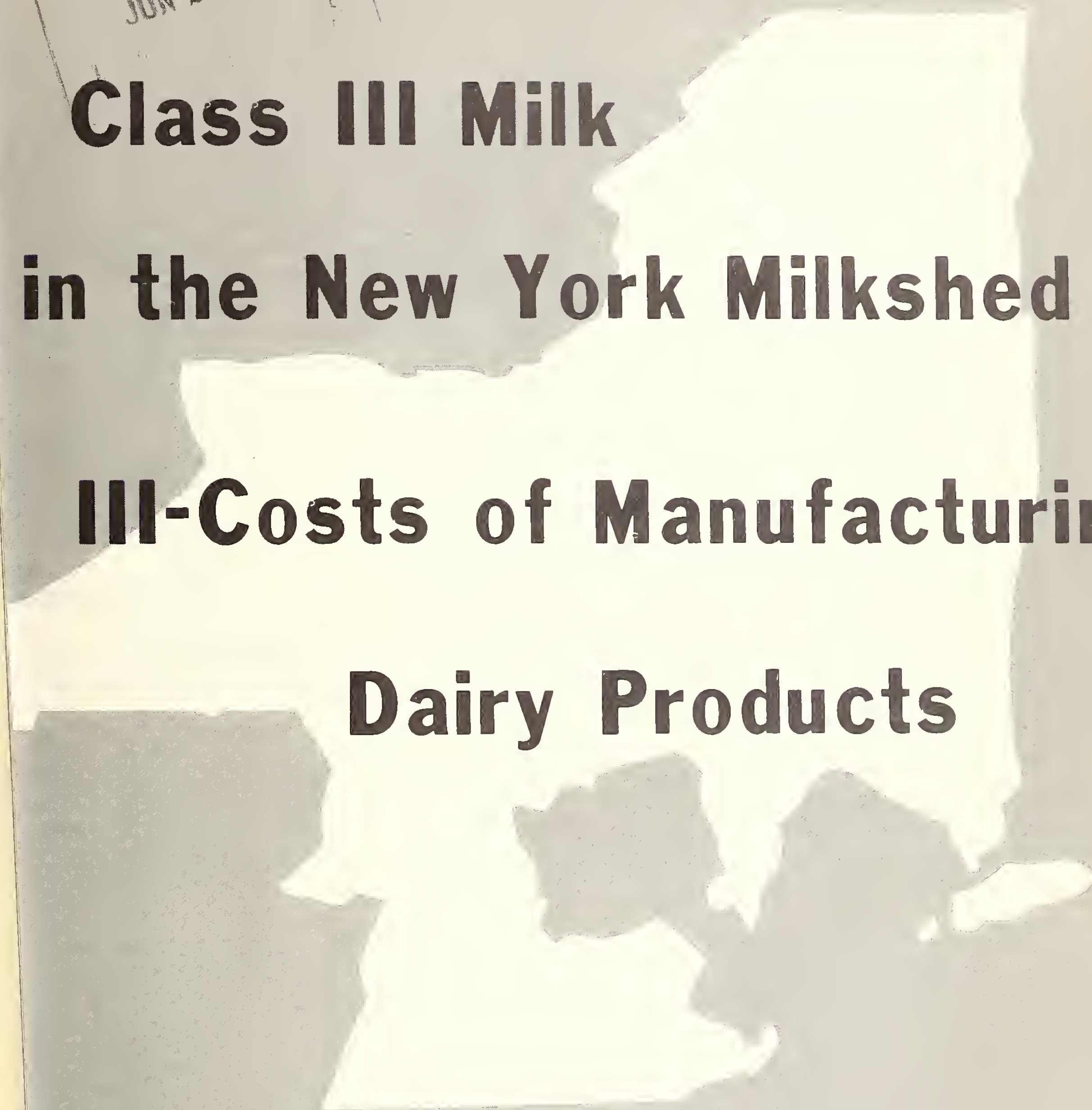
MARKETING RESEARCH REPORT NO. 400

Class III Milk in the New York Milkshed

III-Costs of Manufacturing Dairy Products



U. S. DEPARTMENT OF AGRICULTURE
AGRICULTURAL MARKETING SERVICE
MARKETING ECONOMICS RESEARCH DIVISION

PREFACE

This report is one of a group dealing with Class III milk pricing in the New York-New Jersey milkshed. Particular emphasis is given to factors affecting the market for Class III products and to the decisions which handlers make about the form in which they will dispose of Class III milk. The project under which this group of publications has been developed was carried out by the Marketing Economics Research Division, Agricultural Marketing Service. A substantial part of the cost was financed by a grant from the New York-New Jersey Milk Market Administrator. This project is part of a broad program of marketing research aimed at expanding markets for farm products and improving the efficiency of marketing.

This report describes the development of processing costs for 11 plants; 1 receiving, cooling, and shipping milk, and 10 manufacturing various dairy products or combinations of products. The procedure used was the synthetic method of cost analysis, utilizing the various inputs (in efficient combinations) with current prices to arrive at typical costs for plants of specified volumes. The report describes in detail the procedure by which costs were estimated in three kinds of plants: (1) A receiving station, (2) a Cheddar cheese plant, and (3) a plant producing cream and nonfat dry milk. The report also gives a description and cost analysis of the modifications required to process other combinations of products. Finally, unit costs are presented in terms of processing 100 pounds of milk into the respective products or combinations of products.

Previous reports in this group were:

Class III Milk in the New York Milkshed:

I Manufacturing Operations
II An Economic Description of the Manufactured Dairy Products Industry

Additional reports that we hope to include will relate to processing margins, processors' decisions on utilization of this milk, and economic aspects of pricing Class III milk.

The work on which the reports are based was done by a research team composed of Donald B. Agnew, F. W. Cobb, Jr., C. E. McAllister, and T. R. Owens, under the general supervision of D. A. Clarke, Jr. (on leave from the University of California). Additional assistance was obtained from Irving Dubov (on leave from the University of Tennessee).

The cooperation of representatives of the dairy industry, as well as members of the various regulatory agencies, is gratefully asknowledged. R. G. Bressler, Professor of Agricultural Economics, University of California, and consultant to the Marketing Economics Research Division, contributed substantially to the analysis of the problem with which the study deals, and to the planning of the work. His article, "Pricing Raw Product in Complex Milk Markets" (Agr. Econ. Res. 10(4):113, October 1958), embodies a part of this contribution. Louis F. Herrmann, Head, Dairy Section, Marketing Economics Research Division, contributed both to the inception and progress of the project and to the development and preparation of substantial parts of the study.

CONTENTS

May 1960

SUMMARY

The costs of processing Class III milk into selected products at typical plants were estimated to range from 44.8 cents to 73.5 cents per 100 pounds in the New York-New Jersey milkshed in 1958. These cost estimates were synthesized from data on requirements for buildings, equipment, labor, and other items of expense needed for processing milk into the products selected. They included all cost elements from the receipt of the raw milk until the products were ready for shipment, but omitted some selling, delivery, and administrative expenses and profits. The study was made primarily to provide information for evaluating the net margins available to manufacturers, but such information should help dairy firms in making production decisions, and in evaluating their production efficiency.

The basic estimates were made for three types of plants: A receiving station, a Cheddar cheese plant, and a plant processing milk into cream and nonfat dry milk. Estimates for the cream-nonfat dry milk plant were modified to reflect costs of processing four other products in various combinations. The combinations each consisted of one fat-using product--butter, cream, or ice cream mix--and one skim-milk product--nonfat dry milk, condensed skim milk, or cottage cheese. These products constitute the principal uses made of Class III milk in the New York-New Jersey milkshed.

The processing cost per hundredweight of milk received for the 11 products or combinations of products is as follows:

Receiving station	$0.166
Cheddar cheese	.735
Butter and nonfat dry milk	.626
Butter and condensed skim milk	.476
Butter and cottage cheese	.571
Cream and nonfat dry milk	.599
Cream and condensed skim milk	.448
Cream and cottage cheese	.564
Ice cream mix and nonfat dry milk	.604
Ice cream mix and condensed skim milk ...	.478
Ice cream mix and cottage cheese	.605

This study used the budgetary or synthetic model procedure, widely used recently in developing cost estimates for a variety of agricultural marketing processes. The procedures for the present study, and the results, are presented in detail, so they may be more easily compared with data from various sources, or adjusted for changes in prices over time. Some comparisons with other studies are presented in the report. The measure of agreement was well within the range of costs that probably exists among individual firms within the milkshed.

Class III milk, under the terms of Federal and State milk marketing orders for the New York-New Jersey milkshed, is milk used for manufactured dairy products. It is in excess of current sales of fluid milk (Class I) and certain sales of fluid cream and related products (Class II). About 39 percent of the total milk receipts in the New York-New Jersey pool was used for Class III purposes in 1958.

CLASS III MILK IN THE NEW YORK MILKSHED:

III. COSTS OF MANUFACTURING DAIRY PRODUCTS

by T. R. Owens and D. A. Clarke, Jr. 1/
Marketing Economics Research Division
Agricultural Marketing Service

INTRODUCTION

Purpose of the Study

The central aim of this report is to provide estimates of the costs of processing the major types of manufactured dairy products which utilize Class III milk. Such information will serve two purposes. In the first place, data on such costs were required for an analysis of available net margins from the production of alternative types of dairy products. 2/ Differences in net margins between alternative products influence the profit account of the firms engaged in processing and so can be expected to affect the utilization of milk for manufacturing purposes. Consequently, the relative profitability of alternative combinations of products is a consideration in evaluating the effect of Class III pricing procedures under the Government milk marketing orders. The second purpose served by information on the relative levels of costs associated with alternative combinations is that, properly interpreted, it can be helpful to the dairy firms both in making decisions regarding production, and, by comparison with their own realized costs, in evaluating their productive efficiency.

Minimum prices paid to farmers by distributors in the New York-New Jersey milkshed for milk eligible for fluid consumption are controlled by the operation of Federal Milk Marketing Order No. 27, and concurrent New York and New Jersey orders. These orders are identical, and like similar orders in effect in other markets of the United States they specify the use of a "classified price" plan.

Milk produced in this milkshed area and not sold to consumers as fluid milk (Class I) nor included in certain sales of fluid cream and related products (Class II) is used in manufactured dairy products. This is designated as Class III milk under the above orders. For this milk producers receive the lowest price. About 39 percent of the total milk receipts pooled under the New York-New Jersey Federal-State milk marketing order was used for Class III purposes in 1958.

1/ D. A. Clarke, an associate professor of Agricultural Economics, University of California, was employed by the Agricultural Marketing Service while on leave from the University.

2/ This analysis of net margins will appear in the next publication of this group of Class III studies. McAllister, C. E., and Clarke, D. A., Class III Milk in the New York Milkshed: IV. Processing Margins for Manufactured Dairy Products, U. S. Dept. Agr., Mktg. Res. Rpt. In preparation.

The average price received by producers for pool milk was $4.44 per hundredweight compared to an average price of $5.71 per hundredweight paid by handlers for Class I-A milk in this same period. The Class III price was $3.05 per hundredweight (all these prices were for milk delivered to plants in the 201-210 mile zone).

