MOTION AND TIME TECHNIQUE IN THE MANUFACTURE OF MILK POWDER WITH A SPRAY DRYER

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This is to certify that the

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MOTION AND TIME TECHNIQUE
IN THE
MANUFACTURE OF MILK POWDER
WITH A SPRAY DRYER

By

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A THESIS

Submitted to the College of Agriculture of the Michigan State University
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IMPORTANCE

Dried milk, similar to condensed milk, is a form of concentrated milk. Each form of fluid milk product and fluid milk by-product lends itself to conversion to the powder form. Thus, to-day we have dried whole milk, dried cream, dried skim milk, dried buttermilk, dried whey, dried ice cream mix, dried malted milk and dried sweetened condensed milk.

In most dairy countries volume production of milk powder began with the drying, not of whole milk but of skim milk. This has been true especially of countries that convert a large portion of their milk production to butter and sweet market cream, thus being confronted with the problem of finding a profitable market for large volumes of surplus skim milk. The reason for volume production of dried skim milk is obviously an economic one. But there appears to be only one answer to the problem of profitable exploitation of the creamery skim milk and that is to market it in suitable form for human consumption or animal consumption.

With the advent of dried skim milk supplied not only as such to the kitchen of the consumer, but especially to the prepared food factories, (such as for the manufacture of ice cream mix, candy, confections, milk chocolate, for bread making, as a constituent of sausage, in prepared soups, etc.), hundreds of millions of pounds of surplus fluid skim milk are annually diverted from channels of complete waste and financial loss and turned into channels for human nutrition, profitable returns, and promotion of public health. Thus, the obvious features of the economy of dried skim powder appear as follows:-

(i) Reduction to minimum bulk to facilitate economical transportation to all parts of the world.

(ii) Dependable keeping quality of the finished product.

(iii) Optimum conservation of the natural properties that are characteristics of fresh milk, during storage.

(iv) No refrigeration necessary for storage and long transport.

(v) Use in manufacture of several prepared food stuffs like ice cream, candy, confections, milk chocolate, etc.

(vi) The economic utilization of surplus adding flexibility to the operation of the plant and resulting in a higher profit at the same time.

(vii) Better source of serving the community with reconstituted milk from period of plenty to the period of lean supply as well as from the areas of plenty to the areas of scarcity.

In sharp contrast to the phenomenal production of dried skim milk, the annual output of dried whole milk has been limited, and prior to World War II it appeared relatively static. Foremost among the volume retarding factors has been the problem of the dependable keeping quality. Dried whole milk is subject to oxidation of the milk fat, accompanied by quality - destroying undesirable flavor. Dried skim milk is practically free from this danger. Extensive experimental research was necessary, therefore, to establish means of preventing costly age spoilage of dried whole milk, sufficiently dependable to justify upon embarkation upon a large scale production of this important food product. Due to the food urgency of World War II, these efforts in the interest of quality improvement were redoubled. This has resulted in improved methods of manufacture and packaging, methods that are proving effective in delaying or preventing damaging fat oxidation. These accomplishments have definitely diminished the risk of storage and increased the volume of the manufacture of dried whole milk. Thus, from a production of 30 million pounds in the year 1940 it increased to 217 million pounds in 1945.

In the presence of the marked development that has been made within recent years, in volume of production, and in the perfection of flavor, keeping quality and solubility of dried whole milk, and of the properties of its reconstituted products, it is interesting to note the early verdict of the eminent German dairy Scientist, Dr. W. Fleischmann (Hunziker, 1949) of the University of Gottingen, on the future possibilities of whole milk powder. This investigator commented upon the poor keeping quality , quality, unpalatibility, insolubility, and denatured condition of the protein of dried whole milk made in the latter half of the nineteenth century by the firm Dalsom, Blatchford and Harris, in their factory near New York City. As a result of this failure, Fleischmann reached the following conclusions: (Translated from the German by Mr. Hunziker).

"As a result of this failure, the question whether it is possible to produce a marketable product worthy of the name milk by dehydrating milk and reconstituting the dried mass, is thus answered conclusively and finally for all time".

World War II and the early postwar years saw a rapid shift to the selling of whole milk by farmers rather than selling of farm separated cream. This shift was greatly accelerated by the relatively favorable prices paid for non-fat dry milk solids in that period. To process the resulting increase in the supply of milk, a number of new centralized drying plants were built and production facilities at the existing plants were expanded. Many marketing problems have accompanied this rapid growth in the dry milk industry. They have intensified since the close of the Korean War. The supply of non-fat dry milk solids has greatly exceeded the demand in recent years, and much of the output has been purchased by the government under the price support program. Under this surplus situation the difference between cost and prices received for dried milk have narrowed.

In view of these conditions operators of milk drying plants have shown an increased interest in possibilities of decreasing costs in processing. Increased efficiency and lower costs should enable the plants to return to the farmer a higher percentage of the price which consumers pay for dry milk products.

In the United States the production of only non-fat dry milk solids has been increasing rapidly since 1951. Production in 1955 set a new record high of 1.48 billion pounds.

Table 1 shows the large increases in production of non-fat dry milk from 1947 to 1955 (U.S.D.A., 1957).

TABLE 1. - Production of dry milk products in United States, 1000 pounds 1947-1955.

Year	Type of Dryer		Total	Whole milk	Dry butter milk
	Spray	Roller			
1947	418,704	259,237	677,941	164,888	45,437
1948	436,071	245,461	681,532	170,087	418,39
1949	627,942	306,992	934,934	125,541	49,359
1950	623,967	257,111	881,078	124,986	48,668
1951	546,387	156,089	702,476	131,017	45,467
1952	665,076	198,144	863,220	101,732	47,067
1953	971,578	242,196	1,213,774	104,352	57,424
1954	1,158,537	243,837	1,402,374	93,874	56,348
1955	1,282,000	202,600	1,484,600	103,220	58,350

In 1953, the three leading States, Wisconsin, Minnesota and New York produced respectively 28, 21 and 11 per cent for a combined total of 60 percent of the total United States production of non-fat dry milk solids.

The rate of utilization of skim milk for human food has increased from 51 percent in 1924 to 74 percent in 1952 and there has been a continuing trend away from farm separated cream.

Dried milk in India. - In India the productivity of dairy cattle increases and decreases according to change of climatic conditions and growth of pasture land after rainy season resulting concentration of cattle at different places. Most of the dairy cattle feed on the natural growth and abundance of grass land and agricultural by-products. Because of this concentration, the milk production in such areas increases greatly and sells at a lower rate in absence of sufficient transport facilities to the areas of greater demand. In addition, with the recent agricultural development and cattle improvement program launched in the Five Year Plans, the productivity of milk is likely to increase. The above described surplus areas will have the increasing problem of handling the surplus milk thus produced to points of utilization. Since the distribution of milk from surplus rural areas to urban areas still remains a problem due to insufficient facilities of transport, it appears that the immediate solution for useful utilization of milk at the surplus pockets throughout the country is to convert it to products like butter, ghee and skim powder. These three products can not only be transported easily but will immediately add to the economy of farmers and create a scope for development of dairy cattle and dairy industries in the country. The skim milk powder will be easily reconstituted with whole milk usually having 6 to t0 percent butterfat. This reconstituted milk if standardized to 3 percent butterfat will not only result in increased quantity but will be much less expensive compared to whole milk of high percentage of butterfat, readily enabling more extensive use of milk.

It is understood that this idea of making useful and economical utilization of milk from various surplus pockets in India for benefit of maximum population, has been receiving the active consideration of the government and that a number of creameries and milk drying plants will soon be set up. At present a huge quantity of milk powder is being imported in India and the requirement is increasing day by day.

OBJECTIVES

1. To determine time standards for the required elements of drying plant operations.
2. To recommend conditions pertinent to efficient operation.
3. To recommend improvements in the layout of the working place and material handling for efficient operation, in reference to plants investigated in study.
4. To suggest means of increasing the effectiveness of effort through application of principles of motion economy.

REVIEW OF LITERATURE

Motion and time techniques. - The science of motion and time study has been widely practised throughout the world for the last 70 years. In about 1881 when Taylor pioneered this science, it was not realized that his words of wisdom would in later years meet with such universal acceptance by all of the major industries of the world. Except for the initiative and ambition of those who would make any nation the greatest and most productive industrial nation, motion and time study might never have been recognized as one of the finest tools of management. The largest and strongest labor unions in mass production industries have also recognized the value of motion and time studies as through the years they have gradually developed an acceptance of this art as an accurate technique for establishing standard of performance for man and machine. Industries have used motion and time studies extensively in analysis of their processing and assembly operations. It must be acknowledged that use of this valuable tool has contributed to ever-increasing efficiency, which in turn has produced better merchandise at lower cost, and at the same time has provided a more equitable means of pay.

The dairy industry has been somewhat tardy in applying this valuable tool of management. Only in recent years have several dairy companies throughout this country seen the opportunities afforded by use of motion and time study techniques in analysis of processing, clean up and delivery operations. The results of these studies have reflected improvements in already existing plants and have aided immeasurably in design and layout of new plants, in determining product cost, and in improving methods.

The questions in the minds of the typical dairy plant operator when contemplating the need for time studies in his plant are many. What will the time studies accomplish? Will such a study help in determination of accurate costs? Will information resulting from a time study help in control of labor cost, and if so how? Is time study only for the plant processing half a million pounds a day, or can it be used by small plants? What is the reaction of the plant worker with respect to time studies? Will I be able to do better job of running my business than I am now doing? The answers to such questions are not categorical but are dependent upon many factors of personnel and complexity of plant operation.

One unfortunate prejudice among industrial workers is that time and motion study is a means applied to exploit the labor. Time and motion properly used is not a means of exploiting the worker. It is a means for exploiting his capacity to work and in the benefits of which he is one of the largest sharers.

No matter how uncertain the management of a plant may be, one thing is certain, namely, that it can still increase its profit and production by reorganizing the work according to the principles of time and motion study.

It is a well known fact that the output of work to be expected from any two of the men working in the plant may be as varied as the quantity of milk given by the highest and the lowest production cows in a herd of dairy farm. Why whould one man do more work in a given hour than another? Is it that higher producing worker is stronger? Quicker? Defter? Better trained? Has better tools? Likes his job? Likes his boss? Or a combination of all these things and many more? Whatever may be the reason, management needs now more than ever to look closely at the work and the workman. Work is a vague term; hard work is more vague. It is only comparatively recent that scientists have been trying to measure 'work' in a plant and even so a 'work unit' differs from one part of the country to another, from one country to another. A pound of work in U.S.A. may not be the same as a pound of work in India because the working conditions in the two countries are different. Nevertheless, it is easy enough to compare the work done by two men in the same plant by measurement of work performed by each man even with altered equipment and their layout plans.

Among the various forms of cost are reduction in activities in a processing plant, work simplification, linear programming, operations research, budgetary control and time study. The determination of time standard by a method of time and motion study, for each operation in the plant at its maximum efficiency, has been felt to be of paramount importance in improving plant operations.

Time study can be a precise, expert measuring technique for labor analysis, but the term "time study" can easily lead to a confusion of terms. Stopwatch study, motion picture analysis, micro motion analysis, simultaneous motion study, synthetic standard development and standard data are all related to the study of time.

The use of time and motion study in milk plant operation is so new that very little reference to it can be found in the literature. No reference was found specifically on motion and time study in spray drying of milk.

Therefore most of the references cited have been taken from other industries that have more or less similar operations. The milk industry has always tried to practice some work simplification, although it was never given exactly this methods engineering nomenclature. Some literature on milk drying is available but dealing primarily with the costs involved.

Time and motion study applications in allied industries.- Application of time and motion analysis to non-repetitive operations was demonstrated by Sadoff (1944). He made time and motion studies of all the clean-up and maintenance operations at the large Swift and Company meat packing plant in Chicago. Six senior time study men devoted three years to this study. They were able to simplify the operations and establish standard times for each operation.

Gobb (1937) also established standard times for truckers and sweepers and put these men on an incentive pay plan which reduced the man power required from 19 to 11 men.

Emmons (1937) applied time and motion analysis to the janitors in a factory building, and was able to establish a schedule of operations that resulted in large savings.

In his work with time and motion applications to job order shops, Tidball (1936) proved that it was possible to have time standards for special order shops.

The continuous flow processes of the chemical industries have much in common with milk plant operation. Von Pechmann (1943) and Rossmoore and Aries (1947) applied time and motion analysis to these industries with great succes. They reported savings in time up to 34 percent on some operations.

In the liquor distilleries, a large amount of time is spent in bottling and clean-up operations much like milk plant operations. Vlissinger (1941) applied time and motion studies to these operations and reports savings as high as 33 percent.

All operations in the food industry have much in common. The use of time and motion studies in food plants other than dairy plants has become quite common in recent years. Engel (1940) reports some very interesting savings made in an English walnut food factory. Nadler (1950) applied time and motion study to canning plant operations with a great deal of succes. He lists some of the results of these studies as:

1. Improved schedules.

2. Predetermination of job requirements.

3. Checks on worker efficiency.

4. Determination of best methods.

Mundel (1944) has devoted a large amount of time to application of time and motion study to farm operations such as doing farm chores. These operations in the past have taken a large amount of the farmers time. In some cases Mundel was able to reduce the time required by 50 percent.

Another interesting time and motion application by Mundel was on the hand peeling of tomatoes in a canning factory. By the use of micromotion camera studies, he was able to effect large savings in this operation.

That time and motion study has many uses other than rate setting was brought out by Stearns (1945) when he explained to the plant managers the use of time and motion study by controlling schedules, man power requirements, and methods of operation.

Teranes (1937) made a study of the walking required in a factory packing department. By the use of time and motion analysis he was able to reduce the walking required per man in an 8 hour day from 12,000 feet to 1800 feet, with a resulting saving in labor of over 30 percent.

