 | 21.0 | 1.25 | 2 |
| 137 | Purifier-3 | 2Q R | tr | 11.0 | 20.3 | 1.25 | 2 |
| 138 | Purifier-4 | C Siz R | .0 | 11.0 | 15.0 | 1.25 | 2 |
| 139 | Purifier-4 | 2M R | .0 | 11.0 | 24.5 | 1.25 | 2 |
| 140 | Purifier-4 | F Siz R | 1.20 | 11.0 | 10.3 | .75 | 2 |
| 141 | Purifier-4 | 1T R | .22 | 11.0 | 20.4 | .75 | 2 |
| 142 | Purifier-4 | 2Q R | .23 | 11.0 | 19.3 | .75 | 2 |
| 143 | Purifier-4 | 5Bk R(Asp. P-3 & P-4) | tr | 11.0 | 25.2 | .75 | 2 |

| No. Cyclones | Gravity Spouting (ft) | Conveying Values (lb/min. × ft.) Horizontal | Vertical | Air Volume (CFM) | Required Power (H. P.) |
|---|---|---|---|---|---|
| **Fine Patent System** | | | | | |
| 1 | 0 | 0 | 0 | 0 | 0 |
| 1 | 0 | 0 | 0 | 0 | 0 |
| **Clear Flour System** | | | | | |
| 1 | 3.3 | 0 | 0 | 0 | 0 |
| 1 | 3.3 | 0 | 0 | 0 | 0 |
| 1 | 5.0 | 0 | 0 | 0 | 0 |
| 1 | 5.0 | 0 | 0 | 0 | 0 |
| 1 | 0 | 68.3 | 161.3 | 40 | .37 |
| 1 | 0 | 49.4 | 135.8 | 40 | .37 |
| 1 | 0 | 59.3 | 185.3 | 40 | .37 |
| 1 | 2.0 | .7 | 1.3 | 27 | .20 |
| 1 | 1.0 | 197.6 | 135.8 | 40 | .39 |
| 1 | 2.6 | 18.2 | 14.2 | 9 | .063 |
| 1 | 2.6 | 0 | 0 | 0 | 0 |
| 1 | 2.6 | 66.5 | 38.5 | 27 | .190 |
| 1 | 2.6 | 14.4 | 8.6 | 9 | .070 |
| 1 | 2.3 | 12.9 | 6.1 | 9 | .076 |
| 1 | 2.6 | 12.4 | 10.2 | 9 | .062 |
| 1 | 2.6 | 7.4 | 6.9 | 9 | .059 |
| 1 | 2.6 | 0 | 0 | 0 | 0 |
| 1 | 2.6 | 0 | 0 | 0 | 0 |
| 1 | 3.5 | 0 | 0 | 0 | 0 |
| 1 | 0 | 0 | 0 | 0 | 0 |
| 1 | 2.3 | 3.7 | 2.1 | 9 | .070 |
| 1 | 2.6 | 0 | 0 | 0 | 0 |
| 1 | 2.6 | 15.4 | 13.1 | 9 | .070 |
| 1 | 3.5 | 0 | 0 | 0 | 0 |
| 1 | 3.5 | 0 | 0 | 0 | 0 |
| 1 | 2.6 | 0 | 0 | 0 | 0 |
| 1 | 2.3 | 0 | 0 | 0 | 0 |
| 1 | 2.6 | 12.4 | 13.2 | 9 | .18 |
| 1 | 3.5 | 4.5 | 2.4 | 9 | .19 |
| 1 | 3.5 | 4.4 | 2.5 | 0 | 0 |

Table 10. (concluded)

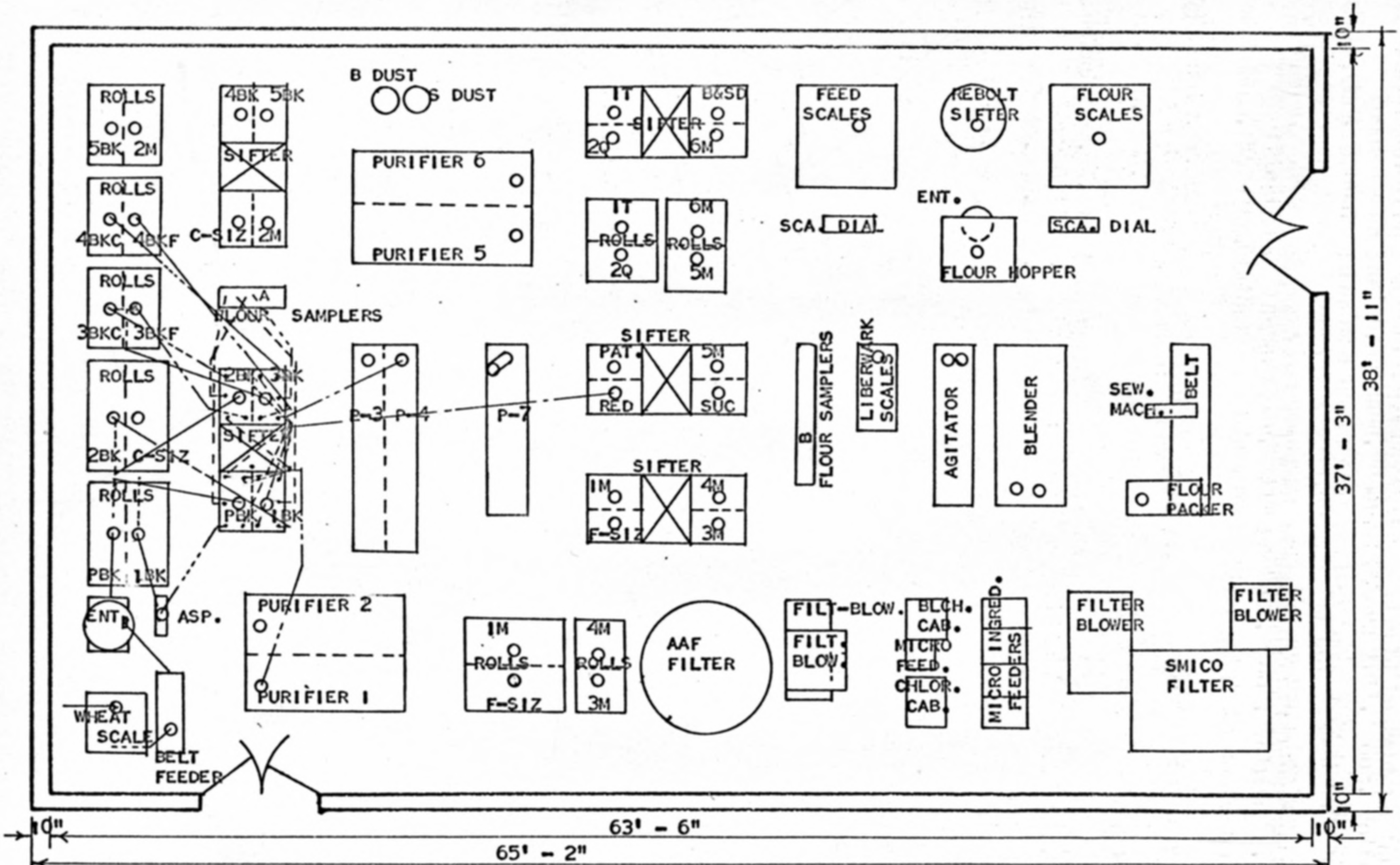
| Lift No. | Description from | Description to | Stock lb/min. | Pneumatic Conveying: Conveying Dist. (ft) Vertical | Horizontal | Tube Dia. (inches) | No. Elbows |
|---|---|---|---|---|---|---|---|
| 144 | Purifier-5 | 2M R | .0 | 11.0 | 19.0 | .75 | 2 |
| 145 | Purifier-5 | F Siz R | 1.05 | 11.0 | 22.0 | 1.00 | 2 |
| 146 | Purifier-5 | 1M R | 1.93 | 11.0 | 21.5 | 1.00 | 2 |
| 147 | Purifier-5 | 1T R | .097 | 11.0 | 14.0 | .75 | 2 |
| 148 | Purifier-5 | 2Q R | .28 | 11.0 | 14.2 | .75 | 2 |
| 149 | Purifier-6 | 3M R | .0 | 11.0 | 27.7 | 1.00 | 2 |
| 150 | Purifier-6 | 2M R | 2.05 | 11.0 | 17.8 | 1.00 | 2 |
| 151 | Purifier-6 | 2Q R | .09 | 11.0 | 13.5 | .75 | 2 |
| 152 | Purifier-6 | 1T R | .05 | 11.0 | 14.4 | .75 | 2 |
| 153 | Purifier-6 | 2Q t R | .34 | 11.0 | 14.6 | .75 | 2 |
| 154 | Purifier-7 | 3M a R | .76 | 11.0 | 12.5 | .75 | 2 |
| 155 | Purifier-7 | 3M b R | .53 | 11.0 | 11.1 | .75 | 2 |
| 156 | Purifier-7 | 1T R | .61 | 11.0 | 15.7 | .75 | 2 |
| 157 | Purifier-7 | 5Bk R | .05 | 11.0 | 28.5 | .75 | 2 |
| Totals | | | 354.370 | 1739.0 | 2248.7 | - | 327 |

| No. Cyclones | Gravity Spouting (ft) | Conveying Values (lb/min. × ft.) Horizontal | Vertical | Air Volume (CFM) | Required Power (H. P.) |
|---|---|---|---|---|---|
| 1 | 2.3 | 0 | 0 | 0 | 0 |
| 1 | 2.6 | 23.2 | 11.6 | 17 | .074 |
| 1 | 2.6 | 41.5 | 21.2 | 17 | .138 |
| 1 | 3.5 | 1.4 | 1.1 | 9 | .063 |
| 1 | 3.5 | 4.0 | 3.1 | 9 | .063 |
| 1 | 2.3 | 0 | 0 | 0 | 0 |
| 1 | 2.6 | 36.5 | 22.6 | 17 | .147 |
| 1 | 3.5 | 1.3 | 1.0 | 9 | .063 |
| 1 | 3.5 | .7 | .6 | 9 | .063 |
| 1 | 3.5 | 5.0 | 3.7 | 9 | .063 |
| 1 | 2.0 | 9.5 | 8.4 | 9 | .060 |
| 1 | 2.0 | 5.9 | 5.8 | 9 | .060 |
| 1 | 3.5 | 9.6 | 6.7 | 9 | .066 |
| 1 | 2.3 | 1.4 | .6 | 9 | .082 |
| 157 | 304.1 | 3269.53 | 4369.06 | 2413 | 18.070 |