Scope and Procedure

This study has been limited to determining costs for plants manufacturing 11 major products or combinations of products. This decision was based in part on the importance of these selected products in the disposition of Class III milk in this area, and in part on the limitations of time available for making the analysis. Cheddar cheese was the only manufactured product made from whole milk. The combinations of other products (utilizing cream and skim milk) included: Cream and spray-process nonfat dry milk, cream and condensed skim milk, cream and cottage cheese, butter and nonfat dry milk, butter and condensed skim milk, butter and cottage cheese, ice cream mix and nonfat dry milk, ice cream mix and condensed skim milk, and ice cream mix and cottage cheese. In addition, costs were computed for a plant receiving milk from producers and shipping whole milk.

This study used the budgetary or synthetic model procedure as developed and applied by Bressler (4), Conner, Spencer, and Pierce (10), Brewster (6), and others. 3/ This technique has been widely used recently in developing unit and total costs for a variety of dairy products ranging from fluid milk (9) to butter (12), butter and nonfat dry milk (25), and evaporated milk (3).

This technique, sometimes called the "building block technique," is used to develop model plants of specific capacity, equipment, and labor force, and to determine their costs. The models are assumed to use the processing techniques, managerial practices, market organization, and institutional arrangements actually prevailing in the industry. Once such a plant has been designed and organized as an efficient and workable operation, it is possible to attach money prices to the various inputs and so to calculate total and unit costs.

The synthetic procedure was selected over the accounting or statistical approach because within the dairy industry differences in wage rates, prices (of equipment, supplies, and other items), input rates, plant and labor efficiency, and managerial skills are such that little comparability exists in costs among plants of the same general size and type. This greatly increases the difficulty and expense of selecting an appropriate sample and collecting data from which statistically reliable conclusions can be drawn. The synthetic technique attempts to overcome this difficulty by applying the same input standards and prices to all plants in the series to be studied.

A second reason for selecting the synthetic model technique was the facility with which this method lends itself to modification and adaptation. This quality enables the investigator to develop costs for a wide variety of

---

3/ Underscored numbers in parentheses refer to items in the Literature Cited, p. 56.

products by modifying the basic model to conform to other sets of processing requirements. In addition, the results can be applied to other areas or time periods involving different prices by merely changing the prices used to determine the various costs.

Three basic types of dairy plants were synthesized for this study: The receiving station, the cheese plant, and the cream-nonfat dry milk plant. The latter was then subjected to several modifications to permit the manufacture of the other combinations of products.

The primary objective of the cost analysis was to determine costs which would be consistent with reasonably efficient operations in the New York-New Jersey milkshed. These reasonably efficient levels were determined by the specifications for equipment, labor, and other inputs developed in the plant synthesis. It is recognized that this procedure will not reflect "average" processing costs for the market--the type of figure that might be used directly for price-setting purposes. Neither does it reflect costs for any particular plant (except for the "hypothetical" plant so specified). However, the level of costs so obtained should represent attainable levels under conditions of efficient organization. Furthermore, costs for processing any one of the alternative products and combinations determined by this method will tend to be consistent with the costs of the others provided that the plant specifications (building and labor requirements) and modifications, as well as the cost rates, are themselves consistent.

Receiving Station

The function of the receiving station is to receive milk from producers, weigh and test it to determine payments to producers, and cool and assemble the milk for transshipment to another plant. The shipment may be to a city milk plant for distribution as fluid milk or to a manufacturing plant. In the latter case, the services provided by the receiving station are of major importance to this study since manufacturing plants require large quantities of raw milk to produce enough to justify the necessary investment.

The quantity of milk drawn from a particular area depends on such factors as number of cows, production per cow, and competition for the supply. If these factors remain fixed, a plant desiring to increase its supply must expand the geographic area it serves. The costs of direct shipment from farm to plant increase with expansion of the supply area until such shipments eventually become uneconomical. A further limitation to increases in the size of milk supply areas has been health regulations which specify that producers' uncooled milk must be received at the plant before a specified hour. 4/ Manufacturing

4/ Sanitary Code of the City of New York, Regulation 48. "Temperature of producers' milk and time of delivery. Milk for pasteurization shall be cooled immediately after milking to a temperature of sixty degrees (60°) fahrenheit or lower . . . except that (a) morning's milk may be delivered without cooling prior to 10:00 a.m. eastern standard time, or eastern daylight time, whichever is in effect . . ." At present this requirement has become less important than it once was as a limitation to the size of milk supply areas, due to the incidence of bulk assembly techniques and the increased cooling efficiency of farm refrigeration systems.

plants have offset these diseconomies of direct hauls from distant farms by making use of "feeder plants" or receiving stations. In 1956-57, there were approximately 200 plants in the New York pool which shipped some part of their supplies to a manufacturing plant. 5/

The physical description of the receiving station synthesized in this study was drawn almost intact from a previously synthesized study on use of labor and equipment in milk receiving plants (8). The plant developed in this latter study, termed "Norma" by its authors, consists of the building, equipment, and labor required for average peak receipts of approximately 92,000 pounds per day. The model receiving plant for the present study was modified from "Norma" in minor respects to conform to conditions in the New York milkshed. One of these modifications involved the application of the seasonal pattern of milk receipts in the New York-New Jersey milkshed. Estimated average daily receipts by months for the model receiving station are shown in table 1.

Table 1.--Receiving station: Estimated average daily receipts of raw milk, by months, New York-New Jersey milkshed, 1958

Month	Average daily receipts
	Pounds
January	66,869
February	66,318
March	79,839
April	82,046
May	89,956
June	91,980
July	74,412
August	62,638
September	58,407
October	59,695
November	54,912
December	58,959
Average	70,522

Based on estimated average daily receipts and assuming 365-day operations, the model receiving station would receive and ship 257,406 hundredweight of milk per year. During the peak season, this plant would handle 1,312 cans per day, while in the months of lower production receipts would drop to 784 cans

5/ Clarke, D. A., McAllister, C. E., and Agnew, D. B. Class III Milk in the New York Milkshed: II. An Economic Description of the Manufactured Dairy Products Industry. U. S. Dept. Agr., Mktg. Res. Rpt. In press.

per day. 6/ This is approximately twice the size of the average receiving station in the New York-New Jersey pool (16). Industry sources indicate, however, that it is an attainable and efficient size.

Cheddar Cheese Plant

Cheese plants do not normally operate for the full year in the New York-New Jersey milkshed. In 1956, there were 14 specialized cheese plants with pool status in the State of New York. 7/ These plants operated from as little as 2 months during that year to a maximum of 10 months. Three plants manufactured cheese for 6 months and four plants were in production for 5 months. Thus, half of the plants studied operated for either 5 or 6 months. All of the plants operated during some part of the period from January through June.

Annual production in these plants ranged from 49,000 pounds of cheese to 2,064,000 pounds. Four plants had an annual production in excess of 1,000,000 pounds and four other plants produced between 500,000 and 1,000,000 pounds annually. The remaining plants made less than 500,000 pounds of cheese during 1956.

The total production for all plants studied indicated an annual output of 13,699,000 pounds of Cheddar cheese in that year. 8/ The production of other cheese in these 14 plants was insignificant. These pool plants in New York accounted for approximately one-half of the Class III milk utilized for Cheddar cheese in the pool (24). The remaining Class III milk used for Cheddar cheese was manufactured in nonpool plants or in pool plants located outside of New York State.

It was assumed that all of the milk available for manufacturing cheese in the model plant would be received directly from producers, and so the quantities received correspond to those handled at the previously described receiving station. The period when cheese is produced is specified to be 6 months, January through June. It is further assumed that this plant will receive milk during the remaining 6 months of the year, but will transship it as whole milk to other plants--either for fluid use or for manufacture of products other than cheese. In this capacity, the model cheese plant serves as a receiving station from July through December.

A yield of 9.5 pounds of cheese per hundredweight of milk of average test was assumed, and so peak daily cheese production (June) was estimated at approximately 8,740 pounds. 9/ Average daily milk receipts for the model Cheddar

---

6/ The number of cans handled was estimated, using the assumption that, on the average, each can contained 70 pounds of milk.

7/ From production data furnished by the New York State Department of Agriculture and Markets.

8/ This includes both Cheddar and Colby cheese. Colby cheese is a modified form of Cheddar cheese containing not more than 40 percent moisture and less than 50 percent fat in the dry matter. For this study it was considered as Cheddar cheese.

9/ The average yield reported by the New York State Department of Agriculture and Markets for 1956 was 9.15 pounds (17). Hence, the yield used in this study leads to a slight understatement of costs per pound.

cheese plant would amount to 79,636 pounds and average daily cheese production to 7,562 pounds. Annual cheese production for the 6-month operating period would amount to approximately 1,369,000 pounds. This annual production estimate is above the average, but well below the production of the largest cheese manufacturing plants in the pool. Estimated daily average milk receipts and cheese production are shown in table 2.

Table 2.--Cheddar cheese plant: Estimated average daily receipts of milk and average daily cheese production, by months, New York-New Jersey milkshed, 1958

Month	Daily receipts of milk	Daily cheese production
	Pounds	Pounds
January	66,869	6,353
February	66,318	6,300
March	79,839	7,585
April	82,046	7,794
May	89,956	8,546
June	91,980	8,738
Average	79,636	7,562

Cream-Nonfat Dry Milk Plant

The model cream-nonfat dry milk plant has been designed to produce only these commodities. However, with minor changes it can be modified to produce other commodities either by eliminating certain processing operations or by adding or substituting other operations. For example, one modification would be to add space and facilities for churning and to process the milk fat into butter. This and similar changes are described in the section on "Plant Modifications."

Available data indicate that typical cream-nonfat dry milk plants in the New York-New Jersey milkshed process from 325,000 to 350,000 pounds of milk per day during the peak season. Average receipts at the model cream-nonfat dry milk plant during the peak month were specified at approximately 340,000 pounds per day.

The model cream-nonfat dry milk plant receives milk both directly from producers and by bulk shipments from other plants. The quantities of milk received from producers (as well as the seasonal pattern) are the same as the milk receipts at the receiving station and the cheese plant. The bulk receipts were then computed to make the overall seasonality of total receipts at the model plant conform with the seasonal pattern of Class III utilization in the entire milkshed. Average daily receipts, both direct receipts from producers and bulk shipments from other plants, are shown in table 3.

Table 3.--Cream-nonfat dry milk plant: Estimated average daily receipts of whole milk, by source, and products manufactured, by months, New York-New Jersey milkshed, 1958

Month	Whole milk receipts		Products manufactured	
	From producers	From other plants	Cream	Nonfat dry milk
	Pounds	Pounds	Pounds	Pounds
January	66,869	132,530	17,981	15,602
February	66,318	170,107	20,382	18,580
March	79,839	216,059	26,297	23,185
April	82,046	251,604	29,299	26,174
May	89,956	224,096	28,140	24,588
June	91,980	249,270	30,362	26,736
July	74,412	184,893	23,273	20,299
August	62,638	127,830	17,194	14,902
September	58,407	84,510	13,187	11,157
October	59,695	65,632	11,655	9,767
November	54,912	51,786	9,850	8,329
December	58,959	69,943	11,643	10,084

Another step in the synthesis of the model plant was to estimate the quantities of the various products manufactured. Conversion of raw milk into product was based on the average fat test of the milk received. Cream yields were estimated by assuming the production of cream with 40 percent butterfat, and production of nonfat dry milk was based on an assumed average yield of 8.6 pounds of powder per hundredweight of whole milk received.

LABOR REQUIREMENTS AND COSTS

Labor and management expense constitutes the largest single item of plant costs for most dairy plant operations. The development of labor inputs and cost rates which accurately represent labor's contribution to plant costs are consequently an important part of the cost synthesis. Greater diversity probably exists among dairy plants with regard to use and efficiency of labor than any other single cost item. Similarly, labor cost rates vary from one area to another depending on local wage scales, local labor supplies, and other factors.