Specific time and motion applications in the dairy industry. - Probably the most extensive use of time and motion study in the dairy industry has been made by H.P. Hood and Sons Company. This dairy firm has established a full time methods engineering and work simplification department. This department has been in operation for more than 8 years, and during this time they have been able by the use of time and motion analysis to reduce their operation time considerably.

Dunlop (1949 a) explained his method of training personnel in work simplification by the use of company schools.

Pelling (1940) reported the use of time and motion analysis applied to wrapping cheese in an Australian cheese factory. He saved 2500 dollars yearly by an improved method.

Morrow (1947) applied time and motion study to the retail delivery of milk with good results.

The use of time and motion study in a British milk bottling plant was discussed by Proctor (1949) in a paper presented at the 1949 World's Dairy Congress.

SPRAY DRYING INSTALLATIONS

Over the last several years operating problems in dairy plants have changed considerably. Modern, high speed, automatic equipment is available now as never before. There has been a significant change in the last ten years in the type of equipment and processing of products.

The capacity of the various pieces of equipment used in the plants is selected to allow the equipment combination, as a unit, to operate as closely as possible to the hourly capacity. The spray dryer, the size of which is determined by plant volume, is the key piece of equipment in this combination. The dryer capacity is determined by evaporator size, heater size and boiler size. Even though equipment is selected that will provide minimum cost at present, excess capacity may exist in a plant because it is not in operation 24 hours a day. However, this excess capacity exists in all pieces of equipment in the combination and the volume of the plant can increase without changes in the equipment combination. By selecting equipment in this manner, processing costs are kept to a minimum, flexibility is retained, and future expansion is possible without prohibitive cost.

The selection of the specific pieces of equipment used in the combination is based upon the following factors:

1. Sanitation and quality requirements.
2. Operating efficiency.

3. Space requirements.

4. Operating cost.

5. Initial cost.

6. Future expansion.

Sanitation and quality requirements were the first consideration. All equipment specified is of stainless steel construction, both on contact surfaces and exterior surfaces. Discussions with representatives of sales outlets, manufacturers, and users, indicate that there is no significant difference in quality and acceptibility of high heat powder produced by different brands of stainless steel equipment. All equipment combinations are capable of producing extra-grade powder acceptable to the trade or government. Under these conditions there seems to be no basis for preferring one brand of equipment to another because of sanitation or quality differences except the operating efficiency differences due to specific individual designs.

The different brands of dryers available, all have the same basic thermodynamic principle underlying their operation. The drying process is carried on in a turbulent mixture of heated air and milk at a relatively high velocity. The efficiency of the dryer and the hourly capacity is, however, affected by the design of the component parts of the dryer. Counter-current dryers, in which the milk and air enter from opposite sides ot the dryer, heat the milk to a higher temperature and do not dry the particles as rapidly as in a parallel flow system. Many dryers on the market at the present time use the parallel current system of drying.

The design of the powder-air separators also influences the capacity and efficiency of the dryer. Dryers using single large diameter separators cannot operate at as high a temperature and velocity as dryers using a series of small diameter separators. This occurs because as the diameter of the separator increases the exhaust velocity increases, the smaller particles of powder are then carried out the exhaust stack. In order to avoid excessive powders losses, it is therefore necessary to install cloth powder collectors in drying systems using large diameter powder-air separators. These cloth collectors sift out the entrained powder in the exhaust air. If the size of the individual separator is decreased, the exhaust velocity from each separator is decreased and the velocity of the entering drying air may be increased without loss of powder. This increase in velocity in the entering air reduces the time the milk particles remain in this drying chamber and because of this reduction in time in the chamber the air heat may be increased without damaging the milk protein in the powder. Also, drying systems using small diameter powder air separators do not require cloth powder collectors to sift out the entrained powder in the exhaust air.

These differences in dryer design result in differences in space requirements for various brands of dryers. Dryers using a vertical drying tube, large powder-air separators and cloth collectors require from 12 to 20 feet more ceiling height than horizontal tube dryers using multicone collectors. At present most dryer manufacturers use a horizontal drying tube and multiclone powder-air separator coupled with increased air velocity. By this means a reduction in initial cost and in operating cost have been achieved because the equipment requires a small floor area and attains a higher operating efficiency.

Several types of evaporation equipment are available. The common types of evaporation equipment in use in the dairy industry at present are the single-, double-, and the triple-effect evaporators. The principle involved in these evaporators is essentially that of heating milk under vacuum, which reduces the boiling point, and separates, condenses and withdraws water vapor. In the single-effect evaporator the steam is used once in the heating process. In the double-effect evaporator the milk enters the first effect and is heated to approximately 160° F. It then enters the second effect, where the vacuum is greater and the temperature lower and there it is heated by the vapor from the first effect. The same process is used in the triple-effect evaporator as in the double-effect except that the temperature in the first effect is higher.

In recent years a low temperature ammonia system of evaporation and a recompression system have been introduced. The low temperature system is used in the processing of concentrated fruit juices where very low temperature is required to reduce the possibility of heat damage. At present no performance data are available on such equipment in use on wide scale in the milk industry. The milk industry. The recompression system of evaporation compresses the vapors used in evaporation. This raises the heat of the vapor, and the vapor is then recirculated and used again for evaporating. This system reduces the fuel and water requirements necessary for evaporation. Relatively few of these recompression systems are in use in the milk industry at present and no performance data are available for comparison with systems in common use. Because of these considerations the low temperature ammonia system and the recompression system were not considered for this study, although their installation and use affects the time standard in operation and production of milk powder.

The selection of evaporation equipment was therefore reduced to a selection of either a single-, double- or triple-effect evaporator. The single-effect evaporator has the lowest initial cost. Since the steam is only used once, however, the operating cost is greater. The double-effect evaporator reduces the steam and water requirements by about one-half, and the triple effect reduces the fuel and water cost by about two-thirds. The possible saving in fuel and water requirements would dictate that triple-effect evaporators be installed in all sizes of plants for the sake of economy. However, triple-effect evaporators necessitate unduly high milk temperatures in the first effect and this greatly increases the possibility of heat damage to the milk protein. Double effect evaporators have been installed in most of the plants.

The operating cost of equipment is a function of all the inputs which are necessary to operate efficiently. Labor is the largest item of manufacturing expense in the manufacture of dry milk. A careful study was made in 1953 by Linley E. Juers and E. Fred Koller in 18 large specialized drying plants in Minnesota in order to obtain the cost of drying milk in specialized drying plants. For the 18 plants in the study, labor costs averaged 34 per cent of the total manufacturing cost. Labor costs for the various plants ranged from 0.68 cent up to 2.03 cents for each pound of dry milk produced. The largest number of plants showed costs between 1.00 cents and 1.10 cents a pound.

Table 2 shows the average labor cost per pound of dry milk for the 18 plants grouped by annual output.

TABLE 2.- Relationship between annual dry milk output per plant and labor cost for 18 Minnesota milk drying plants, 1953.

Annual dry milk output per plant	Number of plants	Average labor cost per pound of dry milk
Million pounds		Cents
Under 2.5	1	2.03
2.5 to 4.9	3	1.21
5.0 to 7.4	7	1.12
7.5 to 9.9	3	1.02
10 and over	4	.97
Average all plants	18	1.10

The average labor cost per pound of dry milk for the 18 plants in 1953 was 1.10 cents as compared with 1.16 cents in 1947. This reduction in labor cost amounts to quite a substantial saving. On the basis of 1953 production, it amounts to an average of over 4000 dollars per plant. With an estimated 38 per cent increase in hourly wage rates between 1947 and 1953, this reduction in labor cost reflects a very substantial improvement in labor efficiency. Much of this increased labor efficiency is probably due to large output in 1953 than in 1947 since the minimum amount of labour becomes the fixed cost of operating. As output is increased this fixed portion of labor cost is spread over more units of output and the resulting average cost of labor per unit of output is less.

The relation between annual volume of production and the dry milk output per hour of plant labor is shown in Figure 1. It is apparent from this figure that, in general, the plants with larger volume have a higher dry milk output per hour of labor than do plants with low volume. But with most of the plants producing in excess of 5 million pounds of dry milk in 1953, some of the relatively smaller plants had achieved manufacturing cost just as low as plants having twice the volume and at the same time there were large variations observed between plants of nearly the same output. These plant to plant variations indicate that factors governing the labor efficiency varied from one plant to the other and that the labor cost was one of the largest variants in determining a plant's costs.

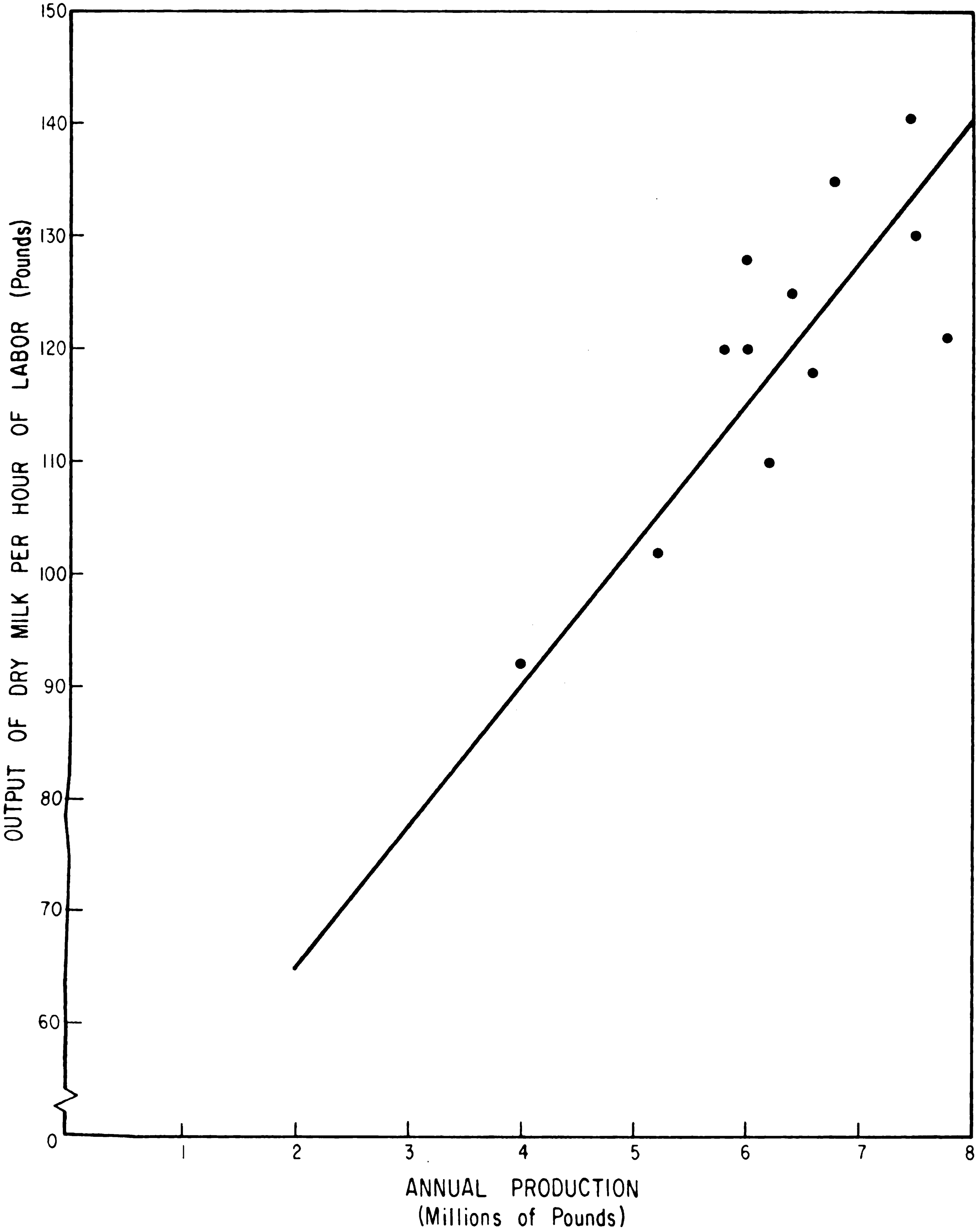


FIG. I RELATIONSHIP BETWEEN ANNUAL VOLUME OF PRODUCTION AND DRY MILK OUTPUT PER HOUR OF LABOR, 12 MINNESOTA DRYING PLANTS, 1953

PROCEDURE

The milk drying operation falls into the non-repetitive class of industry. It is one of the most difficult operations to which to apply time and motion analysis. The ordinary time and motion study is made on short cycle operations of a few elements or steps repeated many times per day.

Broad steps in milk drying operation.- The skim milk was preheated, moisture evaporated by boiling under vacuum, condensed, spray dried and packaged. The operations were carried on mainly in three sections: namely, pan section, dryer section and packaging section.

Steps in operation of pan section:

1. Sanitizing, testing and heating the line.
2. Preheating the milk in two stages: first in the tubular heater and second in hot well (enclosed type) with direct injection of steam.
3. Preparing the pan for boiling the milk under vacuum.
4. Boiling of milk at regulated rate to desired consistency.
5. Maintaining rate of boiling under specified temperature and at desired consistency with control over steam, vacuum and other mechanical operations.
6. Supplying of condensed milk to storage tank for further drying.

Steps in operation of dryer section:

1. Sanitizing and testing the condensed milk lines, pumps, and

motors.

2. Heating the drying chamber of the dryer and fitting the spray nozzles with pipe pieces in working order.
3. Moving condensed milk after preheating.
4. Raising the temperature of the drying chamber to working order and spraying of condensed milk at desired pressure.
5. Regulating the drying temperature in chamber and spraying rate for desired moisture content.
6. Testing the moisture content of the powder and making necessary adjustment in operation.
7. Checking of operation.

Steps in operation of the packaging section.