# APPENDIX C

## Conveying Diagrams and Requirements for Single-floor Mill Using Combined Common Stocks.

PLATE I




SINGLE FLOOR LAYOUT FOR KANSAS STATE UNIV.
FLOUR MILL

SCALE 1/8" = 1' - 0"

RECEIVING, 1ST BREAK, 2ND BREAK, 3RD BREAK
CONVEYING SYSTEMS USING COMBINED LIFTS

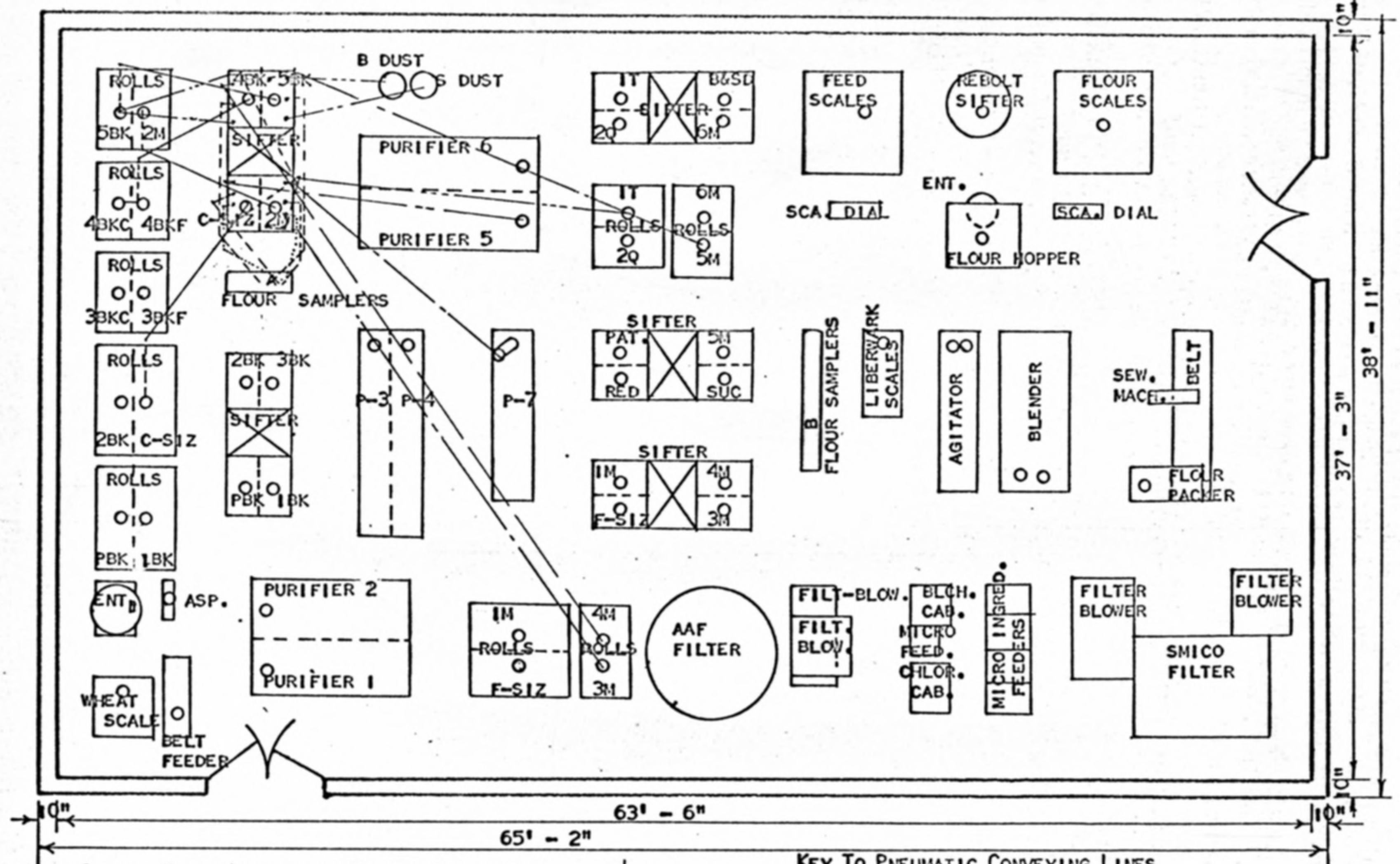
KEY TO PNEUMATIC CONVEYING LINES

BETWEEN MACHINES (EXCEPT SIFTER SEPARATIONS) ————

SIFTER SEPARATIONS

| | |
|---|---|
| BOTTOM FLOUR - - - - - - - - | BOTTOM SCALP —— - —— - —— |
| TOP FLOUR · · · · · · · · · · · · · | 2ND FROM BOTTOM SCALP —— - - —— |
| THRUS OF GRADING OR DUSTING CLOTH —— —— | 3RD FROM BOTTOM SCALP —— - - - —— |
| | 4TH FROM BOTTOM SCALP —— - - - - —— |

PLATE LI




SINGLE FLOOR LAYOUT FOR KANSAS STATE UNIV. FLOUR MILL

SCALE 1/8" = 1' - 0"

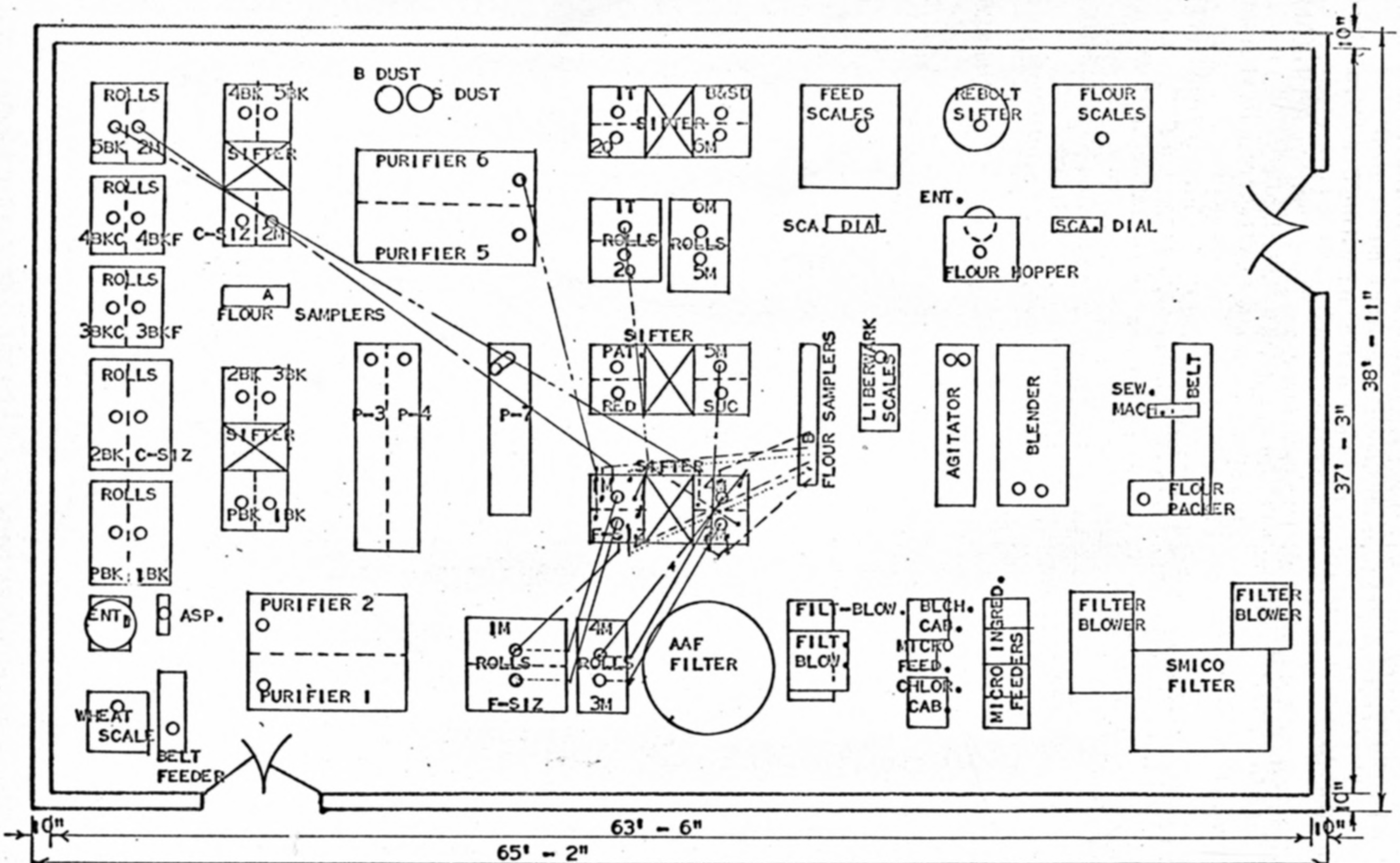
4TH BREAK, 5TH BREAK, CSIZINGS, & 2 MIDDS CONVEYING SYSTEMS USING COMBINED LIFTS