Wage rates for the model plants were taken entirely from a study of eight milk manufacturing plants in the New York milkshed covering the period August 1956 through July 1957 (16). 10/ This study was conducted with the cooperation of the New York dairy industry, and with the assistance of a management engineering firm.

10/ Much of the data used in the current study was provided by the findings of the New York study. Errors or omissions resulting from the use to which these data were put are, however, the sole responsibility of the authors.

The basic schedule indicated the following rates: Skilled labor, $1.54 per hour; general labor, $1.42 per hour; and starting labor, $1.26 per hour. The basic wage rate for each category was subsequently adjusted to include a 6-day workweek (time and one-half for over 40 hours) or 52 hours' pay for 48 hours' work. The adjusted rate schedule is: Skilled labor, $1.67 per hour; general labor, $1.54 per hour; and starting labor, $1.37 per hour.

Estimates of wage costs must also include the employer's share of Social Security, as well as workmen's compensation, paid holidays, paid vacations, and other nonwage payments. These "fringe benefits" were estimated to be 10 percent of the basic wage rate. This 10 percent figure has been used by other investigators (9) and has been arbitrarily selected for the present study.

Another element entering into the determination of plant wage rates is the shift differential--extra wages for workers on evening and night shifts. 11/ Spencer and LaCasse indicate that the typical shift differential encountered in New York milk manufacturing plants amounted to 5 cents per hour for the second shift and 8 cents per hour for the third shift (17). Generally, the second shift refers to the period from 3:00 p.m. to 11:00 p.m. and the third shift from 11:00 p.m. to 7:00 a.m. Due to the rather extreme variation in reporting times in the model plants, application of these shift differentials required some simplifying assumptions. These were: (1) Disallowing the second shift differential for employees reporting before 2:00 p.m.; and (2) disallowing the third shift differential for employees reporting before 10:00 p.m. Since the bulk of the labor requirements fall within the first shift, cost increases due to the shift differential are relatively small.

Labor input rates for the model plants were obtained from other studies (3, 8, 17, 25) or from industry sources and adapted to the specific operating requirements of the model plants. Work crews for each of the model plants were then developed on the basis of the total estimated labor requirements. The following paragraphs describe in detail some of the basic assumptions regarding labor requirements for the receiving station, Cheddar cheese plant, and cream-nonfat dry milk plant.

Receiving Station

The model receiving station requires three operating employees and a plant manager. These requirements were based on estimates by Carter, Brundage, and Bradfield for "Norma" and they are supported by data developed by other investigators (13). It is assumed that the plant manager will be available to handle any unforeseen difficulty arising during the receiving period. In addition, the manager will replace the regular plant operators on their "off" days. Although the plant operates on a 7-day week, each employee works only 6 days.

11/ The application of the shift differential was confined to the cream-nonfat dry milk plant and its modifications since these were the only plants operating more than a single shift.

Cheddar Cheese Plant

Total labor requirements in cheese plants are related in part to the size of vats, number of mechanical agitators used, efficient arrangement of plant equipment, efficiency of individual laborers, and the number and style of cheese packages processed. Size of vats, number of mechanical agitators, and overall arrangement of equipment for the model cheese plant were developed on the premise that specifications for these items represented conditions found in well-managed plants. It was also assumed that no retail packaging would be conducted in the plant and that during the period covered by this study only one shape of cheese would be produced. For this analysis single daisies were arbitrarily selected from the alternative styles. 12/

The model Cheddar cheese plant had average daily receipts of 79,636 pounds of milk and average daily production of 7,562 pounds of cheese (table 2). Labor requirements were therefore developed from standards applied to these daily averages.

A commonly accepted rule for estimating labor requirements in cheese plants in this area is 1 man for every 5,000 pounds of milk received. 13/ This figure was selected as representing average labor input for the model plant. 14/ The average daily labor force for the model Cheddar cheese plant computed on the basis of this assumption numbered 17 employees. This force consisted of a manager, assistant manager, and 15 operating employees. 15/

Cream-Nonfat Dry Milk Plant

Labor requirements for the model cream-nonfat dry milk plant were developed from the New York report (17). Requirements were developed separately for each function and were summed to arrive at the total labor force.

In this report, labor requirements were:

(a) Time required for processing the given quantity of product, taking into account the capacity of the equipment;

(b) The labor standards for handling dairy products and operating dairy plant equipment as developed in the New York study of eight plants manufacturing dairy products (17).

12/ A daisy, also called picnic, is a style or shape of Cheddar cheese, 12-14 inches in diameter, $3\frac{1}{2}$-$4\frac{1}{2}$ inches in height, weighing about 18-24 pounds.

13/ Letter from Henry Leber, Dairymen's League Cooperative Association.

14/ A study of the Columbia Basin (22), presented a figure of 1 man for every 6,700 pounds of milk received. There is some reason to believe, however, that the somewhat lower figure is more representative of actual labor productivity in cheese plants in the New York-New Jersey milkshed.

15/ The operation of the model Cheddar cheese plant as a receiving station during the remainder of the year does permit the retention of "key" employees, a manager, assistant manager, and two other skilled employees.

Manufacturing plants operating in the New York-New Jersey milkshed face a problem in hiring, maintaining, and allocating labor as receipts vary seasonally. Certain minimum forces must be maintained throughout the slack season, even though the force may at times be underutilized. In the flush season, the work force must be augmented to handle the large quantity of milk received for manufacturing. The operating labor force for the model plant varies from a maximum of 24 men in June to a minimum of 11 men in October, November, and December. During most of the year the men work 48 hours a week. Pay scales are adjusted to include time and one-half for all work in excess of 40 hours per week. During May and June, the plant must operate 7 days a week instead of 6 days to handle the increase in receipts during these peak production months. If operations were continued on a 6-day basis, a diversion of approximately 25,000 pounds of skim milk daily would be required in June. In May the situation is not as serious; the plant could handle all of the skim milk in 6 days a week by manufacturing large quantities of the roller-process product. However, under normal price differentials for spray-process nonfat dry milk it is economical for the plant to change to a 7-day processing week.

Within the plant, work is scheduled over a 24-hour period, with a 3-shift arrangement. Sufficient "overlapping" is permitted for efficient utilization of labor. Thus, reporting times for the first shift may be staggered over several hours so that one employee might report at 5:00 a.m. and another at 9:00 a.m. (fig. 1). Figure 1 shows how this staggering effects work hours for the 18 men required to handle the plant during the 6 months of "normal" volume. The staggered reporting times provide for economies in the use of labor since the sequence of processing operations is such that the full labor force of 18 men is not needed at all times of the day.

The adjustment of the plant workweek from 6 to 7 days requires considerable changing of labor schedules, pay scales, or both. Management has two choices to consider in making the most economic adjustment. In the first instance, all employees may be moved from a 6-day to a 7-day week with an appropriate adjustment in wage scale to include the increase in overtime. In the second case, the labor force can be increased and rescheduled to provide a full force working 6 days a week in a plant operating 7 days.

If employees work 7 days, under existing overtime regulations each employee would work 56 hours for 64 hours' pay. A crew of 20 men would earn the equivalent of "straight time" wages for 1,280 man-hours. If employees continue to work only 6 days, the addition of 4 men to the labor force would provide sufficient labor to move into a 7-day operation. A work force of 24 men would require wages for 1,152 hours per week.

This example shows that the less expensive alternative is to add to the labor force, if local labor supply permits. Where part-time labor is available costs can be reduced by avoiding overtime payments to the regular labor force.

In October, November, and December, when 11 men are employed, they all work on each working day. In May and June, when the total number of operating personnel on the payroll is 24 men, average daily operational labor (maximum crew in one 24-hour work period) is only 21. Because the 24 men work 6 days a week, at least 3 men are off each day while the plant is operating 7 days a week. Although this additional help adds to the total labor force, and total