1. Packaging of powder (filling in bags).
2. Weighing.
3. Stitching the bag mouth.
4. Handling to the warehouse.

Three commercial plants were selected according to representative size of the milk drying unit. A brief sketch of work place layout, showing the floor plans of these three plants, are placed in Appendix A. All of them are multiple products type dairy plants. Dairy 'A' has a drying plant capacity of 400 pounds of powder per hour. Dairy 'B' has a drying plant capacity of 1000 pounds per hour. Dairy 'C' has two drying units having capacity of 1200 pounds per hour and 2200 pounds per hour.

The three plants under study have different layouts of equipment and working conditions. Dairy 'A' plant is in an institution and is used for the purpose of training and production. It works casually as and when necessary according to demand. It is a compact unit comparising of a single effect pan and horizontal dryer with working platform at a height of 12' from the ground level. It has powder packaging unit at the basement floor. Dairy 'B' is a very old plant pan operation, drying operation and packaging each being done at different floors and separated from each other. It has a double-effect pan and a horizontal dryer. Three operators are required, one at each section of operation. The plant works most of the time of the year. Dairy 'C' has fairly large plant. There is a new dryer of 2200 pound per hour capacity. It works for about nine months of the year. The dryer is used regularly and the other serves as standby. Both of the dryers and the powder packaging unit are installed on one floor and in one hall. The two single-effect and one double-effect vacuum pans are installed at the second floor away from the dryer house. All the three sections, i.e. pan, dryer and packaging have one operator working at each section.

Considerable credit must be given to the management of these companies for granting permission to make such a study so unusual to the dairy industry. The first thought of a dairy worker on having a stop watch check his work is that the manager is checking on him and is dissatisfied with his production. It was necessary to use a great amount of diplomacy and sell the worker on the purposes of the study. By proceeding on this basis, the entire study was completed without incident and in a spirit of mutual good will. In the mass production industries, this problem would not present itself as their workers are familiar with the use and functions of time and motion study.

Motion study is commonly defined as the study of the motions used in the performance of an operation for the purpose of eliminating all unnecessary motions and building up a sequence of the most useful motions for maximum efficiency. When determining the method of greatest economy for a specific job, consideration must be given to all factors affecting the work and the operator such as materials, tools, equipment and the work place layout. For developing a better method, the following four approaches are generally used during the study of existing operation:

(a) Eliminate all unnecessary work. (motions)

(b) Combine operations or elements.

(c) Change the sequence of operations.

(d) Simplify the necessary operations.

In order to make above approaches there are various tools generally used such as process chart, flow diagram, activity chart, man and machine chart, operation chart, and sino chart. Of course, not all of these different methods would be used on any job. After developing the improved method, the time standard is determined for each element of operation. The next step involves training the operators.

In the present study of motion and time, an attempt has been made to determine accurately the standard number of minutes or hours that a qualified worker should take to perform drying operation. The time is determined for working at a normal pace with the present available tools and equipment under the normal working conditions prevalent in milk drying plants in U.S.A. It was not possible to train the workers nor was it desired as the object of the present study for rate setting or wage incentive design.

According to the above described method the operations of three plants (A,B and C) were studied repeatedly and with the help of process chart. An analyses of each step in the manufacturing process was made for devising an improved method. Careful study of process charts shown in Appendix B will reveal that in the graphic picture of steps in the old method certain unnecessary operations were eliminated, one operation was combined with another, a better route for the movement of operator was found, delays between operations eliminated and the sequence of operation changed under the usual practice. The process chart usually should be based on either the man, showing in sequence the activities of operator, or the product showing in sequence the steps that the product goes through. The chart in this study is the man type since efforts were made to indicate the standard man-hours required for cycle of operation with respect to variation in layout of the equipment in different plants under study. From the summary of the improved method process chart, as in Appendix B, it was found that in dairy plant 'B' in milk drying operation the number of operations were reduced from 23 to 18, number of movements reduced from 23 to 16, and the total movements decreased from 1009 ft to 821 ft. The total observed time for the cycle of operation was reduced from 38.69 minutes to 25.4 minutes for a saving of 34.3 percent of the time.

The next step was to make repeated observations of the process with each equipment. Each operation was broken down into elements or steps that were convenient to time. When it was reasonably certain that each step of a particular operation was followed by the worker without change, a time study of the operation was made.

The watch used was a decimal minute watch with one sweep of the hand divided into one hundred parts of one hundredth of a minute each. All time recorded was in minutes and hundredths of a minute.

The method of timing used was the "snap back method". This method is open to some criticism in that some small amount of time is lost in the snapping of the hand back to zero at the end of each element, even though the watch automatically starts again. Most of the criticism of the system occurs when it is used for rate setting. In this study, rate setting was not involved. Carroll states (1943) "While observing a long series of very fast elements, layman to understand. In all industiral applications of time study, it is desired to find the time required for an average worker to perform a given task. For this reason, the performance is rated as to the effort of the particular worker. Workers vary greatly in their method and speed of performance, this range usually being from one-third of normal performance to twice normal performance. (Carroll, 1943).

In this study it was desirable to arrive at the time required for the average worker to perform the task. All the operators were rated on a basis of 100% to 120% for an average operation. The rating of the performance made it possible to arrive at normal time for the elements and the cycle.

Allowances were then considered and applied to the normal time for the cycle. The concept of allowances is one that may come as a surprise to some of the plant managers. Many of the managers like to believe that they receive close to sixty minutes work per hour from each plant worker, but such is far from actual case. Allowances must be made for personal needs, fatigue and unavoidable delays.

The value of these allowances depends very much on the type of work involved. In some types of work such as blast furnace work in steel mills, the allowance may run as high as 50 percent, while in light work under good conditions it could be as low as 5 percent. Most shop operations fit in a class for which 20 percent is normal allowance. (Carroll, 1943).

the continuous method is invaluable. For practically all other studies, the snap-back method is much preferred. The snap-back includes a small error in each reading. This is inconsequential in comparison with the probable errors in human judgment included when rating the performance".

The elements of such operation was recorded on the regular time study sheets used by the Industrial Engineering Section of the Mechanical Engineering Department at Michigan State University.

Five elemental time values were taken for each step. Recording the time for five complete cycles required considerable time because the occurrence is of the non-repetitive type and takes place only once in twenty four hours. The five elemental times were then averaged arithmetically and the actual time for each element calculated.

Only for the powder packaging operation, which was of the repetitive type and of short cycle, was the "continuous method" of timing adopted. Elemental time values were recorded for ten cycles. Also it could be possible to analyze this cycle according to the laws of motion economy into necessary THERBLIG as developed by Frank B. Gilbreth in his early work in motion study, as in Appendix - C'.

The most important problem of the study was encountered in determining how to rate the performance and the method of applying allowances. This will be the most difficult part for the dairy

The total allowance generally used in dairy industry is 20 percent; 5 percent for personal needs, 10 percent for fatigue allowances, and 5 percent for unavoidable delay allowance. (Hall, 1952). But in the present study since the operator has enough idle time during the cycle of operation of the equipment for the day, the writer is inclined to assess 10 percent of allowance for the total; i.e. 3 percent for personal needs, 5 percent for fatigue, and 2 percent for unavoidable delays. This seemed to be a reasonable allowance for this type of work which is unlike manufacturing for market milk. The packaging section of powder plant involves repetitive type of work and consequently the allowance for the operator should be 20 percent.

The system decided upon to calculate and illustrate the total standard time was by graphical representation. Included are the standard time for the manual operation and automatic time required by machines. The chart illustrates the percentage utilization of the time of operator and his idle time.

The most significant feature in the operation was the automatic time required by machine at different stages entirely dependant upon the design and recommended method. These were the main determinant of the duration of the cycle of operation. Efforts were made to accommodate the maximum of manual operations to their best fit during the automatic time of the machine to reduce the length of the cycle of operation and at the same time the idleness of the operator. In the graphic representation of cycle time the manual operations performed before and after the automatic time of machines have been termed as "external time" and that performed during and within the period of automatic time of the machina as "internal time". In order to reduce the cycle of operation and idleness time of operator, efforts were made to reduce the external time, internalize the external time as well as reduce the automatic time. This method of reduction in cycle time of operation resulted in minimum manhours required for production of a unit quantity of powder in the plant.

RESULTS

TABLE 3.- Elemental times for operation of vacuum pan.

PLANT A

Elemental description	Elemental time, minutes 1	2	3	4	5	Average	Rating
1. Sanitize and preheat first stage	3.1	3.5	3.0	3.1	3.3	3.20	120%
2. Preheat second stage in hot well	.92	.91	.85	.95	.87	.90	"
3. Prepare the pan for boiling	3.6	3.1	3.0	3.8	4.0	3.5	"
4. Start boiling and adjustment of steam and vacuum	2.0	1.80	1.70	1.90	1.85	1.85	"
5. Balance the normal rate of boiling	.58	.60	.50	.52	.55	.55	"
6. Check consistency of condensed milk and pump to storage tank for drying	.82	.81	.78	.79	.80	.80	"

PLANT B

Elemental description	1	2	3	4	5	Average	Rating
1. Sanitize and preheat first stage	3.8	3.1	3.0	3.7	3.9	3.5	"
2. Preheat second stage in hot well	1.15	1.16	1.0	1.06	1.13	1.10	"
3. Prepare the pan for boiling	5.4	5.0	5.1	4.8	4.7	5.0	"
4. Start boiling and adjustment of steam and vacuum	5.2	5.6	4.9	4.5	4.8	5.0	"
5. Balance the normal rate of boiling	.86	.87	.81	.86	.85	.85	"
6. Check consistency of condensed milk and pump to storage tank for drying	.94	.92	.98	.96	.95	.95	"

TABLE 3 (Cont.)

PLANT C

Elemental description	Elemental time, minutes 1	2	3	4	5	Average	Rating
1. Sanitize and preheat first stage	2.9	3.2	3.1	2.8	3.0	3.0	120%
2. Preheat second stage in hot well	1.1	1.18	.90	.92	1.0	1.0	"
3. Prepare the pan for boiling	5.9	6.2	6.6	6.7	6.6	6.4	"
4. Start boiling and adjustment of steam and vacuum	5.6	5.9	5.0	6.0	5.5	5.6	"
5. Balance the normal rate of boiling	2.2	1.92	2.0	1.88	2.0	2.0	"
6. Check consistency of condensed milk and pump to storage tank for drying	1.15	1.12	1.0	1.13	1.10	1.10	"

TABLE 4.- Summary of pan operation in plants A, B and C.

Elemental description	Average elemental time, minutes Plant A.	Plant B.	Plant C.
1. Sanitize and preheat first stage	3.20	3.5	3.0
2. Preheat second stage in hot well	0.90	1.10	1.0
3. Prepare the pan for boiling	3.5	5.0	6.4
4. Start boiling and adjustment of steam and vacuum	1.85	5.0	5.6
5. Balance the normal rate of boiling	0,55	0.85	2.0
6. Check consistency of condensed milk and pump to storage tank for drying	0.80	0.95	1.10

TABLE 5.- Elemental times for operation of spray dryer.

PLANT A

Elemental Description	Elemental time, minutes 1	2	3	4	5	Average	Rating
1. Start heating the drying chamber	.88	.88	.80	.89	.85	.86	120%
2. Sanitize, test, and make the condensed milk line ready for drying	.92	.95	1.10	.99	1.04	1.0	"
3. Preheat the condensed milk and create pressure in the line	1.4	1.1	1.0	1.4	1.1	1.2	"
4. Fit the spray nozzles with pipe pieces in working order	1.94	2.1	2.0	1.98	1.98	2.0	"
5. Start pumping condensed milk, open spray partially, check spray and open full	1.1	1.5	1.2	.98	1.22	1.20	"
6. Adjust spray with temperature	.42	.3	.28	.24	.26	.3	"
7. Start powder conveyor, get powder sample, make moisture test	11.0	10.5	9.0	9.5	10.0	10.0	"
8. Make final adjustment of high-pressure pump	.48	.50	.49	.54	.49	.50	"

PLANT B

Elemental Description	1	2	3	4	5	Average	Rating
1. Start heating the drying chamber	2.1	2.2	2.20	2.12	2.18	2.16	"
2. Sanitize, test, and make the condensed milk line ready for drying	1.3	1.6	1.4	1.5	1.7	1.5	"
3. Preheat the condensed milk and create pressure in the line	1.6	1.9	2.0	2.4	1.6	1.9	"
4. Fit the spray nozzles with pipe pieces in working order	3.2	3.1	2.90	2.8	3.0	3.0	"

TABLE 5 (Cont.)

PLANT B

Elemental Description	Elemental time, minutes 1	2	3	4	5	Average	Rating
5. Start pumping condensed milk, open spray partially, check spray and open full	2.1	2.1	1.90	2.2	1.80	2.0	120%
6. Adjust spray with temperature	.52	.49	.48	.51	.50	.50	"
7. Start powder conveyor, get powder sample, make moisture test	14.0	13.3	12.0	13.2	13.0	13.1	"
8. Make final adjustment of high-pressure pump	1.1	1.3	.90	.85	.85	1.0	"

PLANT C

Elemental Description	1	2	3	4	5	Average	Rating
1. Start heating the drying chamber	.35	.32	.25	.28	.30	.30	"
2. Sanitize, test, and make the condensed milk line ready for drying	.90	.88	.80	.82	.85	.85	"
3. Preheat the condensed milk and create pressure in the line	1.1	1.15	.95	.90	.90	1.0	"
4. Fit the spray nozzles with pipe pieces in working order	2.12	1.90	1.98	1.95	2.05	2.0	"
5. Start pumping condensed milk, open spray and open full	.98	.95	1.1	1.0	.97	1.0	"
6. Adjust spray with temperature	.28	.22	.20	.23	.32	.25	"
7. Start powder conveyor, get powder sample, make moisture test	5.8	6.1	6.15	5.95	6.0	6.0	"
8. Make final adjustment of high-pressure pump	.28	.31	.33	.28	.30	.30	"

TABLE 7 (Cont.)