KEY TO PNEUMATIC CONVEYING LINES

BETWEEN MACHINES (EXCEPT SIFTER SEPARATIONS) ————

SIFTER SEPARATIONS

| | |
|---|---|
| BOTTOM FLOUR - - - - - - - - | BOTTOM SCALP —— - —— - —— |
| TOP FLOUR · · · · · · · · · · · · | 2ND FROM BOTTOM SCALP —— - - —— |
| THRUS OF GRADING OR DUSTING CLOTH —— —— | 3RD FROM BOTTOM SCALP —— - - - —— |
| | 4TH FROM BOTTOM SCALP —— - - - - —— |




SINGLE FLOOR LAYOUT FOR KANSAS STATE UNIV.
FLOUR MILL

SCALE 1/8" = 1' - 0"

F SIZING, 1ST MIDDS, 3RD MIDDS & 4TH MIDDS
CONVEYING SYSTEMS USING COMBINED LIFTS

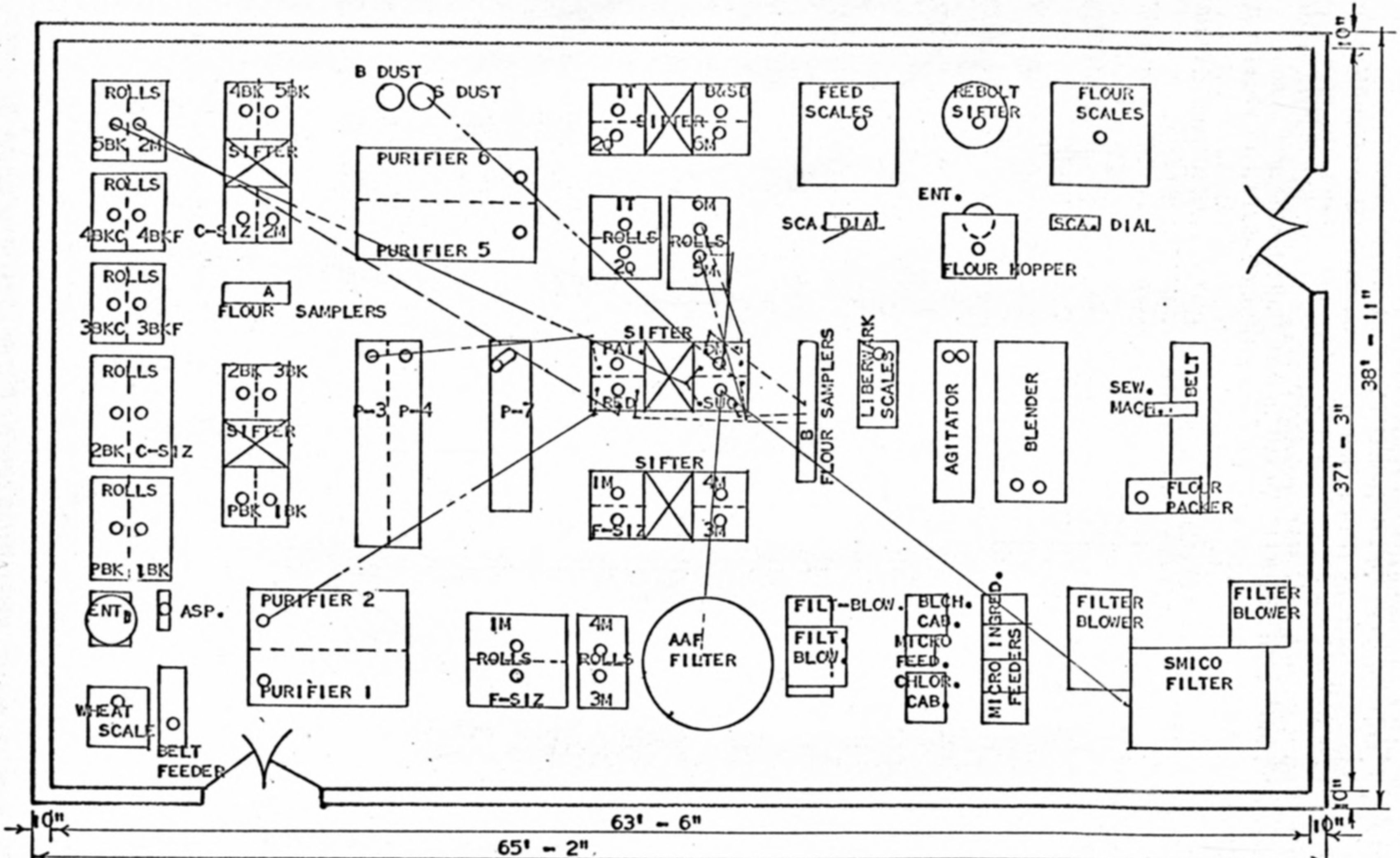
KEY TO PNEUMATIC CONVEYING LINES

BETWEEN MACHINES (EXCEPT SIFTER SEPARATIONS) ————

SIFTER SEPARATIONS

| | |
|---|---|
| BOTTOM FLOUR - - - - - - - | BOTTOM SCALP —— - —— |
| TOP FLOUR ··············· | 2ND FROM BOTTOM SCALP — - - — |
| THRUS OF GRADING OR DUSTING CLOTH —— —— | 3RD FROM BOTTOM SCALP — - - - — |
| | 4TH FROM BOTTOM SCALP — - - - - — |

PLATE LIII




SINGLE FLOOR LAYOUT FOR KANSAS STATE UNIV.
FLOUR MILL

SCALE 1/8" = 1' - 0"

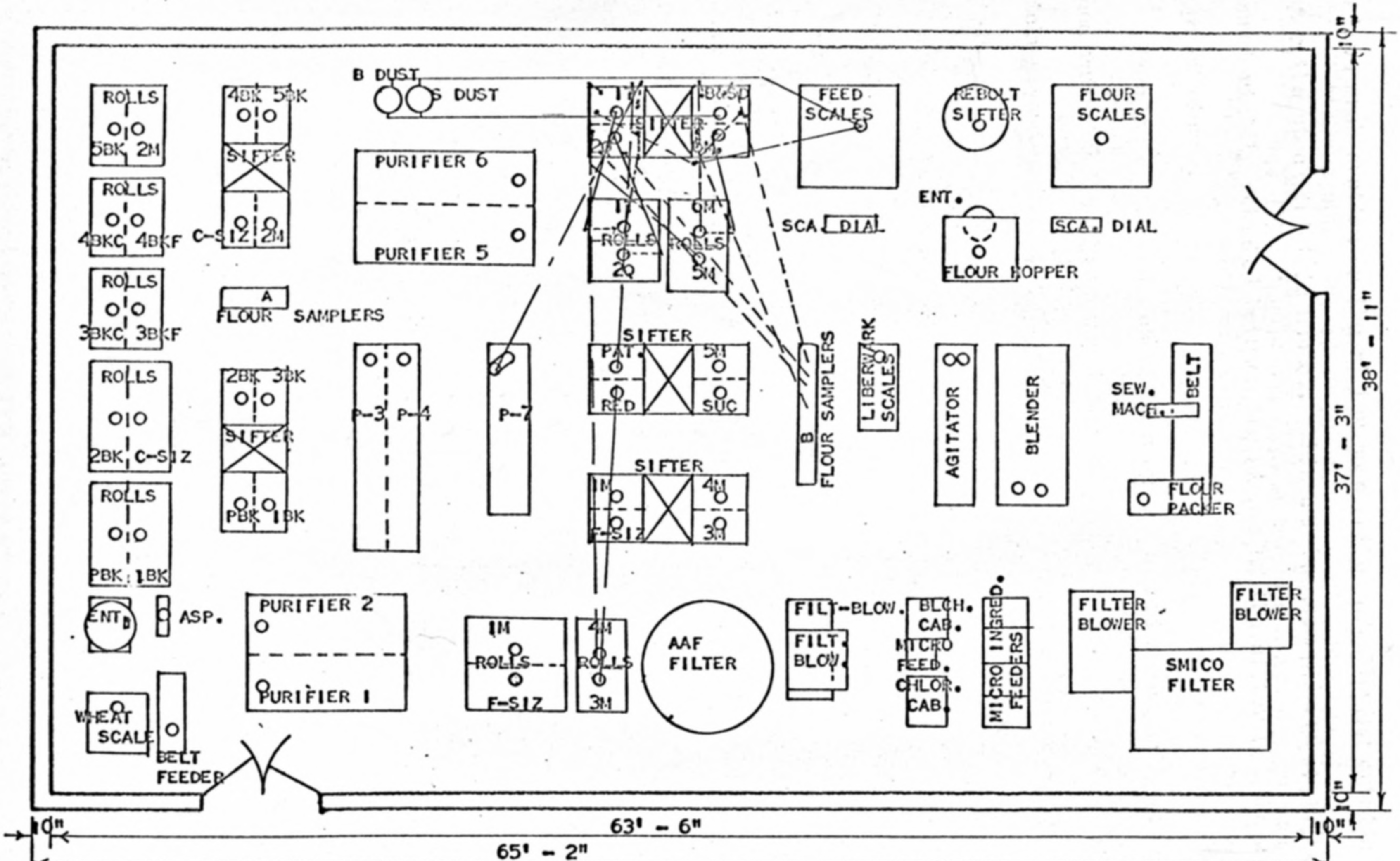
REDUST, 5TH MIDDS & SUCTION CONVEYING
SYSTEMS USING COMBINED LIFTS

KEY TO PNEUMATIC CONVEYING LINES

BETWEEN MACHINES (EXCEPT SIFTER SEPARATIONS) ————————

SIFTER SEPARATIONS

| | |
|---|---|
| BOTTOM FLOUR – – – – – – – – | BOTTOM SCALP ——— – ——— – |
| TOP FLOUR ··················· | 2ND FROM BOTTOM SCALP ——— – – ——— |
| THRUS OF GRADING OR DUSTING CLOTH —— —— | 3RD FROM BOTTOM SCALP ——— – – – ——— |
| | 4TH FROM BOTTOM SCALP ——— - - - - ——— |