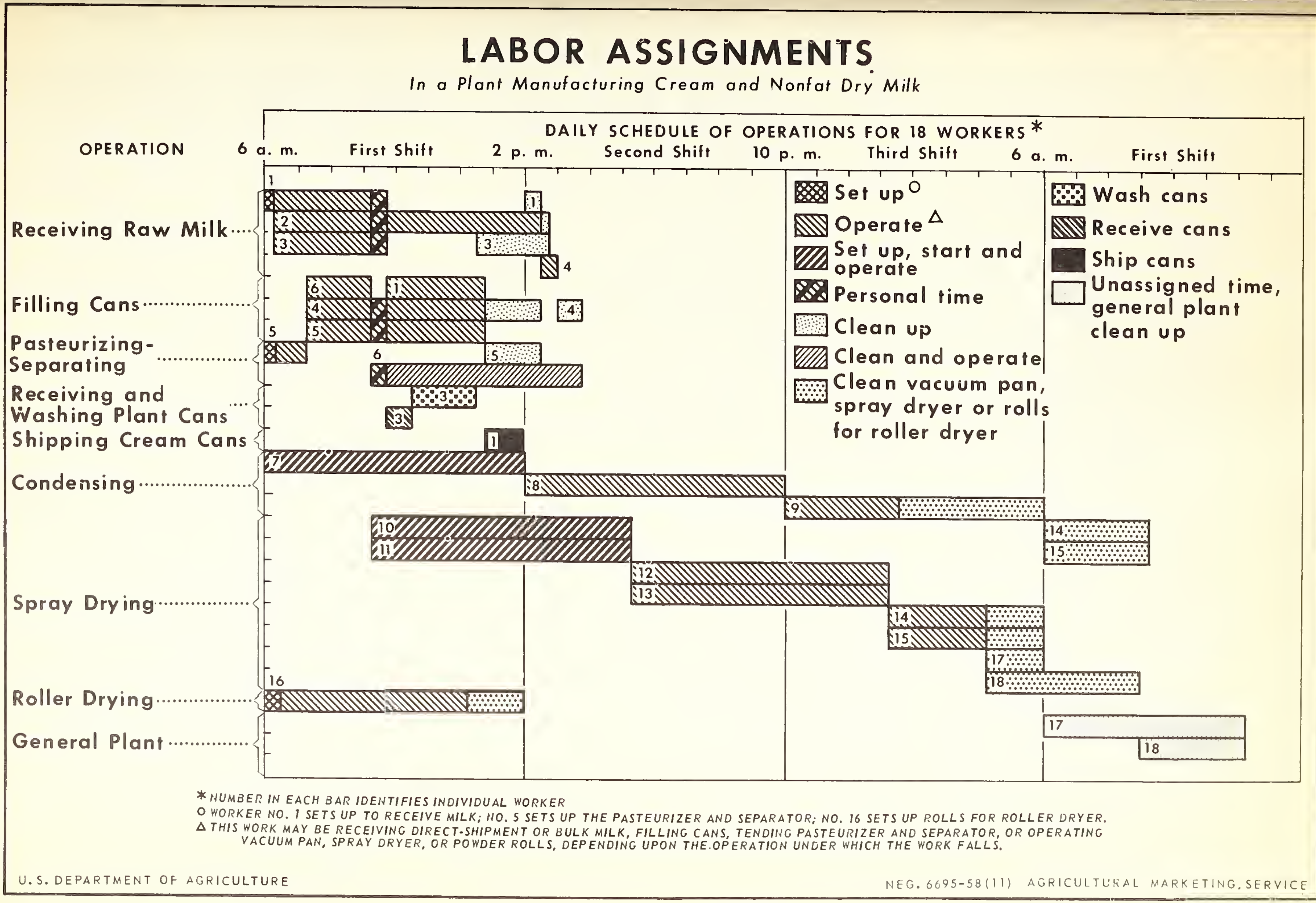

LABOR ASSIGNMENTS
In a Plant Manufacturing Cream and Nonfat Dry Milk
DAILY SCHEDULE OF OPERATIONS FOR 18 WORKERS *
OPERATION
6 a. m.
First Shift
2 p. m.
Second Shift
10 p. m.
Third Shift
6 a. m.
First Shift
Receiving Raw Milk
Filling Cans
Pasteurizing-Separating
Receiving and Washing Plant Cans
Shipping Cream Cans
Condensing
Spray Drying
Roller Drying
General Plant
Set up ○
Operate △
Set up, start and operate
Personal time
Clean up
Clean and operate
Clean vacuum pan, spray dryer or rolls for roller dryer
Wash cans
Receive cans
Ship cans
Unassigned time, general plant clean up
* NUMBER IN EACH BAR IDENTIFIES INDIVIDUAL WORKER
○ WORKER NO. 1 SETS UP TO RECEIVE MILK; NO. 5 SETS UP THE PASTEURIZER AND SEPARATOR; NO. 16 SETS UP ROLLS FOR ROLLER DRYER.
△ THIS WORK MAY BE RECEIVING DIRECT-SHIPMENT OR BULK MILK, FILLING CANS, TENDING PASTEURIZER AND SEPARATOR, OR OPERATING VACUUM PAN, SPRAY DRYER, OR POWDER ROLLS, DEPENDING UPON THE OPERATION UNDER WHICH THE WORK FALLS.
U.S. DEPARTMENT OF AGRICULTURE
NEG. 6695-58(11) AGRICULTURAL MARKETING SERVICE

Figure 1

labor costs, it does not increase average daily labor costs above those in the period of normal volume due to the effect of spreading the total labor costs over 7 days rather than a 6-day week.

It was assumed that the 11-man labor force maintained during October, November, and December was the absolute minimum for the plant. This results from the fact that certain employees could not be replaced without an expensive training period. Such key employees received wage rates during October, November, and December that often were higher than warranted by the work they performed and the responsibilities they had during these slack months. For this reason, the average wage per employee is greater during the slack months than during the flush months. New employees added with the rise in milk receipts are paid at lower rates commensurate with their starting position.

The average daily plant force and the daily wage costs for the model plants being studied are shown in table 4.

Table 4.--Number of workers employed and average daily wages, by type of work performed: Receiving station, Cheddar cheese plant, and cream-nonfat dry milk plant, New York-New Jersey milkshed, 1958

Type of work performed	Receiving station		Cheddar cheese plant		Cream-nonfat dry milk plant	
	Number employed	Average daily wages	Number employed	Average daily wages 1/	Number employed	Average daily wages 2/
	Workers	Dollars	Workers	Dollars	Workers	Dollars
Supervision	1	17.86	2	45.16	4	71.00
Clerical and miscellaneous	---	---	---	---	14	171.82
Skilled	1	14.72	2	29.44	7	105.45
Semiskilled	2	27.04	5	67.60	8	109.56
Unskilled	---	---	8	96.64	---	---
Total	4	59.62	17	237.84	33	457.83

1/ Labor requirements and costs estimated from average volumes of milk processed.
2/ Computed on the basis of the labor force for the month of August, when daily average receipts approximate the daily average for the year. Costs adjusted to agree with weighted average of all months.

PLANT INVESTMENT

Buildings

The buildings developed for the three plants synthesized in this study were specifically designed to meet the needs of the product or products being processed. For this reason these plants, while alike in some respects, differ substantially in others. For example, all of the buildings have concrete block exterior walls. Further, the receiving station and the cheese plant have identical space requirements for receiving (including the weighing, testing, and accounting involved in handling producer milk) and storing whole milk. The cheese plant essentially "grafts" onto the receiving station the space necessary to accommodate the cheese-making vats and to store the product. Since these added buildings are little more than enclosed space, with few costly walls, they substantially increase the total square footage of building space, but reduce the cost per square foot compared with the receiving station.

On the other hand, the cream-nonfat dry milk plant requires more elaborate construction than either of the other model plants. It has been designed of steel frame construction with a minimum height varying from 15 feet in storage areas to 30 feet in processing areas. These more stringent specifications materially affect the cost of building space for this plant.

Estimating building costs for the model plants followed a three-step procedure. First, plant layout and space requirements were determined. Second, specifications were drawn to meet these requirements. Finally, the cost of constructing buildings to meet the specifications was estimated.

The size and layout of plant buildings is a function of the space required for individual pieces of equipment and the space necessary to use and service each equipment item properly. In general, the floor plans for the models were adopted from other studies (8, 20, 25). Several modifications of the original plans were necessary to conform to space requirements of the specific plant models used here. Where modifications were required, an attempt was made to maintain an efficient arrangement.

Receiving Station

Space requirements for the model receiving station were estimated at 2,500 square feet. 16/ Specifications were developed for a one-story concrete block building. Subsequently, an itemized estimate of building costs was derived by modifying a contractor's estimate for a similarly constructed but more elaborate building for processing fluid milk. 17/ Costs developed from this estimate covered the year 1953, and were adjusted to 1958 cost levels by the use of the Department of Commerce Composite Index of Construction Costs (23). The index utilized was based upon building costs for all types of construction

---

16/ "Norma" required 2,704 square feet of floor space or a difference of 204 square feet. This difference resulted mainly from the elimination of space for a second steam generator.

17/ Owens, T. R. Specifications and Costs for Processing Operations in Small Market Milk Plants. Unpub. thesis, Pa. State Univ. 1956.

in all areas of the United States. The adjusted cost of construction for the receiving station amounted to $29,242, or approximately $11.60 per square foot. The contractor's itemized estimate (1953 levels) is shown in table 26. 18/

It was estimated that a building with 2,500 square feet of floor space would require approximately 12,200 square feet of land, including 30 feet on each side of the plant to allow for service and access. The cost of acquiring and developing the site was estimated at $0.325 per square foot (19), or $4,000 for the site. This cost was based upon the estimated value of a level lot adjacent to, but not in, an urban area. The lot was assumed to have access to a hard-surface road and possibly, but not necessarily, access to city sewage and city water. The addition of the site value to the cost of plant construction resulted in a total cost of $33,240 for land and buildings.

Cheddar Cheese Plant

A cheese plant processing 92,000 pounds of milk and with a peak capacity of approximately 8,740 pounds of cheese per day requires 9,360 square feet of floor space. This estimate is based on a one-shift operation with an allowance of 30 days' in-plant storage of green cheese. Building costs for a one-story concrete block building incorporating this area are shown in table 27. These costs were derived from a contractor's itemized estimate of building costs for a fluid milk plant of similar construction. 19/ Total costs, adjusted to 1958 prices (23), amounted to $73,581 or $7.86 per square foot.

It was estimated that a building of 9,360 square feet would require approximately 18,800 square feet of land. This estimate included 30 feet of land on each side of the plant to allow for proper maintenance and servicing. Total costs for land amounted to $6,110, computed from the estimated cost of $0.325 per square foot.

Cream-Nonfat Dry Milk Plant

In developing building costs for the cream-nonfat dry milk plant, reference was made to the space requirements set forth in the Northwest butter-nonfat dry milk study (25) and the companion study on building costs (20). This material was modified in line with space required by the equipment specified for the model cream-nonfat dry milk plant. Space requirements for equipment were drawn from the manufacturer's specifications with allowance for clearance to provide for necessary servicing and maintenance. This space ranged from 2 to 3 feet per side depending on the item. Additional space was provided for working areas and for traffic between contiguous areas of product processing.

It was estimated that 26,675 square feet of floor space would be required to properly house and service the basic functional operations of the cream-nonfat dry milk plant. Plant construction costs were subsequently developed utilizing the itemized estimate of building costs developed by Page and Walker

---

18/ Tables 26 to 39 are in the appendix.
19/ See footnote 17.

(20). These costs were adjusted to 1958 prices by use of the Department of Commerce Composite Index of Construction Costs (23). Estimated building costs for the plant amounted to $302,500 or approximately $11.36 per square foot.

It was estimated that the model plant would require approximately 64,400 square feet of land. This would include 23,700 square feet for building area, 8,600 square feet for service and access, and 32,000 square feet for truck and employee parking. Based on an acquisition and development cost of $0.325 per square foot, site costs amounted to $20,930.

Equipment

Equipment requirements for the model plants were adapted from other studies (8, p. 55), developed from industry sources, or built up independently on the basis of specifications supplied by equipment manufacturers. 20/ Enough capacity was supplied for each kind of plant to process peak receipts of milk. Efforts were directed toward specifying capacities for related pieces of equipment that would permit the product to move smoothly from each operation to the next. Specifications and requirements for steam boilers and refrigeration systems were developed separately to meet peak plant requirements for each system. Requirements for sanitary lines were estimated on the basis of the location of equipment in each plant. All prices for the major items of equipment, including costs of installation, were obtained from dairy equipment manufacturers in 1957-58.

Receiving Station

All milk is assumed to be received from producers in 40-quart cans which, on the average, contain 70 pounds of milk. The model plant must be equipped to receive approximately 1,312 cans per day (92,000 pounds) during the flush season, and an average of 70,522 pounds or 1,007 cans per day throughout the year.

Other assumptions which affected equipment requirements were: (a) That all milk would be received within a period of $3\frac{1}{2}$ hours; and (b) that the mean temperature of incoming milk was 70 degrees. 21/ The temperature of the milk when received affects, in particular, the requirements for cooling equipment.

A 12-can-per-minute, straight-line can washer was selected for the model plant. For most months, this washer will handle all the cans received during the allocated receiving time. In the peak months, receipts during the last half hour of the receiving period would exceed the capacity of the washer since most producers and haulers arrive at the plant during the latter half of the period (8, p. 68). Enough conveyor space was provided to hold the cans that exceed the receiving rate. Similarly, cooler capacity was based upon the total

---

20/ Also, Walker, Scott A., unpublished data.

21/ The Sanitary Code for the City of New York, Regulation 48, June 14, 1949, states that morning's milk delivered before 10 a.m. need not be cooled. The mean temperature of 70° is the assumed average of uncooled morning's milk, and evening's milk cooled to 60°F. or less.

quantities of milk received during the last half hour of the receiving period during the flush months. A plate cooler with a capacity of 50,000 pounds per hour was selected. A minimum cooling of 5 degrees by tap water and maximum cooling of 27 degrees by refrigerated sweet water was assumed. 22/

A two-compartment weigh tank with a capacity of 750 pounds per side was specified for the model. In most months, this would permit the utilization of one compartment per producer, and thus add to the smoothness of the receiving operation.

Other important items, such as the automatic dump and pneumatic sampling equipment, were specified to increase labor efficiency. Each major item was provided with the necessary auxiliary equipment such as steam boilers and refrigeration compressors. An itemized estimate of equipment and costs is shown in table 28.

Cheddar Cheese Plant

Equipment for the model Cheddar cheese plant was specified to handle daily peak receipts of 92,000 pounds in a one-shift operation. The cheese-making process was divided into four primary operations: (1) Receiving raw milk; (2) Cheddaring; (3) cheese pressing and storage; and (4) whey separation and disposal. Specifications for each of the major equipment items utilized in these operations are described in the following paragraphs. Equipment requirements and total investment in equipment for the model Cheddar cheese plant are shown in table 29.