PLANT B

Elemental description	1	2	3	4	5	6	7	8	9	10	Average	Rating
5. Close paper bag, stitch it and set aside the stitching machine	1.93	1.87	1.95	1.92	1.83	1.85	1.95	1.82	2.0	1.92	1.90	130%
6. Slide the bag on tray and position it	Different arrangement											
7. Stack the bag in ware house and position fresh tray	3.2	3.1	2.8	2.9	2.95	2.85	3.2	3.3	2.8	2.9	3.0	"

PLANT C

Elemental description	1	2	3	4	5	6	7	8	9	10	Average	Rating
1. Remove the bag from shifter to weighbridge	.17	.18	.16	.15	.21	.16	.19	.23	.20	.15	.18	"
2. Fit a fresh bag and start the shifter	.37	.39	.32	.33	.34	.40	.41	.31	.30	.33	.35	"
3. Weigh the bag and pre-position the spout	.48	.47	.45	.55	.53	.50	.58	.45	.48	.49	.50	"
4. Close the mouth of liner, tie with cord and push it below	.95	1.0	1.10	.95	.98	.92	1.12	.90	.92	.98	.98	"
5. Close paper bag, stitch it and set aside the stitching machine	1.12	1.08	1.15	1.10	1.0	1.18	[illegible]	1.0	1.19	1.10	1.10	"
6. Slide the bag on tray and position it	1.4	1.3	1.32	1.28	1.45	1.20	1.18	1.50	1.52	1.35	1.35	"
7. Stack the bag in ware house and position fresh tray	3.3	3.1	3.6	3.0	4.1	3.4	4.0	2.9	3.3	3.7	3.5	"
	(For each trip of twelve bags)											

TABLE 6.- Summary of dryer operation plant A, B and C.

Elemental description	Average elemental time, minutes		
	Plant A.	Plant B.	Plant C.
1. Start heating the drying chamber	0.86	2.16	0.30
2. Sanitise, test, and make the condensed milk line ready for drying	1.0	1.5	0.85
3. Preheat the condensed milk and adjust pressure in the line	1.2	1.9	1.0
4. Fit the spray nozzles with pipe pieces in working order	2.0	3.0	2.0
5. Start pumping condensed milk, open spray partially, check spray and open full	1.2	2.0	1.0
6. Adjust spray with temperature	0.3	0.5	0.25
7. Start powder conveyor, get powder sample, make moisture test	10.0	13.1	6.0
8. Make final adjustments of high pressure pump	0.50	1.0	0.30

TABLE 7.- Elemental times for packaging powder in 100 . paper bags.

PLANT A

Elemental description	Elemental time in minutes 1	2	3	4	5	6	7	8	9	10	Average	Rating
1. Remove the bag from shifter to weighbridge	.21	.20	.23	.25	.18	.19	.20	.17	.18	.19	.20	130%
2. Fit a fresh bag and start the shifter	.45	.48	.50	.51	.46	.45	.50	.49	.47	.49	.48	"
3. Weigh the bag and pre-position the spout	.71	.76	.70	.68	.66	.69	.66	.68	.75	.72	.70	"
4. Close the mouth of liner, tie with cord and push it below	1.1	.98	1.1	.95	1.2	1.0	.90	.96	.90	.9[illegible]	.[illegible]	"
5. Close paper bag, stitch it and set aside the stitching machine	1.52	1.50	1.54	1.57	1.47	1.58	1.46	1.42	1.62	1.52	1.52	"
6. Slide the bag on tray and position it	No arrangement											
7. Stack the bag in ware house and position fresh tray	2.0	2.6	2.9	3.0	2.8	2.1	2.[illegible]	2.6	2.7	2.3	2.5	"

PLANT B

Elemental description	1	2	3	4	5	6	7	8	9	10	Average	Rating
1. Remove the bag from shifter to weighbridge	.25	.23	.22	.20	.28	.22	.29	.21	.30	.30	.25	"
2. Fit a fresh bag and start the shifter	.39	.40	.35	.31	.[illegible]	.37	.40	.44	.40	.30	.38	"
3. Weigh the bag and pre-position the spout	.78	.72	.79	.73	.80	.73	.72	.78	.76	.71	.75	"
4. Close the mouth of liner, tie with cord and push it below	1.85	1.90	1.70	1.75	1.95	1.88	1.70	1.77	1.75	1.75	1.80	"

TABLE 8.- Summary of powder packaging of 100 lb. paper bag in plants A, B and C.

Elemental description	Average elemental time, minutes Plant A.	Plant B.	Plant C.
1. Remove the bag from shifter to weigh-bridge	.20	.25	.18
2. Fit a fresh bag and start the shifter	.48	.38	.35
3. Weigh the bag and preposition the spout	.70	.75	.50
4. Close the mouth of liner, tie it with cord and push it below	1.0	1.80	.98
5. Close paper bag, stitch it and set aside the stitching machine	1.52	1.9	1.10
6. Slide the bag on tray and position it	x	x	1.35
7. Stack the bag, ware house and position fresh tray	2.5 (Manual)	3.0 (Manual)	3.5 (twelve bags) (Mechanised)

Total time required for complete cycle of operation including the stacking of bag in ware house is:

Plant A- 6.1 minutes per bag
Plant B- 8.08 minutes per bag
Plant C- 4.75 minutes per bag

RESULTS AND DISCUSSION

Standard Time. - The standard time of the manual operation in three sections of the manufacturing operation cycle in a plant, vary from one plant to the other when compared with each other during this study. The variation is due mainly to the difference in plant layout, size of the plant, and to the difference in design of equipment. The manufacturing process is the same in all the three plants. It may be seen that the pan, dryer and bagging section each located at different floor and at a distance in a plant result in increase of manhours per unit of production.

A study of the floor plan of the layout in appendix 'A' (a), (b), (c) of the three plants A, B and C under study indicates the following:

Plant A. Pan and dryer are housed in only one room with operative platform at a height of 12 ft above ground level. The powder packaging section is located in the basement having a circuitous working path to it from dryer house. Only one operator attends the operation in all the three sections since the plant is very small and packaging section requires only a small amount of handling at intervals. The location of working platform of pan and dryer at different level and packaging section being located at the basement and at a considerable distance from dryer result in the increase of the movement time of the operator.

The location of pan and dryer in a compact unit in this plant result in the standard time in minutes for manual operation of both the units (i.e. 9.90 +15.63) in much less than the corresponding time of both the units combined in the other two plants B and C where pan and dryer are located in different rooms some distance apart.

Plant B. All the three sections of operation are located separately on different floors and operated independently by three operators, one at each section. In this plant the total standard time for manual operation is the maximum although the plant size and production volume are less than the plant C. The standard time of each section is also the highest in this plant due to old design of equipment and defective layout.

Plant C. In this plant the drying and packaging sections are located together on one floor with the improved equipment and layout. The pan section is located in a different hall at a considerable distance with clumsy fittings of old type. The result is that the drying and packaging sections either separately or combined together have lowest standard time. If the pan section with modern design of equipment would have been located together as a compact unit with dryer and packaging this plant would have been more efficient. Three sections are involved with three operators, one at each section. The drying and packaging sections are together at one floor and ordinarily one operator should have been able to handle the operation of both the sections. However, due to higher volume production requiring the full time attention of an operator, due to a production higher than optimum quantity which can be handled by one operator, each of the stations require attention of an operator. This occurs even though the operator at the dryer has ample idle time which could be utilized for attending the evaporator if located at the same place.

The reduction of standard time in manual operations, as observed in the present study, is dependant on two factors. The first is that the layout of the plant as a compact unit to minimise the movement of operator and avoidance of unnecessary motions. The second is the use of improved type of equipment with automatic control devices resulting in the saving of manual operation and repeated inspection.

Labor requirements.- The standard time required for complete cycle of operation during the manufacture of milk powder is comprised of man and machine time. The standard labor time required for manufacture of a unit quantity of powder is comprised of actual working time of operator while the machine is either working or at rest and idle time of the operator during automatic working time of the machine. The total time required for manufacture of unit quantity of powder starting from milk to the finished product in warehouse with certain rate of productivity of the man and machine depend on the length of cycle time of the complete operation.

The graphic representation and measurement of the cycle of operation of a section, as well as combined together in a plant, indicate the total man-hours required for manufacture of unit quantity of powder taking into consideration the standard time, automatic time of machine and total time for complete cycle of operation in each plant. This graphic measurement of the work indicates also the productivity of each plant besides indicating the percentage of useful utilization and idle time of operators in each plant under study.

The graphic representations enumerated in Figures 2 and 3 are based on sequence of operation by man and machine according to the process chart followed during normal working conditions as observed.

Definition of the terms used in the graphic representation:

External time - Manual operation time before or after the automatic working of the equipment employed during operation.

Internal time - Manual operation time performed during automatic working time of the equipment.

Automatic time- Working time of machine or equipment with the aid of steam, electricity, gas or any motive power. Such time may be dependant upon the process design for the product or design of equip-

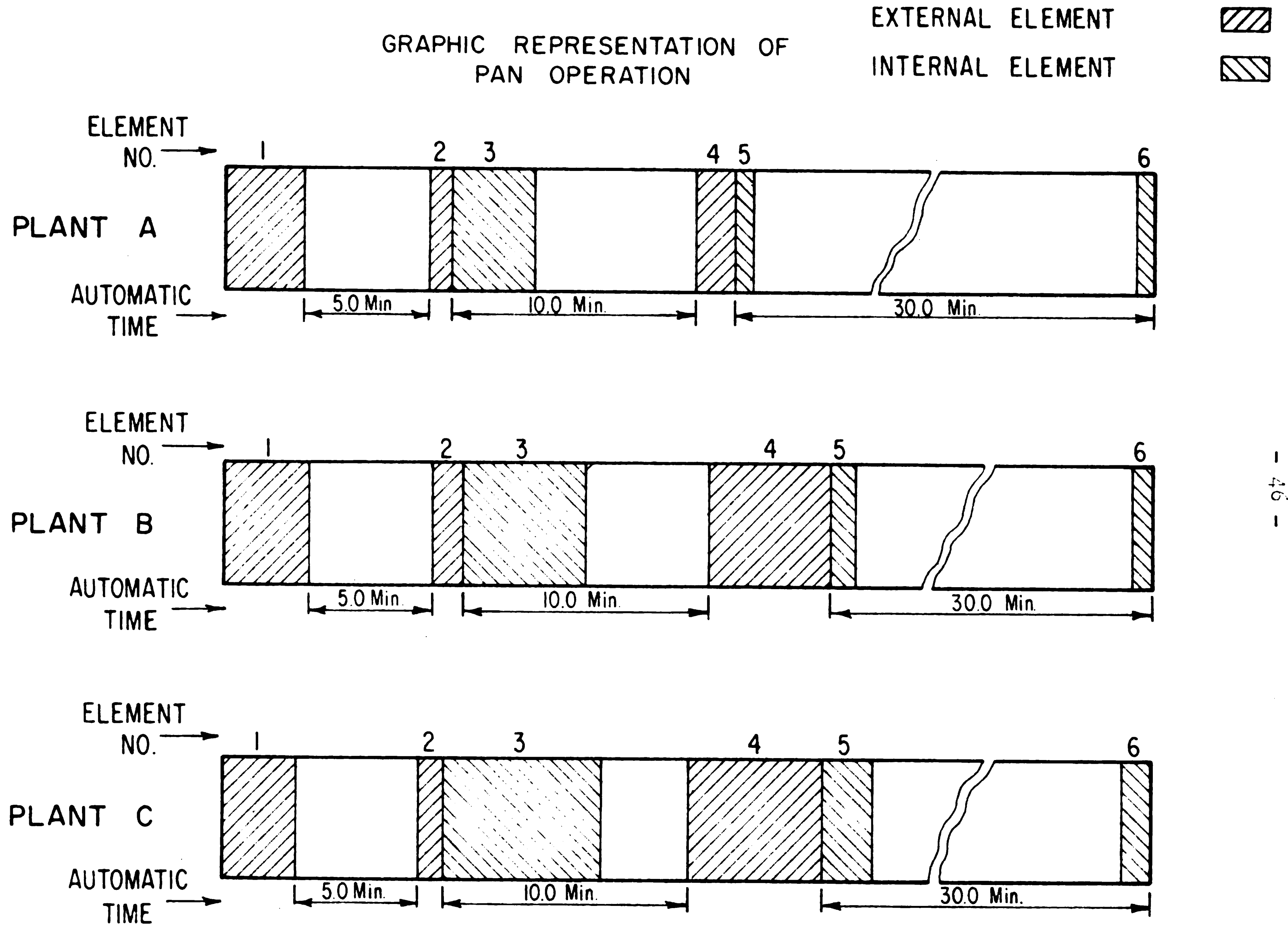


FIG. 2 MAN-MACHINE OPERATION FOR PAN AS OBSERVED FOR NORMAL WORKING CONDITIONS.