SINGLE FLOOR LAYOUT FOR KANSAS STATE UNIV. FLOUR MILL

SCALE 1/8" = 1' - 0"

B DUST, S DUST, B&SD, 6 MIDDS, 1 TAIL & 2 QUAL CONVEYING SYSTEMS USING COMBINED LIFTS

KEY TO PNEUMATIC CONVEYING LINES

BETWEEN MACHINES (EXCEPT SIFTER SEPARATIONS) ————

SIFTER SEPARATIONS

BOTTOM FLOUR – – – – – – – –

TOP FLOUR ·················

THRUS OF GRADING OR DUSTING CLOTH —— ——

BOTTOM SCALP ——— – ———

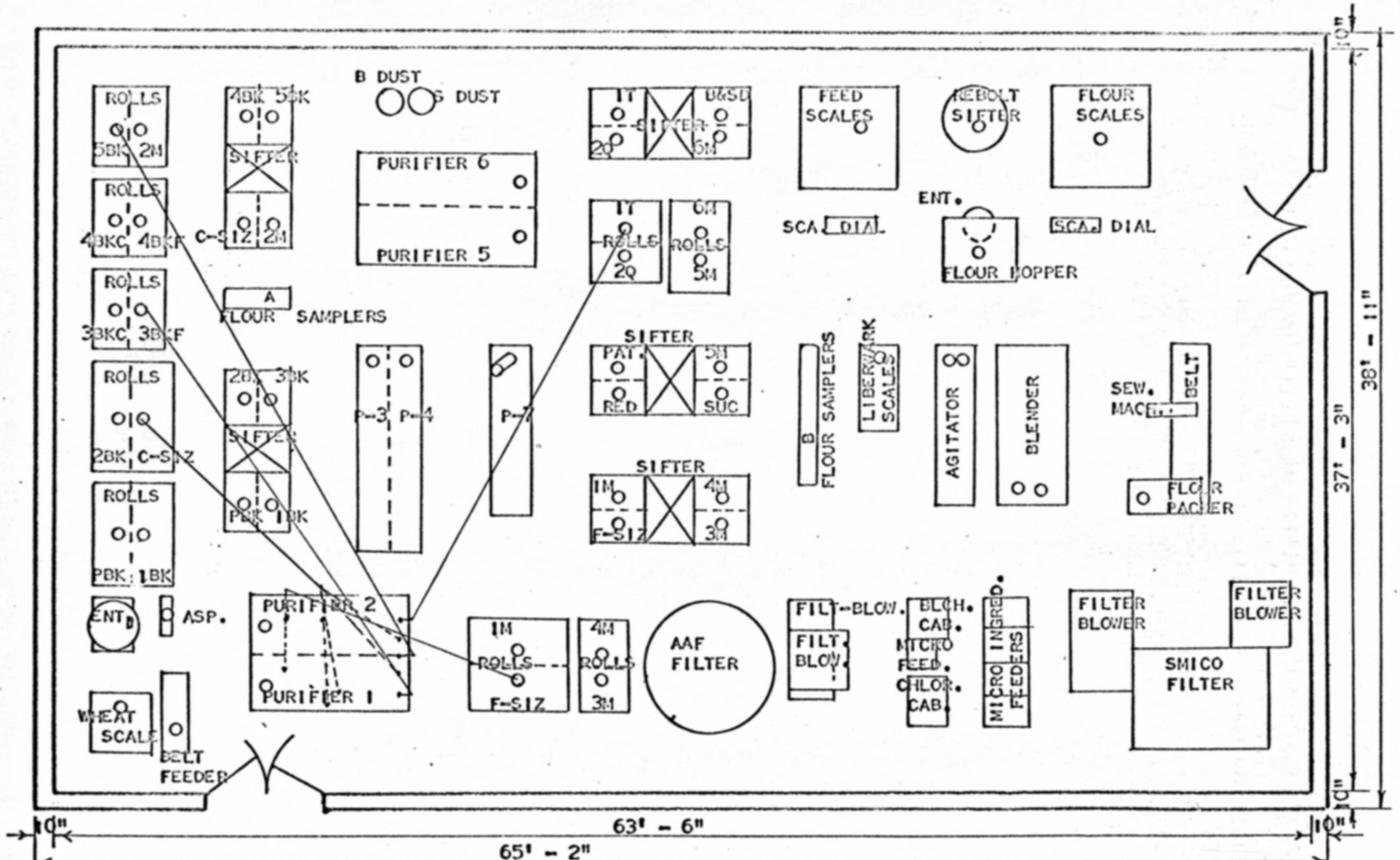
2ND FROM BOTTOM SCALP —— – – ——

3RD FROM BOTTOM SCALP —— – – – ——

4TH FROM BOTTOM SCALP —— – – – – ——

PLATE LIV

PLATE LV




SINGLE FLOOR LAYOUT FOR KANSAS STATE UNIV. FLOUR MILL

SCALE 1/8" = 1' - 0"

P-1 & P-2 CONVEYING SYSTEMS USING COMBINED LIFTS

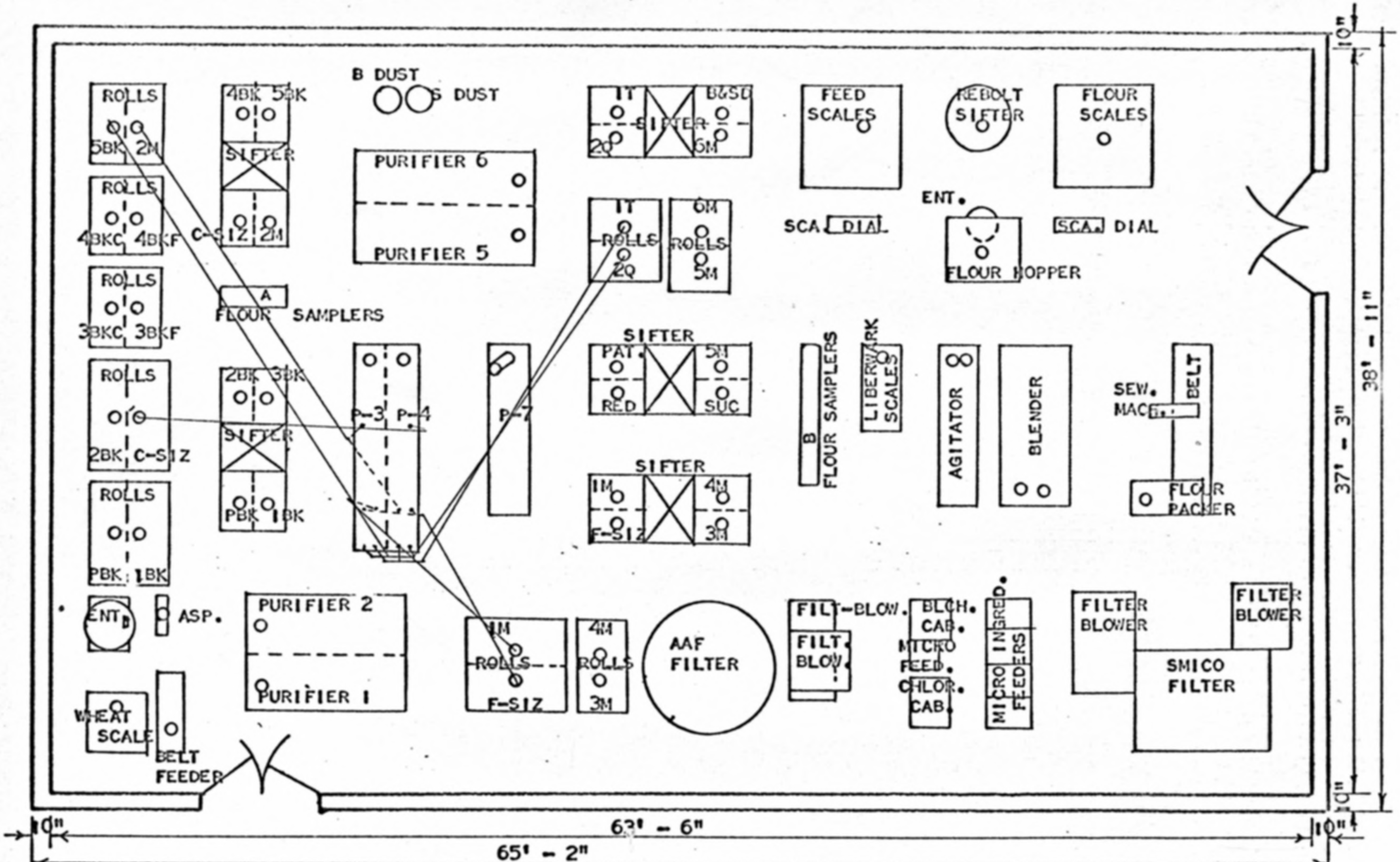
KEY TO PNEUMATIC CONVEYING LINES

BETWEEN MACHINES (EXCEPT SIFTER SEPARATIONS) ————————

SIFTER SEPARATIONS

| | |
|---|---|
| BOTTOM FLOUR - - - - - - - - | BOTTOM SCALP ——— - ——— - ——— |
| TOP FLOUR ················· | 2ND FROM BOTTOM SCALP ——— - - ——— |
| THRUS OF GRADING OR DUSTING CLOTH ——— ——— | 3RD FROM BOTTOM SCALP ——— - - - ——— |
| | 4TH FROM BOTTOM SCALP ——— - - - - ——— |