Equipment for the receiving function was drawn without modification from the previously synthesized receiving station. Cooling equipment and raw milk storage tanks were provided to allow the model cheese plant to function as a pool plant by shipping whole milk in the 6-month period when no cheese is being produced.

In preparing the milk for cheese manufacture, milk is pumped through a plate heat exchanger and discharged at the setting temperature (82°F.) into the cheese-making vats. Seven vats, five of 15,000-pound capacity and two of 10,000-pound capacity, were specified to meet peak receipt requirements in a one-shift operation. The capacity of the heat exchanger was specified at 33,000 pounds per hour. It was estimated that two curd mills were sufficient to provide flexibility in the processing operation and to give some insurance against breakdown.

Whey is drawn from the cheese vats into a whey surge tank from which it is pumped to the separators. Two separators, each with a capacity of 11,000 pounds per hour, were provided to separate the whey. Whey cream would be discharged from the separators into a vat pasteurizer large enough to process 1 day's production of whey cream in one batch. The whey from the separators

22/ Regulation 48 of the New York City Sanitary Code states that "after delivery to a receiving station . . . milk, cream, etc. . . shall be cooled to and maintained at a temperature of fifty degrees (50°F.) or lower until . . ."

would be discharged into steel tanks, located outside the building, where it would be stored prior to disposal. The storage tanks would hold a 4-day supply of whey. Five 20-foot double-row presses were specified to permit a flexible operation when processing most of the common styles of cheese. Enough cheese hoops were provided to process 1 day's supply into each of several styles. Although in many plants two styles of hoops are deemed sufficient, five styles of cheese were specified for the model plant: Cheddars, twins, daisies, 20-pound squares, and 40-pound squares.

Cream-Nonfat Dry Milk Plant

The manufacturing process was divided into a series of functional operations or processing centers. The sum of all such centers constitutes the plant. The following paragraphs describe the major equipment items in the individual processing centers:

Receiving.--Plant capacity for direct receipts from producers was limited to 92,000 pounds per day. This is the same amount specified for the receiving station and the cheese plant. In addition to direct receipts, bulk shipments from feeder plants amounted to approximately 249,000 pounds per day in the peak period--the difference between direct receipts and the approximately 341,000 pounds specified as the peak attainable capacity of the plant. Equipment required for this operation has been described in the section on the receiving station.

Separation.--Enough separators were provided to convert peak daily receipts from all sources into cream and skim milk. Specifications derived from the Northwest butter-nonfat dry milk study (25, p. 32) and from industry sources call for five 11,000-pound-per-hour separators. Processing operations would be scheduled so that only four separators are in operation at one time--while the remaining separator is being cleaned. Thus, the total available capacity of the separation center amounted to 44,000 pounds per hour. Size of auxiliary equipment selected, such as the preheater, was appropriate to the capacity of the center. Separation of peak daily receipts into fat and skim components would yield approximately 30,300 pounds of 40 percent cream, and 310,900 pounds of skim milk. A high-temperature, short-time pasteurizer with an effective capacity of approximately 5,000 pounds of cream per hour was specified to handle peak production of cream. Total investment in cream separating and processing equipment is shown in tables 30 and 31.

Raw cream sales.--The major functions performed in this center are filling cream cans, placing filled cans in the cold room, and receiving and washing returned cans. Consequently, major equipment requirements consist of plant cans and the essential cleaning and handling equipment (table 32).

The average depreciation rate for plant cans, computed on the basis of an estimated rate of 240 trips per can, is about 5 years. 23/ It is partly a function of the total number of cans in the inventory. The computed rate varies to some extent between plants.

23/ See footnote 17.

In computing cream can requirements for the model plant, it was estimated that 5 times the daily peak requirements would provide sufficient flexibility to allow for lags in pickups and returns. This estimate was based on information gained from industry sources as to the type and size of firms which were cream customers and the frequency of delivery. These sources indicated that many cream customers required small lots of cream, that delivery and pickup were infrequent, and that can returns often lagged over long periods. On this basis, 5 times the peak daily requirements appeared to be a reasonable estimate of plant needs. On the other hand, can requirements for condensed skim milk and ice cream mix were estimated as 3 times peak daily requirements. This estimate was based on the fact that these products were delivered and picked up more frequently and that problems of inventory control were not as acute.

Normally, one of the expense items associated with the use of plant cans is a charge for repair and retinning. In this study, no effort was made to compute a retinning charge. However, an annual allowance of 5 percent of the initial price is allocated for repair and maintenance.

Condensing.--Manufacture of nonfat dry milk from fluid skim milk by the spray process is a two-step operation. First, the skim milk is concentrated to 40-45 percent total solids; then the concentrated product is put into the spray box for final processing into powder.

Concentration of total solids requires a double-effect vacuum pan wherein the milk is first heated in vacuum to 155 degrees, then cooled to 110 degrees in higher vacuum. The solids content per unit of volume is increased by the evaporation of water. A standard double-effect vacuum pan with a capacity of 13,600 pounds of skim milk per hour was selected for the model plant. Specifications also call for two interstage raw milk heaters, one a vapor heater using exhaust vapor from the second effect, and the other using steam from the boiler. Sizes of hot wells and other auxiliary equipment corresponded to the size of the vacuum pan. Items comprising the condensing center are listed in table 33.

Spray processing.--Hourly production of 40 percent condensed skim milk amounts to 2,600 pounds. Accordingly, a spray box was selected which would process the condensed milk output at approximately that rate. The capacity of the spray box was specified at 1,200 pounds of powder per hour. Other major equipment items such as the preheater and high-pressure pump were selected in sizes suitable to the capacity of the spray box. Total investment in the spray-drying center is shown in table 34.

Roller processing.--The estimated daily capacity of the condensing pan and spray box, assuming 19.5 hours of operation per 24-hour shift, amounted to 265,200 pounds of skim milk daily. During March, April, May, and June, skim milk supplies exceed this capacity. Two sets of powder rolls with capacities of 185 pounds and 135 pounds of powder per hour were installed to handle the excess skim. 24/ Total investment in roller drying equipment is shown in table 35.

24/ The decision to install powder rolls rather than expand the capacity of the spray drying facilities was based on observations of existing plants in the New York milkshed.

Cost Rates on Building and Equipment

Once the physical specifications for buildings and equipment have been established, the investment costs associated with these items can be calculated for any desired time period. The appropriate cost elements include interest, depreciation, repair, maintenance, taxes, and insurance. These costs are normally considered as fixed, or independent of the volume of milk handled in any given plant.

Interest

Interest is a charge for the use of capital invested. As such, it is a cost of doing business and should be included in any analysis of plant costs. The magnitude of the charge is determined by the return this capital would bring in its best alternative use. This return may be represented by the going rate of interest. For the model plants, a rate of 5 percent of the average investment was selected. This rate was assumed to represent expected returns from similar economic activity involving approximately the same element of risk. Since it was also assumed that investment would decrease to zero at the end of the useful life of the asset, this rate was applied to one-half of the original amount of the investment. Average daily interest charges for buildings amounted to $2.29 for the receiving station, $9.25 for the Cheddar cheese plant, and $25.14 for the cream-nonfat dry milk plant. Interest charges on equipment were $4.58, $17.62, and $40.18 per day for these same three model plants.

Depreciation

As the value of a fixed element decreases through use or obsolescence, the investment is being consumed and the element is subject to replacement. The rate of this consumption or depreciation provides the basis by which costs of large fixed elements such as buildings and equipment are converted to daily costs.

The building depreciation rate for the model plants was estimated at 3 percent per year. This assumes an estimated life span of 33-1/3 years, a figure commonly used for buildings of the type specified for the model plants (8, 22). No effort was made to separate depreciation due to obsolescence from depreciation due to physical wear of the building.

Average daily depreciation on plant buildings amounted to $2.19 for the receiving station, $10.35 for the Cheddar cheese plant, and $28.51 for the cream-nonfat dry milk plant.

Since equipment items depreciate at varying rates depending on use, initial quality, and other factors, no one rate of depreciation is equally applicable to all items. Various sources were examined to find depreciation rates which would represent the expected useful life of the equipment in the model plants. Applicable rates for the major items are shown in the tables on equipment requirements, tables 28 through 39. Where published rates were not available, the physical life of the equipment was estimated from rates applicable to similar pieces of equipment.

Average daily depreciation on equipment was estimated at $11.56 for the receiving station, $49.61 for the Cheddar cheese plant, and $118.35 for the cream-nonfat dry milk plant.

Repairs and Maintenance

Meaningful data on repair and maintenance costs for existing plants usually are not available. Expenditures vary according to intensity of use, policies of individual firms toward maintenance, original quality of the building or equipment, and other factors. Figures of 1 percent of the initial investment in building and 5 percent of the initial investment in equipment were arbitrarily selected to represent annual repair and maintenance costs. These rates have been used frequently by other investigators (8, 22). In the absence of other evidence they were deemed appropriate to represent the actual costs incurred. 25/

Costs per day for building repairs and maintenance averaged $0.80 for the receiving station, $3.41 for the Cheddar cheese plant, and $9.41 for the cream-nonfat dry milk plant. For repair and maintenance of equipment, costs per day averaged $9.15 for the receiving station, $22.40 for the Cheddar cheese plant, and $80.36 for the cream-nonfat dry milk plant.

Taxes

Property is subject to local taxes. These taxes are levied upon the appraised value of the property as determined by the local assessor or other tax authority and are computed on the basis of a specified tax rate per dollar valuation. The appraised value may range from 10 to 100 percent of the actual value. Since both rates and assessed valuations vary from one community to another, the amount of taxes determined for the model plants does not pertain to any particular community. The tax rate selected was taken from a previous study by Owens (19, p. 36), based on a mail survey of tax rates in small Pennsylvania communities. This rate of 60 mills per dollar valuation was applied to an average percentage valuation of 30 percent of the sum of the initial cost of equipment, plus the initial construction cost of the building, including costs of acquiring and developing the site. 26/ Total daily tax costs for the model plants amounted to $4.93 for the receiving station, $19.34 for the Cheddar cheese plant, and $47.04 for the cream-nonfat dry milk plant.

Property Damage Insurance Requirements

Risk of loss, whether from destruction of physical plant by natural or other causes, changes in market conditions, or other changes is a cost to the firm. Some of these risks (such as destruction of physical plant) are insurable so that the price of insurance, or premium, is a measure of the cost of

---

25/ Also, Conner, M. C., unpublished data.

26/ This rate is comparable with that used by other investigators--for example, 30 mills per dollar of average investment (14, p. 12).

risk-bearing. The amount and kinds of insurance carried by a particular plant largely depend upon the attitude of the individual firm toward risk. It is probably true, however, that for the most part management is guided by recommendations made by experts in the field of insurance. In the model plants efforts were directed toward developing an insurance program which would include a minimum of recommended coverages.

Fire insurance.--Fire insurance on business and commercial properties is customarily written under the coinsurance plan. Under this plan the insured agrees to carry insurance in an amount equal to a stipulated percentage of the actual value at risk. In return for this agreement the customary rate is substantially reduced as the stipulated percentage increases. The commonly utilized 80 percent coinsurance clause was stipulated for the model plants. In conjunction with fire insurance, the extended coverage endorsement was specified for the model plants. This endorsement when attached to the fire policy provides coverage against seven additional perils, the most important of which is windstorm.