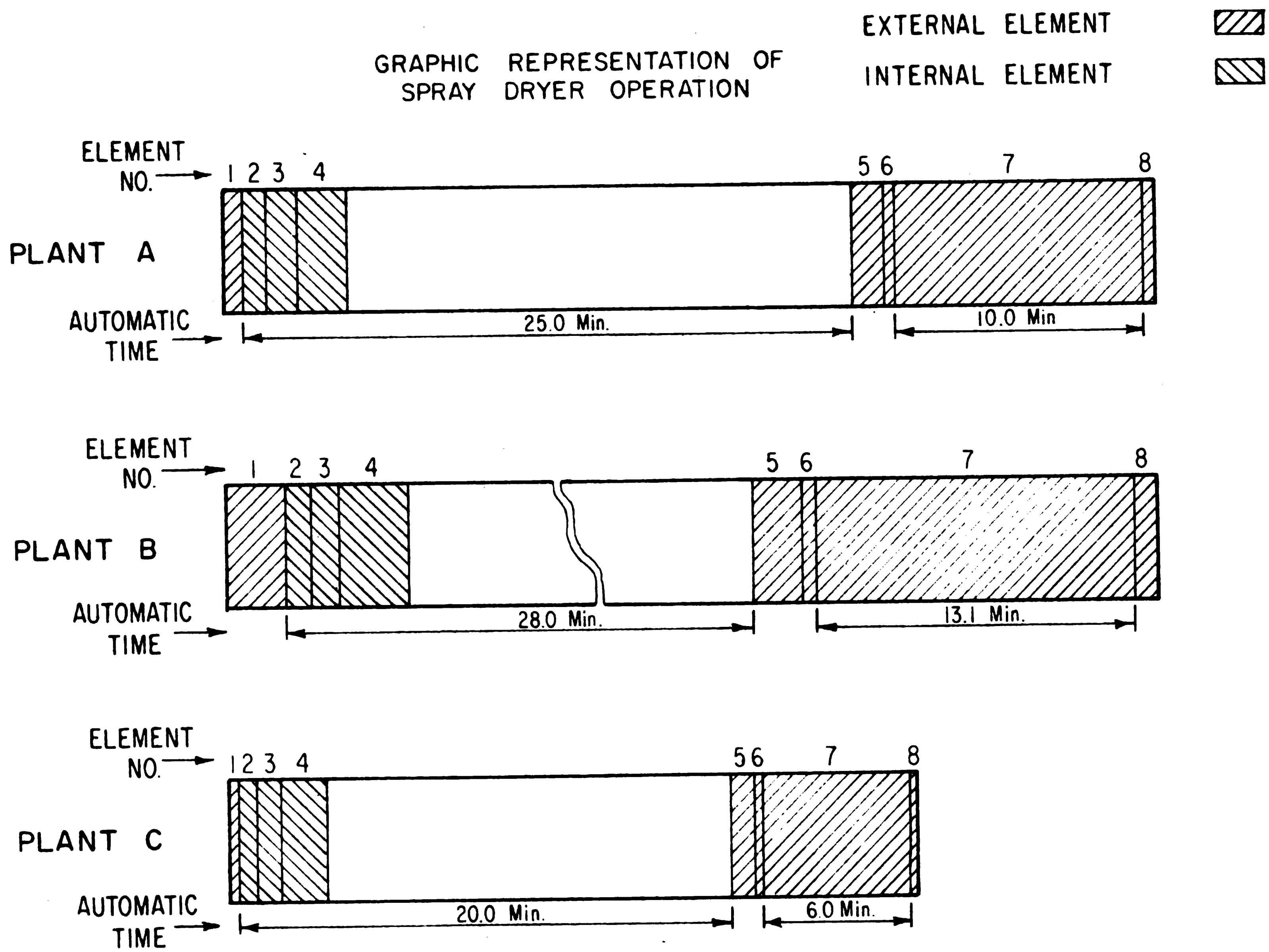


FIG. 3 MAN-MACHINE OPERATION FOR SPRAY DRYER AS OBSERVED FOR NORMAL WORKING CONDITIONS

ment or both.

Cycle time of operation - External time and automatic time.

Total service time of operation - External time and internal time.

Idle time of the operator during cycle of operation - Automatic time minus internal time.

Graphic representation of cycle of operation.- External, internal, elements as in time observation sheet and automatic times are variables depending upon the process, equipment design and layout of the plant.

In Figure 2 the observations for pan section operation are in:

Plant A. External time - Element no. 1 2 4

Time in min. 3.20 + .90 + 1.85 = 5.95

Internal time - Element no. 3 5 6

Time in min. 3.5 + .55 + .80 = 4.85

Automatic time - 5.0 + 10.0 + 30.0 = 45.0 min.

Cycle time = external + automatic = 5.95 + 45.0

= 50.95 min.

Total labor devoted = 5.95 + 4.85 = 10.80 min.

Idle time of operator during the cycle of manufacture =

45.0 - 10.80 = 34.2 min.

Plant B. External time - Element no. 1 2 4

Time in min. 3.5 + 1.10 + 5.0 = 9.60

Internal time - Element no. 3 5 6

Time in min. 5.0 + .85 + .95 = 6.80

Automatic time - 5.0 + 10.0 + 30.0 = 45.0 min.

Cycle time = external automatic = 9.60 + 45.0= 54.60 min.

Manual labor = 16.40 min

Idle time of the operator during the cycle of manufacture =

45.0 - 6.80 = 38.20 min.

Plant C. External time - Element no. 1 2 4

Time in min. 3.0 + 1.0 + 5.6 = 9.6

Internal time - Element no. 3 5 6

Time in min. 6.4 + 2.0 + 1.10 = 9.50

Automatic time - 5.0 + 10.0 + 30.0 = 45.0

Cycle time = 9.6 + 45 = 54.6 min.

Manual labor = 9.6 + 9.50 = 19.10 min.

Idle time of the operator during the cycle of manufacture =

45.0 - 9.50 = 35.50 min.

Similarly for the drying section. In Figure 3 the followings are the observations:

Plant A. External time - Element no. 1 5 7 8

Time in min. .86 + 1.2 + 10.0 + 5.0 = 12.56

Internal time - Element no. 2 3 4

Time in min. 1.0 + 1.2 + 2.0 = 4.2

Automatic time - 25.0 min.

Cycle time = 12.56 + 25.0 = 37.56 min.

Manual labor = 12.56 + 4.2 = 16.76 min.

Idle time of the operator = 25.0 - 4.2 = 20.8 min.

Plant B. External time - Element no. 1 5 6 7 8

Time in min. 2.16 + 2.0 + .5 + 1.0 + 13.1 = 18.76

Internal time - Element no. 2 3 4

Time in min. 1.5 + 1.9 + 3.0 = 6.4

Automatic time - 28.0 min.

Cycle time = 18.76 + 28.0 = 46.76 min.

Manual labor = 18.76 + 6.4 = 25.16 min.

Idle time of the operator = 28.0 - 6.4 = 21.6 min.

Plant C. External time - Element no. 1 5 6 7 8

Time in min. .30 + 1.0 + .25 + 6.0 + 3.0 = 7.85

Internal time - Element no. 2 3 4

Time in min. .85 + 1.0 + 2.0 = 3.85

Automatic time - 20.0 min.

Cycle time = 7.85 + 20.0 = 27.85 min.

Manual labor = 7.85 + 3.85 = 11.70 min.

Idle time of the operator = 20.0 - 3.85 = 16.15 min.

Since the work of the packaging section is of a repetitive type, the cycle time per bag has been studied for each of the three plants as indicated in the summary of the time sheet and total time required. The man-hours required for handling the volume production per working shift of 8 hours has been calculated and shown in the following pages.

Standard time for cycle of manual operation.-

Plant A. Manual standard time in pan operation in minutes.

Normal time for cycle of operation = 10.80 min.

Allowance 10 percent of the normal time for the operator and considering observed performance rating at 120 percent, the standard time = $\frac{10.8}{1.20}$ = 9.0 min.

= 9.0 + 0.9 (10 percent allowance)

= 9.9 min.

Standard time in dryer operation.

Normal time = 17.06 min.

at 120 percent rating normal time = $\frac{17.06}{1.2}$ = 14.21 min.

Allowance at 10 percent normal time = 14.21 + 1.42 = 15.63 min.

Standard time in packaging operation.

Normal time = 6.1 min.

Performance rating at 120 percent

Allowance 20 percent of normal time

Standard time = $\frac{6.1}{1.2}$ = 5.08 + 1.01 = 6.09 min.

Plant B. Standard time in pan section

Normal time = 16.40 min.

Performance rating at 120 percent

(Continued)

<u>Plant B.</u> Allowance at 10 percent

$$\text{Standard time} = \frac{16.40}{1.20} = 13.66 + 1.36 = 15.02 \text{ min.}$$

Standard time in <u>dryer section</u>.

Normal time = 25.16;

Performance rating at 120 percent

Allowance at 10 percent

$$\text{Standard time} = \frac{25.16}{1.2} = 20.96 + 2.09 = 23.05 \text{ min.}$$

Standard time in <u>packaging section</u>.

Normal time = 8.08 min.

Performance rating at 120 percent

Allowance at 20 percent

$$\text{Standard time} = \frac{8.08}{1.2} = 6.73 + 1.34 = 8.07 \text{ min.}$$

<u>Plant C.</u> Standard time in <u>pan section</u>.

Normal time = 19.10 min.

Performance rating at 120 percent

Allowance at 10 percent normal time

$$\text{Standard time} = \frac{19.10}{12} = 15.91 + 1.59 = 17.50 \text{ min.}$$

Standard time in <u>dryer section</u>

Normal time = 11.70 min.

Performance rating at 120 percent

Allowance at 10 percent normal time

(Continued)

Plant C. Standard time = $\frac{11.70}{1.2}$ = 9.75 .97 = 10.72 min.

Standard time in packaging section.

Normal time = 4.7 min.

Performance rating at 120 percent

Allowance at 20 percent of normal time

Standard time = $\frac{4.7}{1.2}$ = 3.91 .782 = 4.692 min.

TABLE 9.- Summary of standard times of manual operation from starting to manufacturing, minutes.

	Pan Section	Drying Section	Packaging Section	Total
Plant A	9.90	15.63	6.09	31.62
Plant B	15.02	23.05	8.07	46.14
Plant C	17.50	10.72	4.69	32.91

<u>Time for manual operation per shift of 8 hours and man hours required for unit production of 1000 lbs. of powder</u>.-

After completion of the cycle of operation in the processing for converting milk into the powder stage, the operator has to do the packaging of powder as well as the routine inspection of the processing at intervals.

<u>In Plant A</u>

First operation cycle = 36.11 min.

Inspection at 2.5 min. per hr. for remaining period of the shift of about 6.5 hr. = 6.5 x 2.5 = 16.25 min.

Bagging at 6.1 min- per bag of 100 lb. each for four hundred pounds per hour i.e. four bags per hour for 6.5 hr. = 6.5 x 4 x 6.1 = 158.6 min.

Therefore, total hours worked in the shift = 36.11 16.25 158.6 = 210.96 min. = 3.51 hr.

Taking performance rating at 120 percent and allowance at 10 percent a total standard time = 3.21 hr.

The production of 26000 lb. during 6.5 hr. requires 3.21 man-hour. Therefore, production of 1000 lb. powder requires =
$\frac{3.21 \times 1000}{2600}$ = 1.23 hr.

Since only one operator attended all the three sections, the man-hours per thousand pound production = 1.23 man-hour per 1000 lb.

In Plant B.

Operation cycle = 52.14 min.

Inspection at 2.5 min. per hour = 16.25 min.

Bagging at the rate of 8.08 min. per bag for production of 1000 lb. per hr; i.e. 10 bags per hour during 6.5 hours production = 6.5 x 10 x 8.08 = 525.20 min.

Therefore, the total hours worked for the shift = 593.59 = = 9.89 hr.

Taking observed performance rating, at 120 percent and allowing 10 percent over all personal, fatigue, delays, allowances, the total standard time per shift = 9.06 min.

Since three operators worked one in each section of the plant as described earlier, the total man-hours required for the shift = 9.06 x 3 = 27.18 man-hr.

For production of 1000 lb. powder, the man-hours required is

$$= \frac{27.18 \times 1000}{6500} = 4.18 \text{ man-hr per 1000 lb.}$$

In Plant C.

Operation cycle = 38.05 min.

Inspection at 2.5 min. per hr. = 16.25 min.

Bagging at 4.75 min. per bag for 2000 lb. per hr; i.e. 20 bags per hour during production period of 6.5 hours, time = 4.75 x 20 x x 6.5 = 617.5 min.

Total normal hours required for production of 13000 lb. powder = 38.05 + 16.25 + 617.5 = 671.80 min. = 11.19 hr.

Performance rating at 120 percent and PFD allowance at the rate of 10 percent. Total standard time for manual operation in the shift = 10.25 hr.

Since three operators worked one in each of the three units for the complete operation in one shift, the total man-hours = = 10.25 x 3 = 30.75 man-hours.

Therefore, for production of 1000 lb. of powder man-hours required = $\frac{30.75 \times 1000}{13000}$ = 2.36 man-hr per 1000 lb.

The labor required for the drying operation varies as equipment size and volume vary. But this does not vary proportionately but increases in discrete steps as dryer capacity or volume passes certain magnitudes.

In this connection it is worthwhile to mention the results of two studies dealing with spray drying costs. (Kolmer et al, 1957) (Juers and Koller, 1957).

<u>Iowa results (Kolmer, et al, 1957).</u>- With any dryer, the operating labor cost per hundred-weight of non-fat drying milk declines as volume increased until the volume becomes great enough to require another labor shift. Only one man is needed to operate the dryer and evaporator on dryers having capacity of less than 750 lb. per hr. At this and larger volumes, it is necessary to add a helper to handle and store the non-fat dry milk. Because labor is hired in units of 40 hr., the labor cost per unit of output increases sharply

as new labor shifts are added with a particular dryer, or as a plant changes from a smaller dryer to a dryer with a capacity of 750 lb. per hour.

While enumerating the processing costs in three model plants studied, of different capacity, it was indicated that processing costs per unit decreases within the volume range of each equipment combination as volume increases. Each equipment combination, when operated at its optimum (lowest unit cost) volume, had a lower unit cost than a smaller equipment combination operated at its optimum volume. The rate of cost decliñe, however, decreases as volume increases. The processing costs decline from 5.28 per hundredweight for a 500 pound dryer combination to 5.06 per hundredweight for 650 pound dryer combination to 4.99 per hundredweight for a 750 pound dryer combination.