PLATE LVI




SINGLE FLOOR LAYOUT FOR KANSAS STATE UNIV. FLOUR MILL

SCALE 1/8" = 1' - 0"

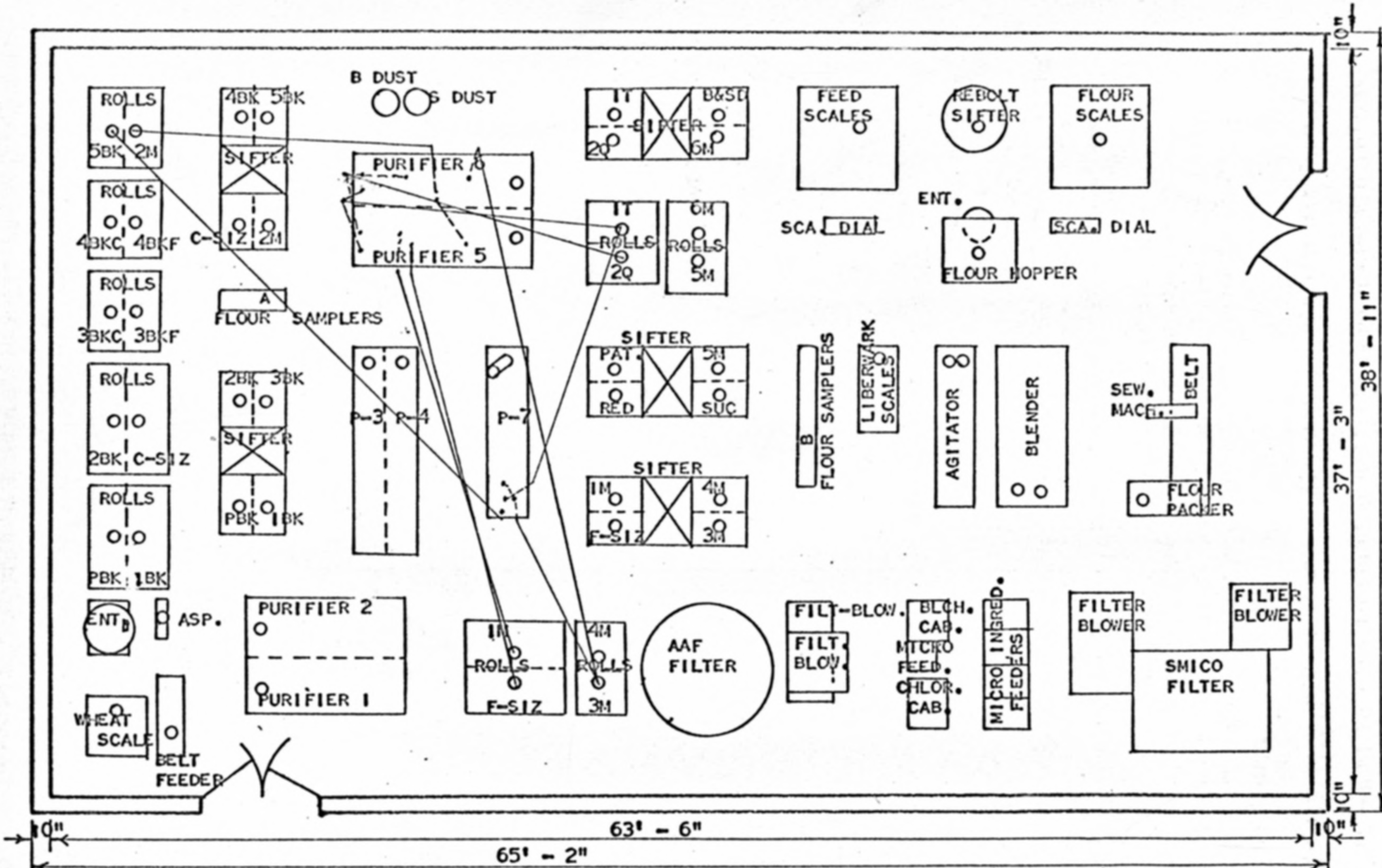
P-3 & P-4 CONVEYING SYSTENS USING COMBINED LIFTS

KEY TO PNEUMATIC CONVEYING LINES

BETWEEN MACHINES (EXCEPT SIFTER SEPARATIONS) ————

SIFTER SEPARATIONS

| | |
|---|---|
| BOTTOM FLOUR - - - - - - - - | BOTTOM SCALP —— - —— - —— |
| TOP FLOUR ..................... | 2ND FROM BOTTOM SCALP —— - - —— |
| THRUS OF GRADING OR DUSTING CLOTH —— —— | 3RD FROM BOTTOM SCALP —— - - - —— |
| | 4TH FROM BOTTOM SCALP —— - - - - —— |




SINGLE FLOOR LAYOUT FOR KANSAS STATE UNIV.
FLOUR MILL

SCALE 1/8" = 1' - 0"

P-5, P-6, & P-7 CONVEYING SYSTEMS USING COMBINED LIFTS

KEY TO PNEUMATIC CONVEYING LINES

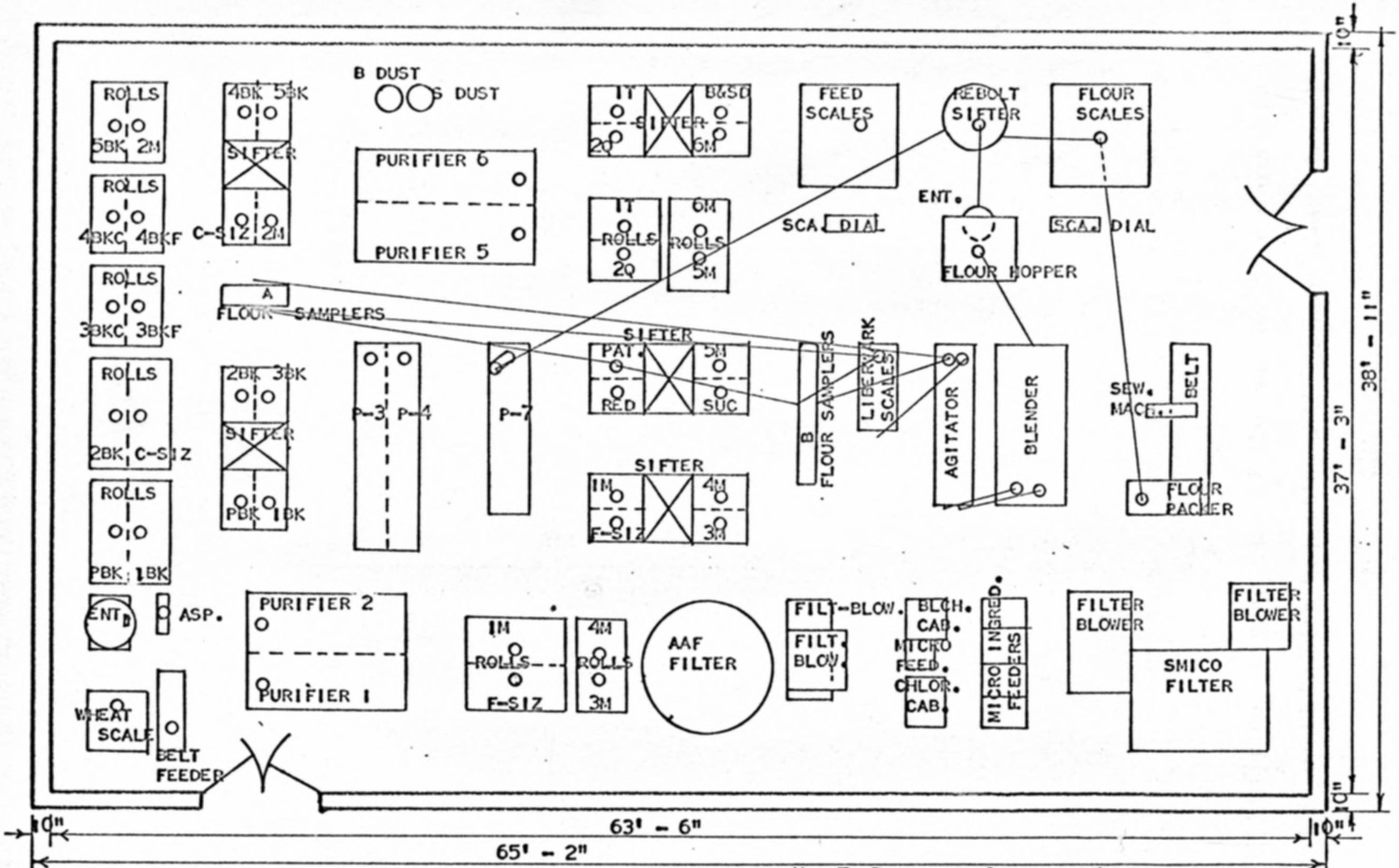
BETWEEN MACHINES (EXCEPT SIFTER SEPARATIONS) ————

SIFTER SEPARATIONS

| | |
|---|---|
| BOTTOM FLOUR – – – – – – – – | BOTTOM SCALP —— - —— - —— |
| TOP FLOUR ················· | 2ND FROM BOTTOM SCALP —— - - —— |
| THRUS OF GRADING OR DUSTING CLOTH —— —— | 3RD FROM BOTTOM SCALP —— - - - —— |
| | 4TH FROM BOTTOM SCALP —— - - - - —— |

PLATE LVII

PLATE LVIII




SINGLE FLOOR LAYOUT FOR KANSAS STATE UNIV. FLOUR MILL

SCALE 1/8" = 1' - 0"