Fire insurance rates are of two types: Class and specific rates. Most commercial policies are rated on a specific basis; that is, the individual character of the property as related to its susceptibility to fire loss determines the rate to be charged. The rate selected for the receiving station and cheese plant was the 80 percent coinsurance rate for a dairy of average construction having National Board Class 6 fire protection. 27/ This rate was quoted at 39 cents per $100 insurance on buildings and 56 cents per $100 insurance on contents. 28/ The rate selected for the cream-nonfat dry milk plant was the 80 percent coinsurance rate for a manufacturing plant of the same general size and construction as the model plants. This rate was quoted at $0.76 per $100 insurance on buildings and $0.86 per $100 insurance on contents.

Direct loss to the firm from the destruction of physical plant constitutes only one source of loss as the result of fire or other peril covered by the fire insurance policy. Many plant expenses, such as salaries, are continuous and must be paid although business is interrupted. Management may find it necessary to pay wages to retain the services of key personnel until operations begin again. Similarly, it is necessary to make temporary arrangements to handle receipts from producers to retain the plant's source of supply. Since these risks result from a contingency which is subject to actuarial measurement, they are insurable. Rates for use and occupancy or business interruption insurance are usually computed as a percentage of the basic building insurance rate. For the model plants, rates for use and occupancy insurance and fire insurance were specified at 77 percent of the 80 percent coinsurance building rate.

27/ The National Board of Fire Underwriters assigns ratings to all areas in the United States on the basis of the quality of local fire protection. These ratings range from unprotected to excellent protection and are graded 0 through 10.

28/ Rates are quoted on an annual basis. The application of the "term rule" provides for 5 years of insurance protection for 4 years' premium. Thus, all rates are reduced by 20 percent assuming the purchase of 5-year policies and cost budgeting over a 5-year period.

Steam Boiler and Refrigeration Insurance.--Steam boiler and refrigeration installations are subject to specific hazards which are inherent in the nature of the equipment. For this reason, all of the model plants were insured against losses resulting from boiler or refrigeration explosions. Annual premiums were developed on the basis of commercial rates for standard boiler insurance policies. Protection was provided against loss of the named equipment, bodily injury to personnel, and damage to the part of the building containing the equipment. Liability limits for this contingency were set at $100,000 per accident.

Property Damage Insurance Costs

Average daily costs of property damage insurance on buildings (the sum of fire insurance and use and occupancy insurance) for the model plants were $0.39 for the receiving station, $2.95 for the Cheddar cheese plant, and $8.10 for the cream-nonfat dry milk plant. Average daily costs on equipment (the sum of fire insurance, use and occupancy insurance, and steam boiler insurance) for these same three plants amounted to $1.32, $6.98, and $15.64.

Liability Insurance Requirements and Costs

As a rule, manufacturers of products sold to the public carry some form of insurance against legal liability resulting from negligence in the manufacturing process. Although it is possible to insure against almost all types of liability resulting from negligence, liability in the model plants was limited to liability for bodily injury resulting from use of their products. The liability limits against bodily injury were specified at $100,000 per person and $300,000 aggregate. Costs for liability insurance were based on commercial rates quoted at $0.108 per $100 of annual gross income.

Liability insurance for the model plants was restricted to the Cheddar cheese plant and the cream-nonfat dry milk plant and its modifications. The receiving station was excepted since this plant processes only raw milk, which must undergo further processing before reaching the ultimate consumer. Daily costs of liability insurance amounted to $2.99 in the Cheddar cheese plant and $9.04 in the cream-nonfat dry milk plant.

UTILITIES

Electrical Requirements and Costs

Electricity is used for lighting, for power, and in some plants for heating. In the model plants, the use of electricity was restricted to power and lighting.

Lighting

The recommended lumination for the various plant operations varied from 10 footcandles 3 feet from the floor in storage areas to 50 footcandles 3 feet from the floor in the plant laboratories. Assuming a source 12 feet from the floor and utilizing 150-watt bulbs (18 candlepower per watt), these recommendations were converted to watts per square foot by the formula:

$$I = \frac{C}{D^2} ;$$

where I is the desired illumination, C the candlepower at the source, and D the distance from the source to the illuminated surface. Number of hours of operation were estimated for each of the individual operating centers. Estimated operating times in the receiving station and the Cheddar cheese plant were computed on the basis of average daily time through the annual operating period. In the cream-nonfat dry milk plant, consideration was given to variations in the length of the daily operating period resulting from month-to-month fluctuations in volume.

Power

Electric power is used to operate separators, can washers, pumps, refrigeration compressors, and many other pieces of dairy equipment. Estimates of power consumption for the various plant operations were developed by a combination of methods. In some instances, empirical data were available indicating power consumption for various operations based on the amount of product processed (17). Where such data were not available, power requirements were computed on the basis of the number of horsepower utilized and the estimated operating time for equipment. In developing power requirements by this method it was assumed that 1 horsepower was equivalent to 1 kilowatt of electricity. 29/ On this assumption, a pump utilizing 3 brake horsepower and operating 3 hours would require 9 kilowatt-hours of electricity.

The refrigeration system was one of the largest power-consuming centers in the model plants. The development of refrigeration loads and power requirements for the model plants involved a large number of assumptions. In general, these relate to the amount of heat to be removed from raw milk and the various manufactured products, the quantity of product held in the coldroom, and the respective losses that occur.

Power requirements (in kilowatt-hours) for steam production and distribution were computed by multiplying the estimated operating time of each boiler by the number of kilowatts drawn. Operating times in turn were estimated by dividing total steam requirements for each plant by the steam output of the boiler (in pounds per hour) as indicated by the manufacturer's specifications. Kilowatt requirements were estimated by taking the motor horsepower requirement from the manufacturer's specifications and converting by the previously mentioned formula.

Similarly, the power consumption for such pieces of equipment as the cooling tower and the evaporative condensers were computed from the manufacturer's specifications as to horsepower and the estimated operating times.

29/ One brake horsepower is theoretically equivalent to 0.746 kilowatt. But, due to losses in motor and drive and frequent underutilization of motor capacity, the theoretical conversion ratio is never attained. A ratio of 1 horsepower to 1 kilowatt is a near approximation consistent with operating conditions commonly encountered.

The average daily electrical requirements for the three model plants for the various types of operations discussed are presented in table 5.

Table 5.--Estimated average daily consumption of electrical energy: Receiving station, Cheddar cheese plant, and cream-nonfat dry milk plant, New York-New Jersey milkshed, 1958

Function	Receiving station	Cheddar cheese plant	Cream-nonfat dry milk plant
	Kw.-hr.	Kw.-hr.	Kw.-hr.
Processing	14	40	1,973
Lighting	29	151	542
Steam	6	12	131
Refrigeration and cooling .	212	117	1,517
Miscellaneous	29	63	109
Total	290	383	4,272

Electrical Energy Costs

Charges for electrical power consist of two elements, the energy charge and the demand charge. The energy charge is based on the amount of electricity used and is expressed as a cost per kilowatt-hour. Ordinarily such cost rates are scheduled in decreasing increments, the last units being less costly than the initial unit. The second element, the demand charge, is a monthly charge based on the maximum rate at which energy is required (or peak load).

The demand quantity was estimated at 22 kilowatts for the receiving station and 42 kilowatts for the Cheddar cheese plant, on the basis of the estimated number of kilowatts drawn during a peak 30-minute period. The large number of power-consuming units and the variations and overlapping in operating times made it difficult to estimate the demand quantity by the same method in the cream-nonfat dry milk plant. Therefore, the weighted average demand charge as determined by the study of 8 manufacturing plants in the New York milkshed was selected for this plant (17). This figure ($480 per month) was subsequently converted to kilowatts demand by reference to the power cost schedule for the city of Ithaca, N. Y. 30/ The conversion indicated a demand quantity of 291 kilowatts which, in light of the information available on horsepower requirements and operating times, appeared to be a reasonable estimate of the demand quantity.

Once the energy requirements and demand quantities have been determined, costs are easily computed by applying an appropriate rate schedule. Again

30/ This was considered to be reasonably typical of schedules that prevail in upstate New York.

using the Ithaca schedule, electricity costs were determined for the receiving station, Cheddar cheese plant, and cream-nonfat dry milk plant (table 6).

Table 6.--Estimated average daily costs of electrical power: Receiving station, Cheddar cheese plant, and cream-nonfat dry milk plant, New York-New Jersey milkshed, 1958

Plant	Energy charge	Demand charge	Total cost
	Dollars	Dollars	Dollars
Receiving station ....:	4.58	0.99	5.57
Cheddar cheese plant ......:	5.69	2.06	7.75
Cream-nonfat dry milk plant:	54.51	17.92	72.43

Water Requirements and Costs

Milk plants use large quantities of water for cleaning, heating, and cooling. Consequently, a dependable source of water is a prerequisite in selecting a plant location. For the model plants it was assumed that an adequate supply of water was available from the local community water facility.

Water costs were based on the rate schedule for the city of Williamsport, Pa. This schedule was selected on the basis of a mail survey which indicated that the schedule was fairly typical for communities in the Northeast. 31/ The average rate developed from this schedule varied around 12 cents per 1,000 gallons depending upon the quarterly consumption of water.

Water requirements for the various elements of the model plants were developed independently, using a variety of standards as appeared appropriate in the specific instance. For example, water consumption for can washing was based on an estimated use of 2 gallons per can washed. Water for personal use was estimated at 25 gallons per man per day. Water requirements for plant cleanup were developed on the basis of the time required to clean a particular piece of equipment. It was assumed that during the cleaning operation water would be running approximately half the time, at an average flow of 3 gallons per minute. On the basis of these assumptions the following formula was used to determine cleaning requirements:

$$C = \frac{3T}{2},$$

where C represents consumption in gallons, and T the cleaning time in minutes.

Conforming to industry practice, cleaning-in-place methods were utilized for the sanitary lines, evaporative condenser system, and high temperature

31/ Unpublished data, Department of Agricultural Economics, Pennsylvania State University, University Park, Pa., 1955.

short time pasteurization system. Estimates were made of the required amount of water and cleaning solution to surge these systems. The estimates, based in part on the recommendations of cleaning solution manufacturers, varied according to the capacity of the equipment being cleaned.

Water is used for cooling purposes in two different ways. It is used directly as a cooling medium in heat exchangers and for compressor cooling for the coldroom and product cooling systems. The amount of water used for cooling depends on the surface area of the cooling equipment and the rate at which the product is cooled. In most instances where water was used for direct cooling in the model plants, the consumption rate was estimated to require a 3-to-1 ratio of water to product. One exception to this rule was the heat exchanger used in the manufacture of ice cream mix. In this case, the manufacturer's specifications called for a 5-to-1 ratio of water to product.

Water requirements for compressor cooling in the receiving station and Cheddar cheese plant were estimated on the basis of 1 gallon per minute per horsepower. This is a commonly accepted standard for this operation (19).

In the cream-nonfat dry milk plant, specifications called for the use of evaporative condensers for compressor cooling to reduce total water requirements. Water consumption rates for these condensers were taken from the manufacturer's specifications.

Large quantities of water are used in conjunction with the evaporating pan to condense and thus eliminate vapor from the milk. Water requirements for this purpose were reduced by specifying the installation of a cooling tower. Under this system, heat picked up by the water in the condensing operation is dissipated in the cooling tower so that the same water may be used over again. This greatly reduces water requirements for the condensing operation. It is noted, however, that savings in water costs may be offset by the costs of the tower and of the electric power required to operate the system.