This decline represents a 4 percent cost reduction between the 500 and 650 pound dryer combinations and on 0.8 percent reduction between the 650 and 750 pound dryer combinations. The volume increase was 18 percent in both the instances. Figure 4 gives the cost of spray drying skim milk with several equipment combinations at various volumes.

Minnesota results (Juers and Koller, 1956).- For 18 drying plants the labor costs averaged 34 percent of the total manufacturing cost. Labor cost for various plants ranged from 0.68 cent to 2.03

cent for each pound of dry milk produced. The largest number of plants had a cost between 1.00 cent and 1.10 cents a pound. It was found that labor was the largest item of expense in the manufacture of dry milk.

TABLE 10.- Relationship between annual dry milk output per plant and labor cost for 18 Minnesota milk drying plants, (1953):

Annual dry milk output per plant.	Number of plants.	Average labor cost per pound of dry milk.
Million pounds		Cents
under 2.5	1	2.03
2.5 to 4.9	3	1.21
5.0 to 7.4	7	1.12
7.5 to 9.9	3	1.02
10 and over	4	0.97
(1) average all plants	18	1.10

The average labor cost per pound of dry milk for the 18 plants in 1953 was 1.10 cents as compared with 1.16 cents in 1947. This reduction in labor cost amounts to quite a substantial saving. On the basis of 1953 production, the saving amounts to an average of over $ 4,000 per plant. With an estimated 38 percent increase in hourly wage rates between 1947 and 1953, this reduction in labor cost reflects a very substantial improvement in labor efficiency.

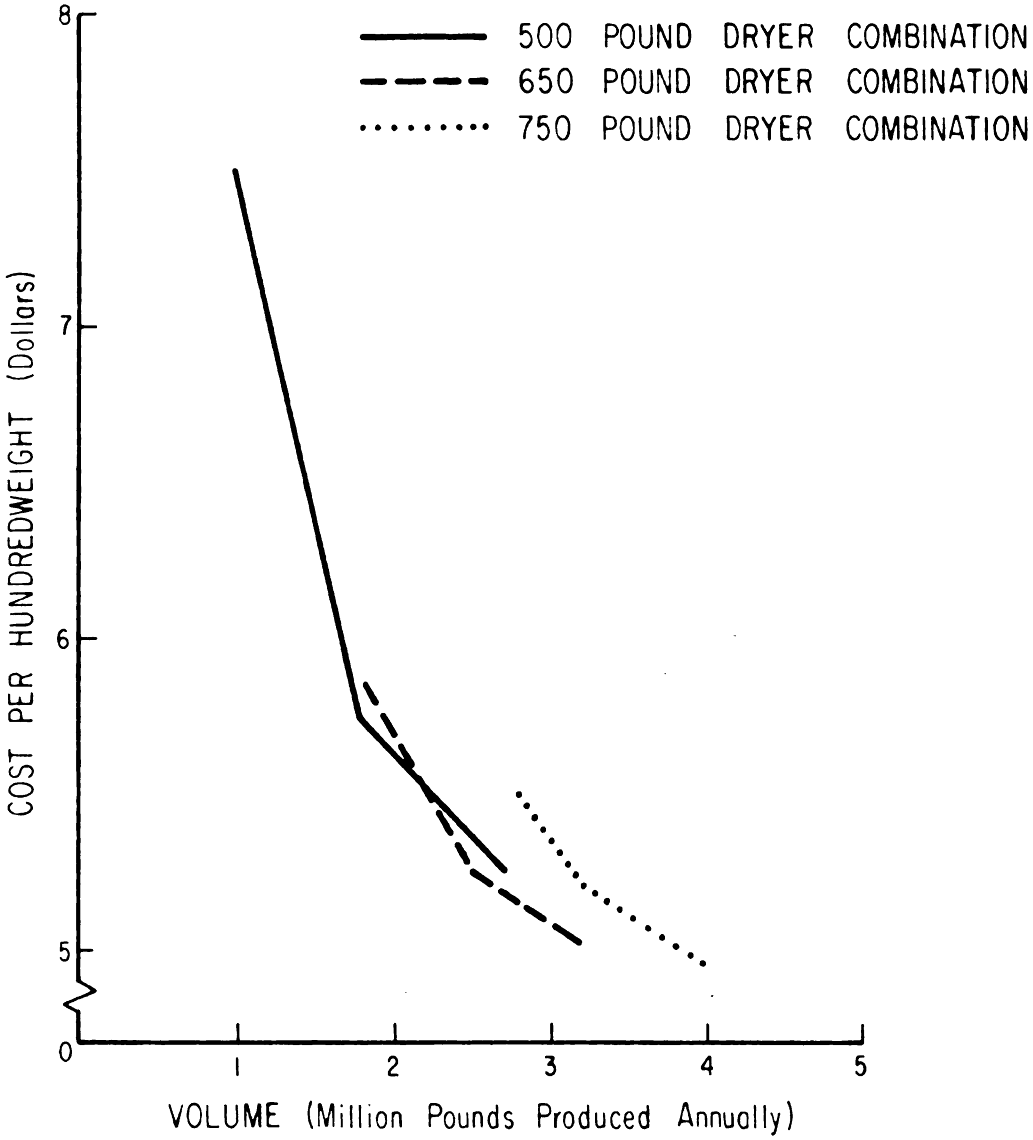


FIG. 4 COST OF SPRAY DRYING SKIMMILK WITH SEVERAL COMBINATIONS AT VARIOUS VOLUMES. THE STUDY IS THE RESULT OF THREE MODEL PLANTS, IOWA STATE COLLEGE, AMES

The relationship between volume of dry milk produced and average manufacturing cost per pound in 17 Minnesota spray drying plants, 1947 and 1953 may be observed in Figure 5. The greatest reduction in manufacturing costs occurred in those plants which increased output from about 3 million pounds to about 5 million pounds during the interval from 1947 to 1953. Those plants which were in the 4 to 5 million pound output range in 1947 and increased to around 6 million pounds in 1953 showed only slight reductions in manufacturing costs.

The plants in the 5 to 6 million pound and 6 to 7 million pound ranges showed increased manufacturing costs. This indicates that, for this type and scale of plant, the greatest cost reduction through increased volume occurs at volumes under 6 million pounds per year. Beyond this output, cost reduction resulting from spreading fixed costs is slight and other methods of increasing efficiency are needed to achieve further cost reductions.

The average cost of manufacturing dry milk in 18 Minnesota spray drying plants has decreased since 1947. Data from these 18 plants indicate a total manufacturing cost of 3.23 cents per pound of non-fat dry milk solids produced in 1953, which is a reduction of 0.32 cent from the 3.55 cents reported in 1947.

The two most important cost factors are labor and fuel, which represent about 34 and 28 percent of the total manufacturing costs respectively according to the Minnesota results. Even with substantial increases in wage rates, increases in labor efficiency

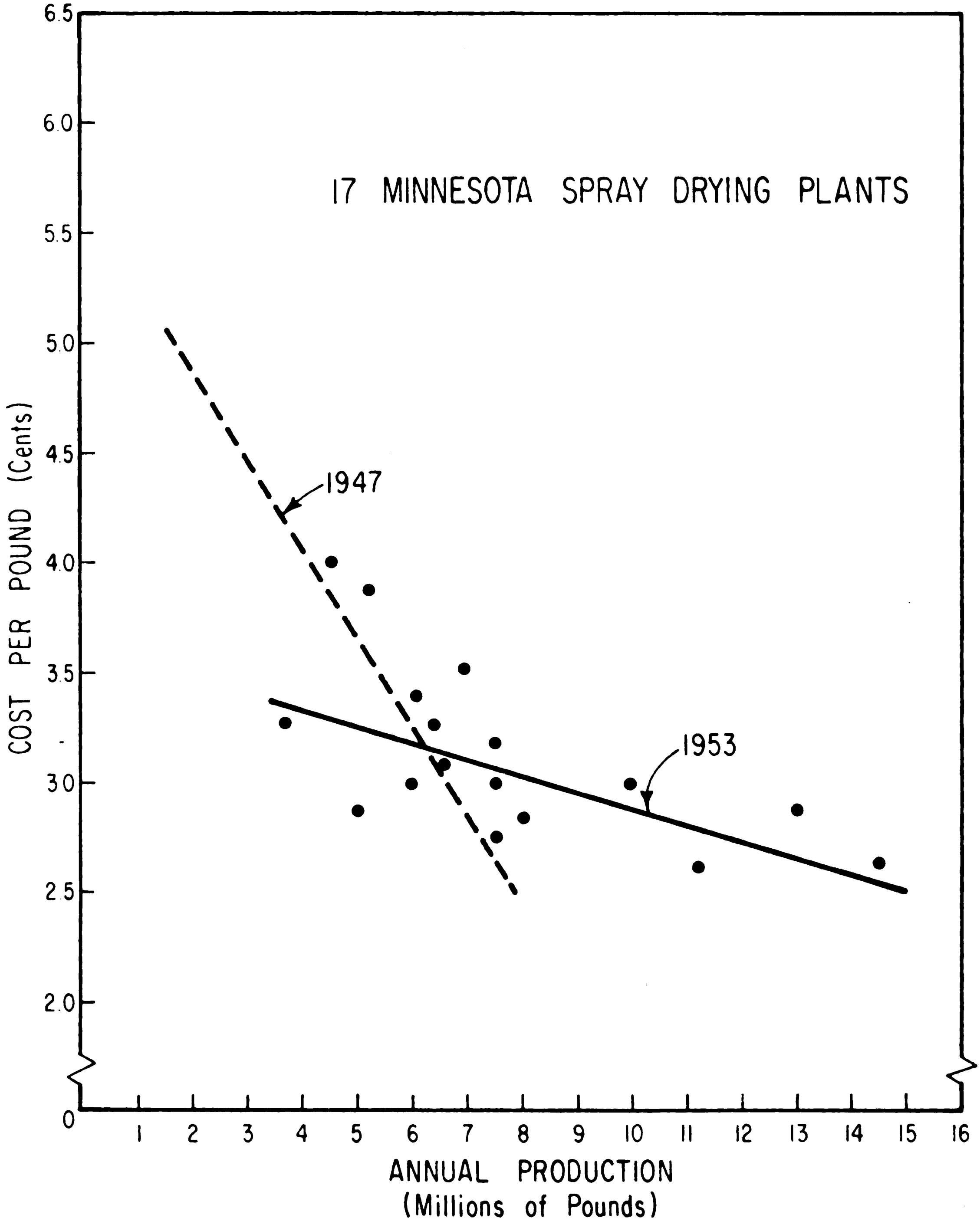


FIG. 5 RELATIONSHIP BETWEEN VOLUME OF DRY MILK PRODUCED AND AVERAGE COST PER POUND

were large enough to cause a reduction in the per unit labor cost.

The output of dried milk per hour of plant labor varies considerably from plant to plant. In general larger plants are more efficient in the utilization of labor although there are large variations between plants of nearly the same output. These plant to plant variations indicate that management as well as volume, plays an important role in maintaining labor efficiency.

The fact that labor cost is one of the largest variants between plants suggests that the quality of management is a major determining factor in a plant's costs.

The bigger wages demanded by managers of exceptional ability are often, in fact, very low when viewed on a per unit basis and compared to the cost reduction that can be achieved. Even in the smaller plants, managerial wages account for only about 0.1 cent per pound of dry milk produced while variations in labor cost due to labor management may be twice this amount. Economising on managerial costs by accepting less capable management is a false economy.

Larger economies can also be achieved in many cases by the adoption of new types of equipment or new techniques which improve labor or fuel efficiency. Advances in both processing and product handling equipments have been quite rapid in recent years and plant managers should stand ready to appraise and adopt any advance which can improve their plant efficiency and reduce costs.

CHECK LIST FOR IMPROVING OPERATIONS

1. Can the solid content of the skim milk be standardized uniformly throughout the process cycle?
2. Can the uniformity of the rate of flow of milk be maintained from reservoir tank to the process?
3. Can gravity feed eliminate the use of pump between reservoir tank and the preheater?
4. Can the instant heating arrangement be made to attain 200° F in few seconds without any damage to protein of the milk?
5. Can air operated values be used to operate the flow of milk in the process to avoid walking and manual operation and thus save labor?
6. Can milk be preheated before evaporation while flowing through a jacketed pipe with steam under high pressure and temperature, from storage tank to the evaporator in order to eliminate the tubular heater and extra pump?
7. Can steam be injected directly in the above arrangement of milk flow in order to aerate the milk and increase the temperature?
8. Can the hot well be eliminated by direct injection of steam and hot air in the pipe in the above arrangement?
9. Can the inlet of milk into the evaporator be regulated according to the rate of evaporation with the help of a regulating valve acting according to the velocity of vapour flow from evaporator to the condenser?

10. Can the above inlet milk regulating valve operation be linked to operate directly the steam inlet valve into the evaporator and the water inlet valve of the condenser for admitting the proportionate flow of steam and cold water?
11. Can the above three valves for milk, steam, and water be operated by an adjustable governor hydraulically or thermostatically operated for quantitative and qualitative control during condensing milk into the evaporator?
12. Can the investment in installation of the above control equipment be justified by the savings?
13. Can the evaporator be fitted with an indicator to show the percent of solids of the condensed milk or percent of the moisture content of the condensed milk automatically with recording devices?
14. Can the above recording pen be used or connected to give a signal after crossing the limit of certain required consistency of the milk either through an electric bell or glow of red lamp?
15. Can an indicator of above type be fitted to give alarm signal in the event of difficient supply of steam into the evaporator or of its sudden failure?
16. Can the spray of milk into the dryer be regulated through the opening and closing of delivery value of high pressure pump governed by the fluctuation of temperature inside the dryer?
17. Can the spray of milk into the dryer be made to attain more

turbulent flow to perform drying under the principle of high temperature short time taking care to prevent damage of protein of the milk?