FLOUR FINISHING SYSTEMS USING COMBINED LIFTS

KEY TO PNEUMATIC CONVEYING LINES

BETWEEN MACHINES (EXCEPT SIFTER SEPARATIONS) ————

SIFTER SEPARATIONS

BOTTOM FLOUR - - - - - - - -
TOP FLOUR ·················
THRUS OF GRADING OR DUSTING CLOTH —— ——
BOTTOM SCALP —— - —— - ——
2ND FROM BOTTOM SCALP —— - - ——
3RD FROM BOTTOM SCALP —— - - - ——
4TH FROM BOTTOM SCALP —— - - - - ——

Table 11. Gravity and pneumatic conveying requirements for

| Lift No. | Description: from | Description: to | Stock lb/min. | Pneumatic Conveying: Conveying Dist(ft) Vertical | Horizontal | Tube Dia. (inches) | No. Elbows |
|---|---|---|---|---|---|---|---|
| 1 | Wheat Scales | Belt Feeder | 18.16 | 11.0 | 3.0 | 2.0 | 2 |
| 2 | Belt Feeder | Entoleter | 18.16 | 11.0 | 3.3 | 2.0 | 2 |
| 3 | Entoleter | PBk R | 18.16 | 11.0 | 3.0 | 2.0 | 2 |
| 4 | PBk R | PBk S | 18.16 | 11.0 | 9.5 | 2.0 | 2 |
| 5 | PBk S | Asp. | 18.00 | 11.0 | 5.4 | 2.0 | 2 |
| 6 | Asp. | 1Bk R | 18.00 | 11.0 | 4.5 | 2.0 | 2 |
| 7 | PBk S | Fl. Sam. | .033 | 11.0 | 11.0 | .75 | 3 |
| 8 | 1Bk R | 1Bk S | 18.00 | 11.0 | 9.5 | 2.0 | 3 |
| 9 | 1Bk S | 2Bk R | 12.1 | 11.0 | 11.0 | 2.0 | 3 |
| 10 | 1Bk S | Fl. Sam. | .52 | 11.0 | 11.0 | 1.25 | 3 |
| 11 | 2Bk R | 2Bk S | 12.1 | 11.0 | 9.8 | 2.0 | 2 |
| 12 | 2Bk S | 3Bk C R | 5.07 | 11.0 | 8.5 | 1.25 | 2 |
| 13 | 2Bk S | 3Bk F R | 1.99 | 11.0 | 6.9 | 1.00 | 2 |
| 14 | 2Bk S | Fl. Sam. | .60 | 11.0 | 6.0 | .75 | 2 |
| 15 | 3Bk C&F R | 3Bk S | 7.06 | 11.0 | 918 | 1.25 | 2 |
| 16 | 3Bk S | 4Bk F R | 2.85 | 11.0 | 12.5 | 1.25 | 2 |
| 17 | 3Bk S | 4Bk F R | 1.54 | 11.0 | 13.8 | .75 | 2 |
| 18 | 3Bk S | Purifier-4 | 1.59 | 11.0 | 6.9 | .75 | 2 |
| 19 | 3Bk S | Fl. Sam. | .63 | 11.0 | 7.0 | .75 | 3 |
| 20 | PBk S<br>1Bk S<br>2Bk S | Purifier-1 | 6.16 | 11.0 | 12.0 | 1.25 | 2 |
| 21 | PBk S<br>1Bk S<br>2Bk S<br>3Bk S | Bk Red | 3.86 | 11.0 | 16.7 | 1.25 | 2 |
| 22 | 4Bk C&F R | 4Bk S | 4.39 | 11.0 | 5.0 | 1.25 | 2 |
| 23 | 4Bk S | 5Bk R | 3.81 | 11.0 | 5.0 | 1.25 | 2 |
| 24 | 4Bk S | Fl. Sam. | .24 | 11.0 | 9.8 | .75 | 2 |
| 25 | 5Bk R | 5Bk S | 3.81 | 11.0 | 10.3 | 1.25 | 2 |
| 26 | 5Bk S | B Dust | 2.90 | 11.0 | 5.0 | 1.25 | 2 |
| 27 | 5Bk S | S Dust | .60 | 11.0 | 7.0 | .75 | 2 |
| 28 | 5Bk S | Sm | .12 | 11.0 | 23.5 | .75 | 2 |
| 29 | 5Bk S | Fl. Sam. | .25 | 11.0 | 10.2 | .75 | 2 |
| 30 | 2M R | 2M S | 5.17 | 11.0 | 9.0 | 1.25 | 2 |
| 31 | 2M S | 3M R | 2.24 | 11.0 | 27.5 | 1.00 | 2 |
| 32 | 2M S | Fl. Sam. t | 2.11 | 11.0 | 4.8 | 1.00 | 2 |
| 33 | 2M S | Fl. Sam. b | .44 | 11.0 | 4.0 | .75 | 2 |
| 34 | C Siz R | C Siz S | 4.28 | 11.0 | 11.0 | 1.25 | 2 |
| 35 | C Siz S | Purifier-5 | 3.59 | 11.0 | 15.3 | 1.25 | 2 |
| 36 | C Siz S | Fl. Sam. t | .24 | 11.0 | 5.2 | .75 | 3 |
| 37 | C Siz S | Fl. Sam. b | .01 | 11.0 | 4.0 | .75 | 3 |
| 38 | C Siz S | 1M R | .12 | 11.0 | 27.0 | .75 | 2 |

K.S.U. mill on single-floor using separate lifts for combined stocks.

| No. Cyclones | Gravity Spouting (ft) | Conveying Values (lb/min. × ft.) Horizontal | Vertical | Air Volume (CFM) | Required Power (H. P.) |
|---|---|---|---|---|---|
| 1 | 1.0 | 54.0 | 198.0 | 75 | .50 |
| 1 | 0 | 54.0 | 198.0 | 75 | .50 |
| 1 | 2.0 | 54.0 | 198.0 | 75 | .50 |
| 1 | 0 | 153.0 | 198.0 | 75 | .60 |
| 1 | 0 | 97.2 | 198.0 | 75 | .50 |
| 1 | 3.0 | 81.0 | 198.0 | 75 | .50 |
| 1 | 2.0 | .4 | .4 | 9 | .059 |
| 1 | 0 | 104.5 | 198.0 | 75 | .70 |
| 1 | 3.0 | 133.1 | 133.1 | 75 | .50 |
| 1 | 2.0 | 5.7 | 5.7 | 9 | .059 |
| 1 | 0 | 118.6 | 133.1 | 75 | .50 |
| 1 | 2.3 | 43.1 | 55.8 | 27 | .17 |
| 1 | 2.3 | 13.7 | 21.9 | 27 | .17 |
| 1 | 2.0 | 3.6 | 6.6 | 27 | .17 |
| 1 | 0 | 69.2 | 77.7 | 27 | .18 |
| 1 | 2.3 | 35.6 | 31.4 | 27 | .17 |
| 1 | 2.3 | 21.3 | 16.9 | 9 | .072 |
| 1 | 2.3 | 11.0 | 17.5 | 9 | .062 |
| 1 | 2.0 | 4.4 | 6.9 | 9 | .052 |
| 1 | 3.0 | 73.9 | 67.8 | 27 | .20 |
| 1 | 0 | 64.5 | 42.5 | 27 | .18 |
| 1 | 0 | 37.3 | 48.3 | 27 | .17 |
| 1 | 2.3 | 19.1 | 41.9 | 9 | .17 |
| 1 | 2.0 | 2.4 | 2.6 | 9 | .056 |
| 1 | 0 | 39.2 | 41.9 | 27 | .17 |
| 1 | 3.2 | 14.5 | 31.9 | 27 | .17 |
| 1 | 3.2 | 4.2 | 6.6 | 9 | .056 |
| 1 | 3.0 | 2.8 | 1.3 | 9 | .076 |
| 1 | 2.0 | 2.6 | 2.8 | 9 | .058 |
| 1 | 0 | 46.5 | 56.8 | 27 | .18 |
| 1 | 3.0 | 62.3 | 24.6 | 17 | .180 |
| 1 | 2.0 | 10.1 | 23.2 | 17 | .060 |
| 1 | 2.0 | 1.8 | 4.8 | 9 | .052 |
| 1 | 0 | 49.6 | 47.1 | 27 | .17 |
| 1 | 4.5 | 54.9 | 39.5 | 27 | .18 |
| 1 | 2.0 | 1.2 | 2.6 | 9 | .052 |
| 1 | 2.0 | .04 | .1 | 9 | .052 |
| 1 | 2.6 | 3.2 | 1.3 | 9 | .080 |