Daily water requirements and costs for the three model plants are shown in table 7. These requirements are based on average daily volumes processed.

Table 7.--Estimated average daily water requirements and costs: Receiving station, Cheddar cheese plant, and cream-nonfat dry milk plant, New York-New Jersey milkshed, 1958

Plant	Average daily requirements	Cost per 1,000 gallons	Daily cost
	Gallons	Dollars	Dollars
Receiving station	34,846	0.13402	4.67
Cheddar cheese plant	11,546	.16023	1.85
Cream-nonfat dry milk plant	44,991	.12873	5.79

Plant Waste and Sewage Costs

Disposal of dairy waste is an important problem for dairy manufacturing plants. Costs vary widely, depending in part on whether community sewage-disposal systems are available or the plant must provide its own disposal system. In view of the lack of current and readily available data on operating requirements and costs, the estimation of sewage costs based on alternative systems was considered beyond the scope of the study even though such information may have been desirable for purposes of comparison. Since some community sewage facilities will accept both treated and untreated dairy waste, costs for the model plants were based upon rates reported by Kolmer and others (15, p. 12). The rate chosen was $0.06 per 100 cubic feet of water discharged into the local sewage system.

The amount of waste discharged into the system was estimated separately for each plant. In computing daily plant waste, the following sources of waste water were considered: Personal use, cleanup water, condensate, whey, buttermilk, butter wash water, and miscellaneous. In addition, an increment of 25 percent of the total waste water was included to account for solids content and to provide a factor for error. The average daily waste for the cream-nonfat dry milk plant amounted to 3,050 cubic feet, with a consequent daily average cost of $1.83 for waste disposal.

Waste disposal costs were not included in the plant cost computations for the receiving station and the Cheddar cheese plant. For the receiving station it was assumed that the quantity of waste was relatively small and thus could be disposed of through a small trickling filter or local sewage facility at no measurable cost to the plant. In the Cheddar cheese plant, it was assumed that whey would be disposed of at no cost or profit to the plant. Cheese plant wastes, other than whey, then, would be disposed of by the same methods as at the receiving station.

Steam Requirements and Costs

Steam is the most widely used source of heat for general use in dairy plants. It is economical and is easily transmitted from the boiler to the place of use. In the model plants, steam was used for can washing, water heating, product processing, and for plant heating. Standards for steam consumption were derived from other studies or taken from technical sources.

Steam uses for can washing were based upon direct steam consumption of 2 pounds per can (11, p. 287). In the model plants, total steam consumption for this use was based on the average daily number of cans received. 32/ Steam for water heating was estimated on the basis of 1 pound of steam for each 10 pounds of water (22). Hot water requirements, in this instance, were limited to water required for plant and equipment cleaning and for washing producers' cans. Steam requirements for plant heating were estimated at the rate of 1 pound of steam for each 3 square feet of floor space. 33/ The standard for

---

32/ The number of cans received was estimated on the assumption that, on the average, each can contains 70 pounds of milk.

33/ See footnote 17.

plant heating assumed a well-constructed masonry building located in the Northeast. 34/

Steam consumption rates for product processing were adapted from other studies. For example, steam requirements for cheese cooking--which were estimated at 2.75 pounds per hundredweight of milk--were drawn from the Columbia Basin studies (22). Similarly, requirements for condensing and spray drying, estimated at 50 pounds per hundredweight of skim milk processed and 550 pounds per hundredweight of powder, were taken from the study of 8 manufacturing plants in the New York milkshed (17).

Total steam consumption by each function for each of the model plants is shown in table 8.

Table 8.--Average daily steam requirements: Receiving station, Cheddar cheese plant, and cream-nonfat dry milk plant, New York-New Jersey milkshed, 1958

Center	Receiving station	Cheddar cheese plant	Cream-nonfat dry milk plant
	Pounds	Pounds	Pounds
Processing	2,014	8,047	218,113
Plant heating	834	2,920	9,000
Water heating	2,122	2,564	5,028
Miscellaneous	497	1,353	3,507
Total	5,467	14,884	235,648

Fuel Consumption and Costs

Fuel consumption was estimated on the basis of average daily steam requirements. The standard used--112 pounds of steam per gallon of fuel--is commonly accepted for estimating fuel requirements (19). Fuel costs were based on the use of No. 6 fuel oil, at the estimated price of $0.096 per gallon. Average daily requirements and costs for steam and fuel in the model plants are shown in table 9.

34/ Plant heating requirements vary with differences in annual mean temperature between the interior and exterior of the plant and in the quality of insulation. Thus, the standard used requires some specific assumptions regarding plant location and building construction.

Table 9.--Average daily steam and fuel requirements, and cost of fuel: Receiving station, Cheddar cheese plant, and cream-nonfat dry milk plant, New York-New Jersey milkshed, 1958

Plant	Steam	Fuel oil	Daily cost of fuel oil
	Pounds	Gallons	Dollars
Receiving station	5,467	48.4	4.64
Cheddar cheese plant	14,884	132.9	12.63
Cream-nonfat dry milk plant	235,648	2,104.1	201.99

MISCELLANEOUS PLANT REQUIREMENTS AND COSTS

Some plant expense items, usually small, constitute a "miscellaneous" group. These include such items as cleaning supplies, laboratory and office supplies, uniforms, and laundry.

For the model plants, cleaning supply costs were developed from standards and from prices furnished by the cleaning supply industry. Daily cleaning supply expense amounted to $1.50 in the receiving station, $3.79 in the Cheddar cheese plant, and $12.03 in the cream-nonfat dry milk plant. This was equivalent to 0.21 cent per hundredweight received in the receiving station, 0.48 cent per hundredweight received in the Cheddar cheese plant, and 0.51 cent per hundredweight received in the cream-nonfat dry milk plant.

Lacking reliable empirical data on consumption rates, it was not considered feasible to estimate costs of laboratory and office supplies directly. Walker and others developed a figure of 7.0 cents per 1,000 pounds received for office supplies from records of 12 Northwest butter-nonfat dry milk plants studied, during 1948-49 (25). This same study indicated a range of 1.0 to 15.0 cents per 1,000 pounds received with no pronounced decline in costs associated with increases in the size of plant.

In view of the range exhibited by the Walker study, it is clear that office supply expense is subject to rather extreme variation. For this study the cost rate for office supplies in the model plants was arbitrarily selected to be 7.7 cents per 1,000 pounds received. On the basis of this estimate, daily office supply expenses amounted to $5.60 for the Cheddar cheese plant and $18.08 for the cream-nonfat dry milk plant. Office supply expense was not computed separately for the receiving station since it was assumed that major administrative requirements for this plant would be handled by a central office. It was further assumed that minor office supply expenses incurred by the receiving station would be included in the allowance for miscellaneous costs.

Boles, in a study of plant costs for evaporated milk plants, indicates that laboratory supply costs vary according to:

1. Number of producers
2. Policy with respect to accumulating samples
3. Method of receiving (can or bulk)
4. Variety and frequency of control tests (3).

In the same study, he reports laboratory supply costs of 0.9, 1.6, and 1.9 cents per 1,000 pounds received for 3 large fluid milk plants in California. Boles notes that these plants received almost all of their supplies in bulk from large producers and cautions that these costs are probably lower than for plants receiving in cans from small producers.

Other investigators have reported laboratory supply expense per 1,000 pounds received ranging from 2.3 cents in a plant receiving 15,400 pounds of milk to 4.7 cents in a plant receiving 114,000 pounds of milk per day (1, pp. 43, 47). On the basis of this information, Boles used a figure of 4.0 cents per 1,000 pounds received to estimate laboratory expense for evaporated milk plants. In the absence of other data, this estimate of 4.0 cents per 1,000 pounds received was utilized in the model plants. Laboratory supply expense amounted to $3.20 per day in the Cheddar cheese plant and $9.04 in the cream-nonfat dry milk plant. Laboratory supply expenses were not computed separately for the receiving station but were assumed to be included in the allowance for miscellaneous expense.

Most plants furnish uniforms and laundry service for operating personnel. For the model plants, it was assumed that the cost of uniforms and laundry service, plus incidental plant laundry, would approximate $0.65 per man per day (19). Charges for uniform and laundry expense amounted to $1.97 per day in the receiving station, and $9.75 per day in both the Cheddar cheese and the cream-nonfat dry milk plant.

PLANT MODIFICATIONS

Requirements and Costs of Input Factors

Previous sections have described the way in which processing costs have been developed for three specialized plants--receiving station, cheese plant, and the more complex cream-nonfat dry milk plant. The third plant--though originally designed to produce only those specific commodities--can be easily modified to manufacture alternative products. For example, it can be converted to a butter-nonfat dry milk plant by installing a churn and the necessary packaging equipment. Obviously, such modifications will affect the total costs, both fixed and variable. The following sections specify the modifications required to adapt this complex plant for alternative products and to determine appropriate processing costs.

Plant Buildings

Construction costs in the basic cream-nonfat dry milk plant were based upon the number of square feet of floor space required for plant operations for these specific products. These costs were discussed on page 13. Utilizing the same cost per square foot, construction costs were also estimated for model plants designed to produce cream and condensed skim milk, butter and condensed skim milk, butter and nonfat dry milk, ice cream mix and condensed skim milk, ice cream mix and nonfat dry milk, and ice cream mix and cottage cheese. The number of square feet of floor space required and total building costs for these plants are shown in table 10.

Table 10.--Estimated space requirements, construction costs, and average daily building costs, alternative dairy-product plant modifications, New York-New Jersey milkshed, 1958

Plant	Area	Estimated construction cost: Cost per square foot	Estimated construction cost: Total cost (1958) 1/	Average daily building costs 2/
	Square feet	Dollars	Dollars	Dollars
Butter-nonfat dry milk	26,263	11.36	298,000	88.06
Butter-condensed skim milk	20,867	11.36	237,000	70.14
Butter-cottage cheese	21,788	7.86	171,500	51.68
Cream-nonfat dry milk	26,675	11.36	302,500	89.27
Cream-condensed skim milk	19,703	11.36	224,000	64.82
Cream-cottage cheese	22,220	7.86	174,500	52.66
Ice cream mix-nonfat dry milk	27,795	11.36	316,000	92.85
Ice cream mix-condensed skim milk	19,363	11.36	220,000	65.13
Ice cream mix-cottage cheese	22,990	11.36	260,500	74.50

1/ Rounded to nearest $500.
2/ Depreciation, repair, maintenance, insurance, taxes, and interest.

A different cost per square foot was used in synthesizing costs for the cream-cottage cheese plant and the butter-cottage cheese plant. Inspection of the building requirements for these operations indicated they are more like the building requirements for the Cheddar cheese operation than those for the cream-nonfat dry milk plant. Cheese plants need large open areas to hold vats and other widely dispersed equipment. They do not require, however, the high ceilings that are needed for the operation of condensing pans or spray boxes. For this reason, it was assumed that a concrete block building of the same general type as the Cheddar cheese plant would meet building requirements for these plants.

The ice cream mix-cottage cheese plant combined certain features of both the basic cream-nonfat dry milk operation and the Cheddar cheese operation. The condensing pan requires a high ceiling (at least 28 feet) and therefore an area with a high cost per square foot, while the cheese vats require a large floor area with a lower cost per square foot, approximating that for the Cheddar cheese plant. It is probable, therefore, that the cost per square foot for this building would lie somewhere between the costs for the cream-nonfat dry milk plant and the costs for the Cheddar cheese plant. In the absence of any data which would permit the interpolation of costs for this plant, the larger figure of $11.36 per square foot was used for computing building costs.