18. Can the spray of milk into the dryer in multidirection be adjusted in a manner so as to attain maximum utilization of heat under optimum condition?

19. Can a saturation point be fixed for maximum utilization of heat under dryer operation with optimum output of powder and for different products under different working conditions?

20. Can a characteristic curve be drawn on the fixation of above saturation point and a direct relation of variation or percentage deviation of this curve in relation to the fluctuation of exhaust temperature of the dryer be established, for recording and expressing the dryer control?

RECOMMENDATIONS

1. The layout of the equipment should be designed for the most compact unit in a milk powder plant to enable the operator work at maximum efficiency and at the least man-hours required per unit of production of milk powder.

   All the units under operation should be located on one floor with least possible distance from one unit to the other with control panel in the middle.

2. Reduce cycle of starting operation to gain longer production hours by elimination of waste motions and rearranging the sequence of operation.

   Internalize external time; i.e. perform maximum amount of manual work during automatic operation of the equipments into the process.

   In the process of manufacturing milk powder, the condensing of milk by evaporator requires the longest time among all the elements of operation. Efforts should be made to perform all other elements in the starting operation during the longest element of condensing operation. When beginning the heating of evaporator, the preheating of milk by instant heating process for the fraction of a minute and heating of the dryer should be completed before the condensed milk is ready for spray drying. This arrangement will reduce the cycle of starting operation and result in more production hours with increased plant efficiency.

3. Reduce labor by effecting improvement in methods, employing improved design of equipment and by employing automatic control devices as far as practicable.

4. For smooth working of the operation and efficient maintenance, the improvement in design of fittings is necessary to meet the following defects normally experienced in a dryer.

   (i) Spray nozzle gasket gets damaged due to fitting defects.

   (ii) Spray nozzles get choked due to burned or some foreign particles in the milk although there is strainer over the pressure pump. There should be a gage to indicate the gradual choking of the nozzles. Every eight hours spray nozzles have to be taken out one by one and cleaned of deposited solid particles.

   (iii) Gland leakage of high pressure pump along circulating water.

   (iv) Gland packing for plunger made of compressed fibre lasts about two weeks. It can be replaced by spring type metallic packing.

   (v) When the electric motors driving the intake and exhaust fans into the dryer fails, the high pressure pump floods the dryer with milk. There should be device to stop the high pressure pump when the fans fail.

   (vi) Unless the pre-heater is full of water or milk, the steam inlet should not open for preheating the liquid.

5. The following automation can be used for attaining improvement in quality and quantity although not necessarily economy of the production of milk powder at higher working efficiency:
   (a) Instant heating of milk at 300° F in few seconds and elimination of tubular heater and hot well.
   (b) Use of thermo-compression for attaining fuel economy.
   (c) Use a liquid controller between preheater and evaporator.
   (d) Flow-diversion valve at the delivery of evaporator to control the consistency of condensed milk with indicator chart.
   (e) Thermostatic controlled valve to balance the proportion of vacuum and steam supply into the evaporator to ensure uniform quality of condensed milk and prevent frequent checking and adjustment.
   (f) Use of Mechallis trap for pumping condensed milk from the evaporator against vacuum. This will operate automatically with the help of steam and vacuum and will avoid the use of motive power for the pump.
6. It has previously been reported that only one man is needed to operate the evaporator and dryer having dryer of 750 lb. per hr. capacity, but the present study enables the author to say that in an ideal plant having capacity up to 1000 lb. per hr. only one man will be needed to operate all the three units from evaporator to the powder packaging.
7. Determination of standard time for each element of operation

for manufacture of skim milk powder is subject to further modification based on more refined and accurate data.

3. Further time study appears necessary for determining the monetary losses sustained per unit production of milk powder in unbalanced and plants outmoded.

SUMMARY AND CONCLUSIONS

To make the most profitable investment in a new set-up and to make useful utilization of the investment already made for manufacture of milk powder, dairy plant managers and directors need reasonably accurate information on fundamentals of management.

In the present study it was found that the standard time of operation and work required for production of 1000 lb. of powder varied considerably from 1.23 man-hr. to 4.2 man-hr. The smaller plant was more efficient in utilization of labor than the larger plant which had units on different floors with a separate operator for each unit.

The reason for the layout of such outmoded plants is that the milk drying untis were accommodated in multi-product plants as subsidiary units in the available space without the scientific planning desired.

In a multi-product plant in which the receiving and separating equipment for milk are required for other products, the drying operation is used as an outlet for the plant surplus (without additional inputs) with a view to maximise the profit.

In butter plants, the maximization of the profit is attempted by addition of a skim milk drying unit and the drying operation becomes the major source of revenue. The prime consideration in these plants is to have available facilities which will add flexibility to the overall plant operations and also dispose of surplus skim milk as economically as possible. But the rate of utilization of skim milk powder for human food has increased tremendously making it a major item of dairy product in the whole world and milk drying operation is a major source of revenue for the plant. As such it deserves all the more economic consideration now than ever before and the management needs more to look closely at the work and workmen.

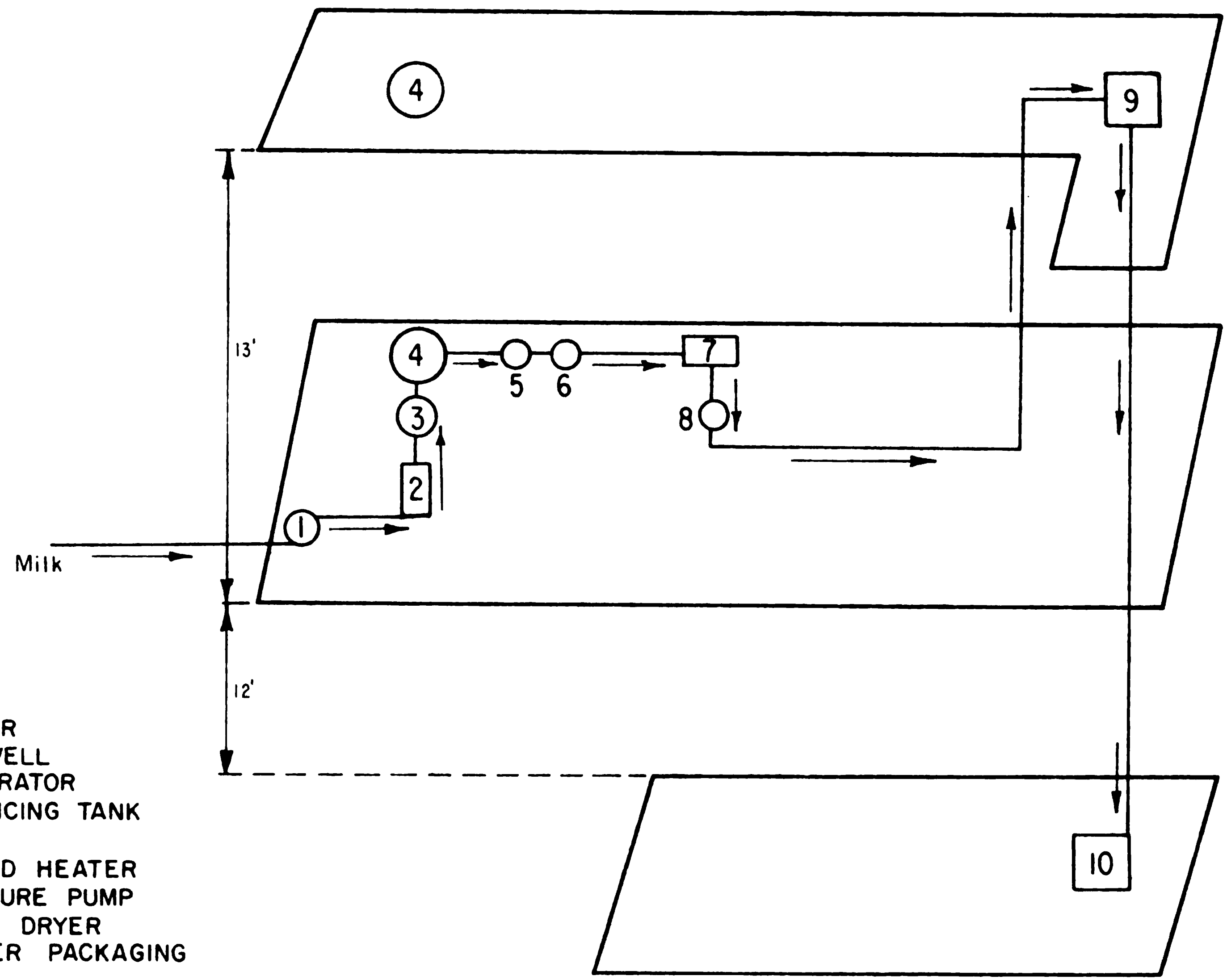
This comment along with the method of motion and time analysis used in the data collection for this thesis will give an excellent basis for work simplification, methods improvement, cost reduction, invaluable information on a company's operation and improved engineering design of equipment and plant layout. In a properly designed plant one man can operate spray drying equipment with a capacity of 1000 lb. per hr.

The machine cycle time of an operator varied from 45 to 55 minutes, of which the operator was idle from 34 to 38 minutes. Suggestions are presented for decreasing the idle time.