Table 11. (continued)

| Lift No. | Description from | Description to | Stock lb/min. | Pneumatic Conveying: Conveying Dist. (ft) Vertical | Conveying Dist. (ft) Horizontal | Tube Dia. (inches) | No. Elbows |
|---|---|---|---|---|---|---|---|
| 39 | C Siz S<br>2M S | 1T R | .174 | 11.0 | 17.2 | .75 | 2 |
| 40 | 2M S<br>4Bk S | Purifier-7 | .76 | 11.0 | 13.5 | .75 | 2 |
| 41 | B Dust<br>S Dust | B&SD S | .36 | 11.0 | 16.0 | .75 | 2 |
| 42 | B&SD S | 6M R | .17 | 11.0 | 18.2 | .75 | 2 |
| 43 | B&SD S | Fl. Sam. | .35 | 11.0 | 12.3 | .75 | 2 |
| 44 | 2Q R | 2Q S | .97 | 11.0 | 8.0 | .75 | 2 |
| 45 | 2Q S | 1T R | .15 | 11.0 | 4.5 | .75 | 2 |
| 46 | 2Q S | Purifier-7 | .70 | 11.0 | 17.3 | .75 | 2 |
| 47 | 2Q S | 3M R | .10 | 11.0 | 22.4 | .75 | 2 |
| 48 | 2Q S | Fl. Sam. | .064 | 11.0 | 14.4 | .75 | 2 |
| 49 | 1T R | 1T S | 1.70 | 11.0 | 9.0 | 1.00 | 2 |
| 50 | 1T S | 5M R | .53 | 11.0 | 8.0 | .75 | 2 |
| 51 | 1T S | 4M R | .45 | 11.0 | 22.6 | .75 | 2 |
| 52 | 1T S | Fl. Sam. | .099 | 11.0 | 13.5 | .75 | 2 |
| 53 | 6M R | 6M S | .37 | 11.0 | 6.0 | .75 | 2 |
| 54 | 6M S | Fl. Sam. | .17 | 11.0 | 14.2 | .75 | 2 |
| 55 | B&SD S<br>6M S<br>1T S | Feed Scales | 1.10 | 11.0 | 8.5 | .75 | 2 |
| 56 | B Dust<br>S Dust | Feed Scales | 3.55 | 11.0 | 23.0 | 1.25 | 2 |
| 57 | Red S | Purifier-2 | 1.60 | 11.0 | 20.5 | 1.00 | 2 |
| 58 | Red S | Purifier-3 | 1.48 | 11.0 | 12.8 | 1.00 | 2 |
| 59 | Red S | 2M R | .62 | 11.0 | 28.3 | .75 | 2 |
| 60 | Red S | Fl. Sam. | .17 | 11.0 | 10.5 | .75 | 2 |
| 61 | Smico Filt | Suc S | .19 | 12.0 | 13.3 | .75 | 2 |
| 62 | AAF Filt | Suc S | .10 | 12.0 | 25.3 | .75 | 2 |
| 63 | Suc S | 5Bk | .05 | 11.0 | 33.0 | .75 | 2 |
| 64 | Suc S | 5M | .09 | 11.0 | 9.0 | .75 | 2 |
| 65 | Suc S | Fl. Sam. | .09 | 11.0 | 4.4 | .75 | 2 |
| 66 | 5M R | 5M S | 1.00 | 11.0 | 7.8 | .75 | 2 |
| 67 | 5M S | S Dust | .20 | 11.0 | 19.0 | .75 | 2 |
| 68 | 5M S | 6M R | .19 | 11.0 | 7.5 | .75 | 2 |
| 69 | 5M S | Fl. Sam. | .40 | 11.0 | 6.7 | 1.25 | 2 |
| 70 | F Siz R | F Siz S | 4.17 | 11.0 | 11.0 | 1.25 | 2 |
| 71 | F Siz S | 1M R | 1.10 | 11.0 | 7.9 | .75 | 2 |
| 72 | F Siz S | Fl. Sam. | .53 | 11.0 | 11.0 | .75 | 2 |
| 73 | F Siz S | Fl. Sam. | .06 | 11.0 | 10.0 | .75 | 2 |
| 74 | 1M R | 1M S | 5.27 | 11.0 | 10.5 | 1.25 | 2 |
| 75 | 1M S | 2M R | 2.28 | 11.0 | 30.4 | 1.00 | 3 |
| 76 | 1M S | Fl. Sam. | 1.68 | 11.0 | 9.3 | 1.00 | 2 |
| 77 | 1M S | Fl. Sam. | .73 | 11.0 | 11.5 | .75 | 2 |
| 78 | 3M R | 3M S | 2.86 | 11.0 | 10.8 | 1.00 | 3 |
| 79 | 3M S | 4M R | .93 | 11.0 | 12.7 | .75 | 2 |
| 80 | 3M S | Fl. Sam. | 1.84 | 11.0 | 6.3 | .75 | 2 |

| No. Cyclones | Gravity Spouting (ft) | Conveying Values (lb/min. × ft.) Horizontal | Vertical | Air Volume (CFM) | Required Power (H. P.) |
|---|---|---|---|---|---|
| 1 | 3.5 | 3.0 | 1.9 | 9 | .068 |
| 1 | 2.0 | 10.3 | 8.4 | 9 | .063 |
| 1 | 0 | 5.8 | 4.0 | 9 | .068 |
| 1 | 2.0 | 3.1 | 1.9 | 9 | .068 |
| 1 | 2.0 | 4.3 | 3.9 | 9 | .068 |
| 1 | 0 | 7.8 | 10.7 | 9 | .054 |
| 1 | 3.5 | .7 | 1.7 | 9 | .052 |
| 1 | 2.0 | 12.1 | 7.7 | 9 | .068 |
| 1 | 2.0 | 2.2 | 1.1 | 9 | .074 |
| 1 | 2.0 | .9 | .7 | 9 | .063 |
| 1 | 0 | 15.3 | 18.7 | 17 | .108 |
| 1 | 2.0 | 4.2 | 5.8 | 9 | .054 |
| 1 | 2.0 | 10.1 | 5.0 | 9 | .074 |
| 1 | 2.0 | 1.3 | 1.1 | 9 | .063 |
| 1 | 0 | 2.2 | 4.1 | 9 | .063 |
| 1 | 2.0 | 2.4 | 1.9 | 9 | .054 |
| 1 | 0 | 9.4 | 12.1 | 9 | .064 |
| 1 | 0 | 81.7 | 39.1 | 27 | .20 |
| 1 | 3.0 | 32.8 | 17.6 | 17 | .132 |
| 1 | 2.3 | 18.9 | 16.3 | 17 | .070 |
| 1 | 2.3 | 17.5 | 6.8 | 19 | .082 |
| 1 | 2.0 | 1.8 | 1.9 | 9 | .058 |
| 1 | 0 | 2.5 | 2.3 | 9 | .063 |
| 1 | 2.0 | 2.5 | 1.2 | 9 | .078 |
| 1 | 2.3 | 1.6 | 1.6 | 9 | .084 |
| 1 | 2.0 | .8 | 1.0 | 9 | .056 |
| 1 | 2.0 | .4 | 1.0 | 9 | .052 |
| 1 | 0 | 7.8 | 11.0 | 9 | .056 |
| 1 | 3.2 | 3.8 | 2.2 | 9 | .070 |
| 1 | 2.0 | 1.4 | 2.1 | 9 | .055 |
| 1 | 2.0 | 2.7 | 4.4 | 9 | .054 |
| 1 | 0 | 45.9 | 45.9 | 27 | .17 |
| 1 | 2.6 | 8.7 | 12.1 | 9 | .064 |
| 1 | 2.0 | 5.8 | 15.8 | 9 | .058 |
| 1 | 2.0 | .7 | .7 | 9 | .057 |
| 1 | 0 | 55.3 | 58.0 | 27 | .17 |
| 1 | 2.3 | 69.3 | 25.1 | 17 | .181 |
| 1 | 2.0 | 15.6 | 18.5 | 17 | .108 |
| 1 | 2.0 | 8.4 | 8.0 | 9 | .059 |
| 1 | 0 | 30.9 | 31.5 | 17 | .126 |
| 1 | 2.0 | 11.8 | 10.2 | 9 | .061 |
| 1 | 2.0 | 11.6 | 20.2 | 9 | .062 |

Table 11. (continued)

| Lift No. | Description from | Description to | Stock lb/min. | Pneumatic Conveying: Conveying Dist. (ft) Vertical | Horizontal | Tube Dia. (inches) | No. Elbows |
|---|---|---|---|---|---|---|---|
| 81 | 4M R | 4M S | 2.06 | 11.0 | 10.6 | 1.00 | 3 |
| 82 | 4M S | 5Bk R | 0 | 11.0 | 35.5 | 1.25 | 2 |
| 83 | 4M S | 5M R | .69 | 11.0 | 15.3 | .75 | 2 |
| 84 | 4M S | Fl. Sam. | 1.15 | 11.0 | 5.2 | .75 | 2 |
| 85 | F Siz S, 1M S, 3M S | 1T R | .28 | 11.0 | 15.0 | .75 | 2 |
| 86 | F Siz S, 1M S | Purifier-6 | 2.58 | 11.0 | 15.0 | 1.00 | 2 |
| 87 | Purifier-1, Purifier-2 | F Siz R | 1.92 | 11.0 | 10.6 | 1.00 | 2 |
| 88 | Purifier-1, Purifier-2 | C Siz R | 4.28 | 11.0 | 18.0 | 1.25 | 2 |
| 89 | Purifier-1 | 3Bk F R | .55 | 11.0 | 23.5 | .75 | 2 |
| 90 | Purifier-2 | 1M R | .93 | 11.0 | 13.3 | .75 | 2 |
| 91 | Purifier-2 | 1T R | tr | 11.0 | 22.6 | .75 | 2 |
| 92 | Purifier-1, Purifier-2 | 5Bk R (Asp.) | tr | 11.0 | 30.3 | .75 | 2 |
| 93 | Purifier-3, Purifier-4 | 2M R | .19 | 11.0 | 19.5 | .75 | 2 |
| 94 | Purifier-3, Purifier-4 | F Siz R | 1.20 | 11.0 | 9.0 | .75 | 2 |
| 95 | Purifier-3, Purifier-4 | 1T R | .22 | 11.0 | 20.3 | .75 | 2 |
| 96 | Purifier-3, Purifier-4 | 2Q R | .23 | 11.0 | 18.5 | .75 | 2 |
| 97 | Purifier-3 | 1M R | 1.19 | 11.0 | 12.9 | .75 | 2 |
| 98 | Purifier-4 | C Siz R | 0 | 11.0 | 15.0 | .75 | 2 |
| 99 | Purifier-3, Purifier-4 | 5Bk R (Asp.) | tr | 11.0 | 25.2 | .75 | 2 |
| 100 | Purifier-5, Purifier-6 | 2M R | 2.05 | 11.0 | 14.0 | 1.00 | 2 |
| 101 | Purifier-5, Purifier-6 | 1T R | .15 | 11.0 | 14.0 | .75 | 2 |
| 102 | Purifier-5, Purifier-6 | 2Q R | .71 | 11.0 | 14.0 | .75 | 2 |
| 103 | Purifier-5 | 1M R | 1.93 | 11.0 | 21.5 | 1.00 | 2 |
| 104 | Purifier-5 | F Siz R | 1.05 | 11.0 | 22.0 | .75 | 2 |
| 105 | Purifier-6 | 3M R | 0 | 11.0 | 27.7 | .75 | 2 |
| 106 | Purifier-7 | 3M R | 1.29 | 11.0 | 9.5 | .75 | 2 |
| 107 | Purifier-7 | 1T R | .61 | 11.0 | 15.7 | .75 | 2 |
| 108 | Purifier-7 | 5Bk R | .05 | 11.0 | 28.5 | .75 | 2 |