APPENDIX A

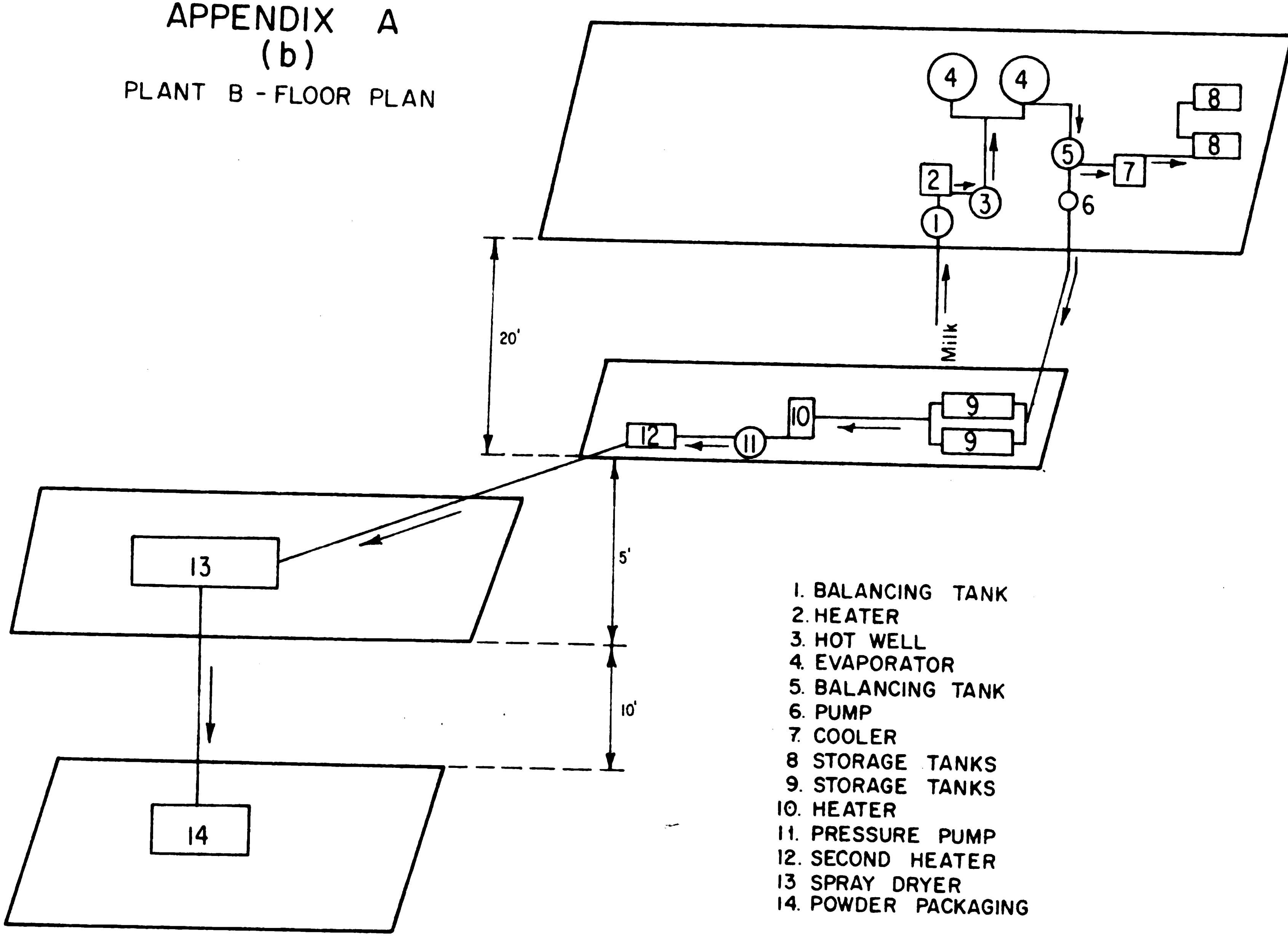
Floor Plans of Plants Studied

APPENDIX A
(a)
PLANT A - FLOOR PLAN



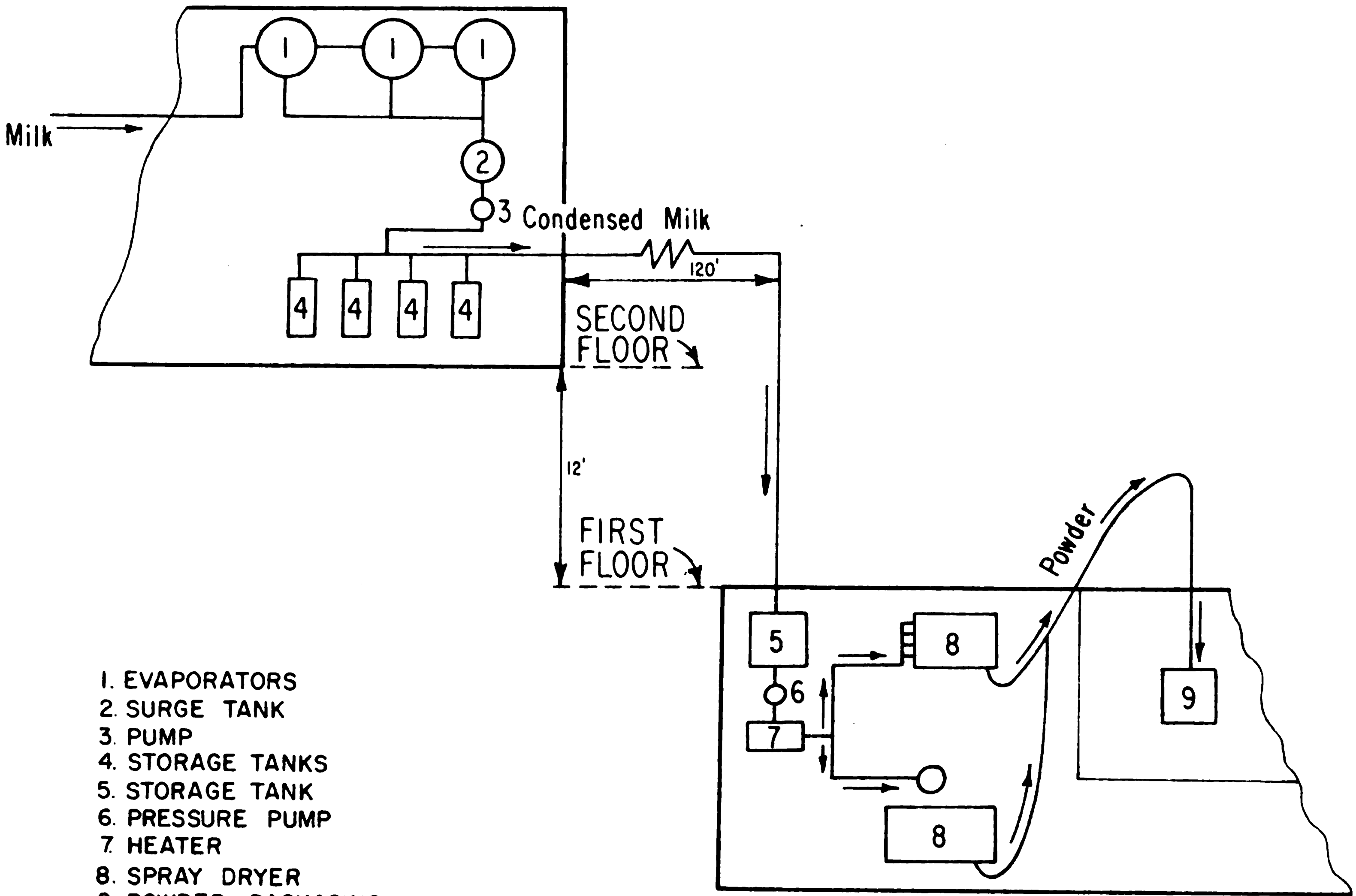
1. PUMP
2. HEATER
3. HOT WELL
4. EVAPORATOR
5. BALANCING TANK
6. PUMP
7. SECOND HEATER
8. PRESSURE PUMP
9. SPRAY DRYER
10. POWDER PACKAGING

APPENDIX A
(b)
PLANT B - FLOOR PLAN



1. BALANCING TANK
2. HEATER
3. HOT WELL
4. EVAPORATOR
5. BALANCING TANK
6. PUMP
7. COOLER
8 STORAGE TANKS
9. STORAGE TANKS
10. HEATER
11. PRESSURE PUMP
12. SECOND HEATER
13 SPRAY DRYER
14. POWDER PACKAGING

APPENDIX A
(c)
PLANT C - FLOOR PLAN



1. EVAPORATORS
2. SURGE TANK
3. PUMP
4. STORAGE TANKS
5. STORAGE TANK
6. PRESSURE PUMP
7. HEATER
8. SPRAY DRYER
9. POWDER PACKAGING

APPENDIX 'B'

Flow Process Chart

MILK POWDER DRYING OPERATION

PLANT A

Step	Old Method	Dis-tance in ft.	Time in Min.
1	Open steam by pass valve to heat the coil		.18
	To spray nozzle of the dryer	35	
2	Open all the nozzles by pass valves		.82
	To containing temp. recording chart open almira	30	
3	Pick up recording chart and close almira		.65
	To temperature recorder	40	
4	Fix up chart on the recorder		.25
	To mechanical shaker	5	
5	Start the shaker		.10
	To condensed milk preheater circulating pump starting switch	25	
6	Start circulating pump with water for circulation in milk line		.58
	To pressure pump	12	
7	Start pressure pump		.24
	To spray nozzles	70	
8	Open, wash and fix nozzles in pipe pieces and close all nozzle valves		8.0
	To circulating pump switch	70	
9	Stop circulating pump		.64
	To spray nozzles	60	

MILK POWDER DRYING OPERATION
(Cont.)

Step	Old Method	Dis-tance in ft.	Time in Min.
10	Fix up pipe pieces with spray nozzles in working order		3.0
	To main steam valve for heating the coil	35	
11	Open the steam valve fully		.3
	To drying chamber exit air damper	20	
12	Open the damper		.2
	To blower fans starter	25	
13	Start the inlet and outlet blower fans and shut off		1.5
	To condensed milk storage tank	50	
14	Open the outlet valve of the storage tank		.5
	To starting switch for milk pump and heater condensate pump	15	
15	Start milk pump and condensate pump for the preheater		1.0
	To pressure pump	12	
16	Start pressure pump and develop pressure up to 1500 pounds and shutt off the pressure pump		2.0
	To blower fans starter	50	
17	Start the blower fans for raising temperature of drying chamber- await for the rise of temperature in drying chamber		.5 .16
	To hi-pressure pump starter (alternative arrangement)	5	

MILK POWDER DRYING OPERATION

(Cont.)

Step	Old Method	Distance in ft.	Time in Min.
18	Restart hi-pressure pump		.2
	To spray nozzles	35	
19	Open nozzles partly, check the spray and open full		3.0
	To powder conveyor switch	10	
20	Start conveyor		.10
	To powder packaging room for powder sample	155	
21	Get sample of powder from bag		1.10
	To laboratory for moisture test	175	
22	Testing of moisture content in powder and record it		12.5
	To hi-pressure pump	40	
23	Adjust hi-pressure pump to desired working		1.15
	To outlet air damper	25	
24	Adjust damper to desired temperature		1.0

MILK POWDER DRYING OPERATION

PLANT A

Step	Improved Method	Distance in ft.	Time in Min.
1	Open steam valve to heat the coil		.18
	To drying chamber air outlet damper	25	
2	Open damper, start shaker, fix up temp. recording chart out of a box attached to it		1.6
	To blower fans starter	30	
3	Start blower fans for heating the drying chamber		.38
	To condensed milk preheater pumps starter	50	
4	Start condensed milk preheater pumps with water		.5
	To hi-pressure pump	12	
5	Start hi-pressure pump with water and circulate it through the nozzle by pan line and shut off the pump		1.0
	To spray nozzles	70	
6	Fix up spray nozzles with other pipe pieces in working order and open by pan valves		3.0
	To condensed milk storage tank	75	
7	Open storage tank outlet valve		.5
	To circulating pump for preheater	8	
8	Start circulating pump with condensed milk and also condensate pump, simultaneously		.3
	To hi-pressure pump	6	

MILK POWDER DRYING OPERATION

(Cont.)

Step	Improved Method	Distance in ft.	Time in Min.
9	Start hi-pressure pump, create pressure in the line and expel water from the line through nozzle by pan		1.0
	To nozzles	60	
10	Stop hi-pressure pump		.1
	To hi-pressure pump	60	
11	Close by pan valves and open nozzles partially		1.0
	To spray nozzles	60	
12	Start hi-pressure pump and develop pan		.5
	To temperature recorder	30	
13	Check spray and open valves full		1.5
	To powder conveyor switch	2.5	
14	Observe variation of temperature after spray and adjust the damper		.5
	To powder packaging room	155	
15	Start powder conveyor	2.5	
	To laboratory	175	
16	Get powder sample for moisture test	.5	
	To hi-pressure pump	40	
17	Test moisture content of the powder and record the results	12.5	
	Adjust hi-pressure pump to required pressure		1.0

APPENDIX C

Milk Powder Packaging Operation
"THERBLIG" in Plant 'C'

PLANT "C"

MILK POWDER PACKAGING OPERATION

THERBLIG

Left-Hand Elemental Description			Right-Hand Elemental Description
1. Move hand to empty bag.	TE	TE	1. Move hand to metalic ring.
2. Grasp empty bag.	G	G	2. Grasp metalic ring.
3. Move empty bag to sifter.	TL	TL	3. Move ring over the top of bag.
4. Hold bag.	H	A	4. Insert ring over bag mouth.
5. Hold bag.	H	A	5. Fit over powder chute.
6. Reach sifter switch.	TE	I	6. Idle.
7. Push the starter switch.	U	I	7. Idle.
8. Reach to bag on weigh scale platform.	TE	TE	8. Reach to spatula.
9. Grasp the bag.	G	G	9. Grasp the spatula
10. Hold the bag.	H	TL	10. Move the spatula to powder drum.
11. Hold the bag.	H	U	11. Draw or grab powder.
12. Hold the bag.	H	TL	12. Move powder to bag.
13. Hold the bag.	H	RL	13. Release powder to bag.
14. Reach to tag.	TE	TL	14. Move spatula to destination.
15. Grasp tag.	G	RL	15. Release.
16. Move to bag.	TL	PP	16. Preposition.
17. Grasp bag liner mouth.	G	TE	17. Reach bag liner mouth.

Plant C - Milk Powder Packaging Operation. (Cont.)

18. Draw liner mouth to goose neck.	U	U	18. Draw liner mouth to goose neck.
19. Hold goose neck.	H	G	19. Grasp tag.
20. Hold goose neck.	H	U	20. Tie liner mouth.
21. Push liner below.	U	G	21. Grasp bag mouth's one end.
22. Grasp bag mouth's other end.	G	G	22. Grasp bag mouth's one end.
23. Lift the bag a little and release.	U	U	23. Lift the bag a little and release.
24. Fold bag mouth.	U	U	24. Fold bag mouth.
25. Hold the fold of bag.	H	TE	25. Reach to stitching machine.
26. Hold the fold of bag.	H	G TL	26. Grasp and move swinging stitching machine to bag.
27. Hold the fold of bag.	H	U	27. Stitch bag mouth.
28. Hold the fold of bag.	H	TL	28. Move stitching machine to its position.
29. Hold the fold of bag.	H	RL	29. Release.
30. Hold the fold of bag.	H	TE	30. Reach to bag.
31. Hold the fold of bag.	H	G	31. Grasp the bag tray.
32. Move aside the bag on tray.	TL	TL	32. Move aside the bag tray.
33. Release.	RL	RL	33. Release.
34. Reach to sifter switch.	TE	TE	34. Reach to sifter platform vibrator switch.
35. Push the switch to stop sifter.	U	U	35. Push the switch for vibrating the bag.
36. Reach to bag.	TE	TE	36. Reach to bag.

Plant C - Milk Powder Packaging Operation. (Cont.)

37. Grasp the bag.	G	G	37. Grasp the bag.
38. Move the bag to weigh scale platform.	TL	TL	38. Move the bag to weigh scale platform.
39. Release the bag.	RL	RL	39. Release the bag.
40. Move hand to empty bag.	TE	TE	40. Move hand to empty bag.

PLANT "C"

POWDER PACKAGING OPERATION

IN 50 POUND BAG WITH POLYETHYLENE LINER

DESCRIPTION OF ELEMENT	CONDENSED DESCRIPTION AND END POINT OF THE ELEMENT FOR TIMING THE ELEMENT
1. When the bag is full of powder close the sliding door of the powder chute under sifter by a shutter, switch off the sifter, untighten the bag mouth from the sifter and remove the bag to weighing scale platform behind.	1. Stop sifter and remove powder bag from sifter to weighing scale platform. End point of element - put the bag on weigh scale platform.
2. Pick up fresh bag from the side and fit in the powder chute of the sifter for filling; tighten the mouth, and start the sifter again.	2. Fit fresh bag in mouth of sifter chute for filling. End point of the element - Push the starting switch of the sifter.
3. Turn towards weigh scale, pick up spout and take out or fill in powder in the bag for correct measurement, read the scale, keep away the spout at pre-position.	3. Weigh the bag to desired quantity. End of element - keep away the spout in its position.
4. Close the mouth of polyethylene liner inside the paper bag by making goose neck and tie with cotton thread knots.	4. Close and tie the mouth of polyethylene liner inside the paper bag. End of element - Push tied polyethylene liner mouth below.
5. Straighten the bag, vibrate it, fold the mouth edge of paper bag for closing. Pull the hanging stitching machine and stitch the bag mouth. Set aside the stitching machine.	5. Close the mouth of paper bag and stitch it. End of element - set aside the stitching machine.

Plant C (Cont.)

6. Hold the bag from both hands and aside it over the tray loaded on the fork truck.

6. Remove the bag to tray for further transporting it in warehouse. End point of element - release the bag on tray.

7. Drive away the fork truck after lifting the bag tray to warehouse. Stack the bag tray. Pick up another tray and place it near the weighing scale for bag piling.

7. Stack the powder bags in the warehouse with the help of fork lift truck. End of element - position fresh day.

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