| No. Cyclones | Gravity Spouting (ft) | Conveying Values (lb/min. × ft.) Horizontal | Vertical | Air Volume (CFM) | Required Power (H. P.) |
|---|---|---|---|---|---|
| 1 | 0 | 21.8 | 22.7 | 17 | .123 |
| 1 | 2.3 | 0 | 0 | 0 | 0 |
| 1 | 2.0 | 10.6 | 7.6 | 9 | .064 |
| 1 | 2.0 | 6.0 | 12.7 | 9 | .060 |
| 1 | 3.5 | 4.3 | 3.1 | 9 | .064 |
| 1 | 4.5 | 38.7 | 28.4 | 17 | .138 |
| 1 | 2.6 | 20.4 | 21.1 | 17 | .111 |
| 1 | 2.6 | 77.0 | 47.1 | 27 | .17 |
| 1 | 2.3 | 12.9 | 6.1 | 9 | .076 |
| 1 | 2.6 | 12.4 | 10.2 | 9 | .061 |
| 1 | 3.5 | 0 | 0 | 9 | .072 |
| 1 | 0 | 0 | 0 | 9 | .082 |
| 1 | 2.3 | 3.7 | 2.1 | 9 | .070 |
| 1 | 2.6 | 10.8 | 13.2 | 9 | .064 |
| 1 | 3.5 | 4.5 | 2.4 | 9 | .070 |
| 1 | 3.5 | 4.3 | 2.5 | 9 | .070 |
| 1 | 2.6 | 15.4 | 13.1 | 9 | .066 |
| 1 | 2.6 | 0 | 0 | 9 | .064 |
| 1 | 0 | 0 | 0 | 9 | .082 |
| 1 | 2.6 | 28.7 | 22.6 | 17 | .135 |
| 1 | 2.6 | 2.1 | 1.6 | 9 | .063 |
| 1 | 2.6 | 9.9 | 7.8 | 9 | .063 |
| 1 | 2.6 | 41.5 | 21.2 | 17 | .136 |
| 1 | 2.6 | 23.2 | 11.6 | 9 | .074 |
| 1 | 2.3 | 0 | 0 | 9 | .082 |
| 1 | 2.0 | 12.3 | 14.2 | 9 | .064 |
| 1 | 3.5 | 9.6 | 6.7 | 9 | .066 |
| 1 | 2.3 | 1.4 | .6 | 9 | .082 |

Table 11. (concluded)

| Lift No. | Description from | Description to | Stock lb/min. | Pneumatic Conveying: Conveying Dist. (ft) Vertical | Conveying Dist. (ft) Horizontal | Tube Dia. (inches) | No. Elbows |
|---|---|---|---|---|---|---|---|
| | Patent Flour System | | | | | | |
| 109 | Fl. Sam. a | Pat. Agit. | 5.07 | 11.0 | 36.1 | 1.25 | 2 |
| 110 | Fl. Sam. b | Pat. Agit. | 7.33 | 11.0 | 7.7 | 1.25 | 2 |
| 111 | Agit | Blender | 12.41 | 11.0 | 4.5 | 1.50 | 2 |
| | Fine Patent System | | | | | | |
| 112 | Fl. Sam. -a | Pat. Reb. S | 0 | 11.0 | 19.2 | 1.25 | 2 |
| 113 | Fl. Sam.-b | Pat. Reb. S | 0 | 11.0 | 9.6 | 1.25 | 2 |
| | Clear Floor System | | | | | | |
| 114 | Fl. Sam.-a | Liberwark Scales | 0 | 11.0 | 32.4 | 1.25 | 2 |
| 115 | Fl. Sam.-b | Liberwark Scales | 0 | 11.0 | 5.4 | 1.25 | 2 |
| 116 | Liberwark Scales | Agitator | 0 | 11.0 | 6.5 | 1.25 | 2 |
| 117 | Agitator | Blender | 0 | 11.0 | 4.0 | 1.25 | 2 |
| 118 | Blender | Hopper | 12.41 | 13.0 | 5.5 | 1.50 | 2 |
| 119 | Entoleter | Rebolt S | 12.41 | 11.0 | 4.0 | 1.50 | 2 |
| 120 | Rebolt S | Fl. Scales | 12.35 | 15.0 | 4.8 | 1.50 | 2 |
| 121 | Rebolt S | Purifier-7 | .06 | 11.0 | 26.0 | .75 | 2 |
| 122 | Fl. Scales | Packer | 12.35 | 11.0 | 16.0 | 1.50 | 2 |
| Totals | | | 356.16 | 1350.0 | 1676.4 | - | 254 |

| No. Cyclones | Gravity Spouting (ft) | Conveying Values (lb/min. × ft.) Horizontal | Vertical | Air Volume (CFM) | Required Power (H. P.) |
|---|---|---|---|---|---|
| 1 | 5.0 | 183.0 | 55.8 | 27 | .24 |
| 1 | 5.0 | 56.4 | 80.6 | 27 | .22 |
| 1 | 3.0 | 49.6 | 136.5 | 40 | .34 |
| 1 | 0 | 0 | 0 | 0 | 0 |
| 1 | 0 | 0 | 0 | 0 | 0 |
| 1 | 3.3 | 0 | 0 | 0 | 0 |
| 1 | 3.3 | 0 | 0 | 0 | 0 |
| 1 | 5.0 | 0 | 0 | 0 | 0 |
| 1 | 5.0 | 0 | 0 | 0 | 0 |
| 1 | 0 | 68.3 | 161.3 | 40 | .37 |
| 1 | 0 | 49.4 | 135.8 | 40 | .37 |
| 1 | 0 | 59.3 | 185.3 | 40 | .37 |
| 1 | 2.0 | .7 | 1.3 | 9 | .078 |
| 1 | 1.0 | 197.6 | 135.8 | 40 | .39 |
| 122 | 233.0 | 3118.6 | 3985.7 | 2257 | 16.270 |

# CONCEPTS OF A SINGLE-FLOOR FLOUR MILL

by

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B. S. Kansas State University, 1963

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AN ABSTRACT OF A THESIS

submitted in partial fulfillment of the

requirements for the degree

MASTER OF SCIENCE

Department of Flour and Feed Milling Industries

KANSAS STATE UNIVERSITY

Manhattan, Kansas

1964

The number of flour mills in the United States is decreasing for several reasons, but the capacity of mills to produce flour is remaining quite constant. Location is an important factor, initially based on availability of grain, sales territory, and cost of power, transportation and labor. Old mills, with original buildings and equipment, find difficulty in meeting sanitation requirements of the Food and Drug Administration.

New transportation rates on wheat grain proposed in 1961 by the Southern Railway, now in effect subject to final approval, make it cheaper to ship wheat than flour from Kansas to the southeast. Low income areas, such as the Southeast, consume more flour per capita than others, thus providing excellent markets. Kansas mills are "out of position" for competition with the few existing Southeastern mills. Many Kansas mills must ultimately (a) cease operations, (b) obtain lower flour transportation rates, (c) move to the Southeast, or (d) find new markets.

Moving a mill requires new construction of the most economical and efficient type. This thesis proposes a single-floor flour mill, in a prefabricated building constructed on a slab of concrete floor.

Flour milling equipment has changed greatly in appearance but still performs the same basic functions. Lineshaft drives are being replaced by individual motors for many machines. Pneumatic conveying aids sanitation and eliminates the need for special floors to accommodate bucket elevators. Finally, hydraulic or individual motor drives for the rolls and a direct lift system make it possible to establish the entire mill on one floor.

To develop the single-floor design, several arrangements of equipment were made. Pneumatic pickup from the roller mill and purifier presents no difficulty. The sifter pickup is the major problem. It was found that there is little difference in power requirement (using clean air) between a rigid pneumatic pickup and a gyrating pickup attached to the sifter, transmitting air through a flexible hose above the sifter. When loaded to the choking point, however, the stationary pickup conveyed 60 to 80 percent more stock than the gyrating pickup. Different introduction of the stock could possibly improve the gyrating pickup.

Multi-floor and single-floor layouts were compared using the milling machinery now in the Kansas State University pilot mill. The single-floor layout required 48 percent less floor area. Overall requirements for spouting and conveying, using a separate lift for each stock in comparison with single lifts for combined common stocks, were compared with those of the Kansas State University mill showing that many more lifts are required for a single-floor layout but that the average length of the runs are shorter. Horsepower requirements are a little greater in the single-floor mill, partly because the small size of the mill studied precluded loading of the lifts to efficient capacities. Improvements are suggested.

Initial cost of a single-floor mill should be comparable to those of a conventional mill; increased pneumatic equipment costs in the former would be balanced by lower building and installation costs. Power costs for pneumatic conveying would be somewhat higher in the single-floor mill, but labor costs could be lower, as all operations could be observed and controlled from a central location. Further studies are needed to reduce power requirements in the single-floor mill.