Plant Equipment

In the initial synthesis of the cream-nonfat dry milk operation, the various functions were departmentalized so that they could be revised in whole or in part by the addition or subtraction of other pieces of equipment. Thus, the synthesis of the cream-condensed skim milk operation from cream and nonfat dry milk involves elimination of the spray box and accessory equipment, additions for cooling and storing condensed skim milk, and changes in refrigeration and steam boiler equipment to meet changing requirements for these items. Similarly, the processing of fat into butter requires the addition of a butter-processing center and auxiliary equipment, and the elimination of certain kinds of cream-processing equipment as well as space.

Table 11 summarizes the estimated equipment investment and the average daily cost of owning the equipment in each of the complex plants.

Table 11.--Estimated equipment investment and average daily equipment costs: Alternative dairy-product plant modifications, New York-New Jersey milkshed, 1958

Plant	Estimated equipment investment 1/	Average daily equipment cost 2/
	Dollars	Dollars
Butter-nonfat dry milk	506,103	271.48
Butter-condensed skim milk	464,397	285.13
Butter-cottage cheese	426,219	224.07
Cream-nonfat dry milk	516,718	283.46
Cream-condensed skim milk	498,576	288.46
Cream-cottage cheese	435,434	235.41
Ice cream mix-nonfat dry milk	503,500	311.63
Ice cream mix-condensed skim milk	471,343	320.38
Ice cream mix-cottage cheese	545,678	309.44

1/ 1958 prices installed.
2/ Depreciation, repair, maintenance, insurance, taxes, and interest.

Labor

Labor requirements for the various plant modifications were developed from data taken from the study of 8 manufacturing plants in the New York milkshed (17) and from industry sources. In general, the same procedure was followed in the modifications as in basic cream-nonfat dry milk plants. That is, the manufacturing process was broken down into functional operations and labor requirements were determined for each function. Total labor force was the sum of these requirements. Comparative labor costs for each plant modification are shown in table 12.

Table 12.--Estimated average daily labor costs: Alternative dairy-product plant modifications, New York-New Jersey milkshed, 1958

Plant	Average daily labor cost
	Dollars
Butter-nonfat dry milk	504.75
Butter-condensed skim milk	494.45
Butter-cottage cheese	461.51
Cream-nonfat dry milk	457.83
Cream-condensed skim milk	451.35
Cream-cottage cheese	446.79
Ice cream mix-nonfat dry milk	534.18
Ice cream mix-condensed skim milk	504.71
Ice cream mix-cottage cheese	503.51

Utilities

Total utility requirements and costs for each of the major plant modifications were developed in the same manner as those for the cream-nonfat dry milk plants. That is, the requirement for each plant was developed separately according to the quantity of the factor consumed by each plant operation. The sum of these individual requirements constituted the quantity of the factor or utility required by the plant. Prices were subsequently applied to these quantities and average daily utility costs obtained for each plant. These costs are summarized in table 13.

Table 13.--Estimated average daily utility expense, alternative dairy-product plant modifications, New York-New Jersey milkshed, 1958

Plant	Average daily utility costs 1/
	Dollars
Butter-nonfat dry milk	280.80
Butter-condensed skim milk	176.55
Butter-cottage cheese	87.72
Cream-nonfat dry milk	282.03
Cream-condensed skim milk	188.33
Cream-cottage cheese	88.03
Ice cream mix-nonfat dry milk	251.38
Ice cream mix-condensed skim milk	174.09
Ice cream mix-cottage cheese	115.97

1/ Includes costs of fuel, water, electric energy, and sewage disposal.

COSTS OF PACKAGING MATERIALS

Package requirements in the model plants were of two types: (1) Plant-owned cans and (2) single-trip items such as parchment liners, boxes, and bags. It was assumed that fluid products such as cream, condensed skim milk, and ice cream mix are packaged in returnable plant-owned cans. As mentioned earlier, can requirements for these fluid products were capitalized as an equipment item and are included in the list of equipment costs.

Consumable items used in marketing fluid products in plant cans were seals, wire, and parchment. Requirements for these items were estimated on the basis of the average number of cans shipped per day. This estimate was increased by 2 percent to provide for waste incurred in use.

Package requirements and costs for butter and spray-process nonfat dry milk were based on the work of other investigators. Walker and others used a figure of 1.05 cents per pound to represent package costs of spray-process nonfat dry milk (25, p. 43). Kolmer and others estimated the cost of packaging the same product at 1.36 cents per pound (15, pp. 6-7). This latter figure reflected the costs of packaging in 220-pound hard-board barrels with liners of kraft paper and polyethylene. Juers and Koller indicated a range of .90 to 1.27 cents per pound in costs of packaging nonfat dry milk (14, p. 17). These investigators indicated that the range in costs reflected varying proportions of total output packed in 220-pound hard-board barrels and 100-pound kraft paper bags with polyethylene liners. For the model plants, the figure of 1.05 cents per pound was selected to represent the costs of packaging nonfat dry milk. This appeared to be a reasonable estimate for packaging costs incurred by plants packaging powder in both bags and barrels.

Butter processed in the model plants was assumed to be packaged in 64-pound cardboard containers with parchment liners. The cost of this type of container has been estimated by one investigator at .3 cent per pound of butter (25). This figure included some other minor cost items such as salt and butter color. In a study of 12 Iowa butter plants, Frazer and others indicated butter packaging costs ranging from .25 to .38 cent per pound with a mean of .32 cent and a median of .30 cent per pound (12, pp. 810-811). On the basis of the evidence presented by these investigators, the .3 cent per pound figure was selected for butter packaging costs in the model plants.

Packaging costs for cheese were computed on the basis of data developed in this study. It was assumed that only one style of cheese (single daisy) would be produced and that each package would consist of 1 cheese bandage, 2 circles, 4 ounces of wax, and 1 box. Estimated total requirements were increased by 2 percent to allow for normal loss and damage to packaging supplies. Prices were obtained from manufacturers of each individual package item and total package costs were computed on the basis of the average daily number of cheeses produced. These costs amounted to approximately 2.23 cents per pound of cheese produced, or 21 cents per 100 pounds of milk received.

It was assumed that cottage cheese would be marketed in 50-pound nonreturnable tins with parchment lid liners. Prices for tins and liners were obtained from industry sources and costs were computed on the basis of average daily volume produced. Again a 2 percent allowance was added for loss and damage. Costs for this item amounted to approximately 60 cents per 50-pound tin, or 1.2 cents per pound of cottage cheese produced.

Package costs for selected manufactured products are summarized in table 14.

Table 14.--Estimated package costs for selected manufactured dairy products, New York-New Jersey milkshed, 1958

Product	Package cost per pound
	Cents
Butter	0.30
Nonfat dry milk	1.05
Cheddar cheese	2.23
Cottage cheese	1.20

UNIT PROCESSING COSTS

The major objective of this study was to arrive at a series of unit processing costs. These costs were designed to represent annual average unit costs of reasonably efficient operations under conditions--such as seasonal variations in receipts, and prevailing wages and other input cost structures--typical of manufacturing plants in the New York-New Jersey milkshed. In line with this objective, previous sections have described the development of factor inputs and prices for a series of model dairy manufacturing plants processing specified volumes of milk. In this section, the previously determined cost elements for the various types of plants are summarized and converted into annual average processing costs per hundredweight of milk received. These are shown in tables 15 through 25.

Unit Costs by Products or Combinations of Products

In the model plants the problems inherent in allocating costs between specific products are avoided by computing unit costs in terms of "joint product" costs. In other words, the processing costs for the cream-nonfat dry milk plant, for example, are shown in terms of the combined cost, per 100 pounds of milk received, of processing whole milk into the joint cream and nonfat dry milk products. Each combination of fat- and skim-containing products is by technical necessity produced in fixed proportions so that each combination is best treated as a single product (7, pp. 75-76).

Table 15.--Receiving station: Major expense items, estimated average costs per day and per hundredweight of raw milk received, New York-New Jersey milkshed, 1958

Expense item	Cost of item per day	Cost of item per cwt. of raw milk
	Dollars	Dollars
Labor	59.62	0.085
Building:		
Depreciation	2.19	
Repair and maintenance	.80	
Taxes	1.64	
Insurance	.39	
Interest	2.29	
	7.31	.010
Equipment:		
Depreciation	11.56	
Repair and maintenance	9.15	
Insurance	1.32	
Taxes	3.29	
Interest	4.58	
	29.90	.042
Utilities:		
Electricity	5.57	
Water	4.67	
Fuel	5.83	
	16.07	.023
Supplies and miscellaneous	3.97	.006
Total	116.87	.166

Table 16.--Cheddar cheese plant: Major expense items, estimated average cost per day, per hundredweight of raw milk received, and per pound of cheese produced, New York-New Jersey milkshed, 1958 1/

Expense item	Cost of item per day	Cost of item per cwt. of raw milk	Cost of item per pound of cheese
	Dollars	Dollars	Dollars
Labor	207.08	0.260	0.027
Building:			
Depreciation	10.35		
Repair and maintenance	3.41		
Taxes	6.66		
Insurance	2.95		
Interest	9.25		
	32.62	.041	.004
Equipment:			
Depreciation	49.61		
Repair and maintenance	22.40		
Taxes	12.68		
Insurance	6.98		
Interest	17.62		
	109.29	.137	.014
Liability insurance	2.99	.004	4/
Utilities:			
Electricity	7.75		
Water	1.85		
Fuel	11.88		
	21.48	.027	.003
Miscellaneous:			
Cleaning supplies	3.79		
Office supplies	5.60		
Laboratory supplies	3.20		
Uniforms and laundry	9.75		
Other supplies 2/	20.29		
	42.63	.054	.006
Packaging supplies 3/	169.20	.212	.022
Total	585.29	.735	.076

1/ Assumes plant produces cheese for 6 months and operates as shipping station for 6 months.
2/ Rennet, starter, salt, and coloring.
3/ Single daisies, bandage, circles, wax, box, and nails.
4/ Less than .001.

Table 17.--Cream-nonfat dry milk plant: Major expense items, estimated weighted average costs per day and per hundredweight of raw milk received, New York-New Jersey milkshed, 1958

Expense item	Cost of item per day	Cost of item per cwt. of raw milk
	Dollars	Dollars
Labor	457.83	0.194
Building:		
Depreciation	28.51	
Repair and maintenance	9.41	
Insurance	8.10	
Taxes	18.11	
Interest	25.14	
	89.27	.038
Equipment:		
Depreciation	118.35	
Repair and maintenance	80.36	
Insurance	15.64	
Taxes	28.93	
Interest	40.18	
	283.46	.120
Liability insurance	10.29	.004
Utilities:		
Electricity	72.42	
Water	5.79	
Fuel	201.99	
Sewage	1.83	
	282.03	.120
Miscellaneous:		
Cleaning supplies	12.03	
Office supplies	18.08	
Laboratory supplies	9.04	
Uniforms and laundry	9.75	
	48.90	.021
Packaging supplies	241.30	.102
Total	1,413.08	.599

Table 18.--Butter-nonfat dry milk plant: Major expense items, estimated weighted average costs per day and per hundredweight of raw milk received, New York-New Jersey milkshed, 1958 1/

Expense item	Cost of item per day	Cost of item per cwt. of raw milk
	Dollars	Dollars
Labor	504.75	0.214
Building	88.06	.037
Equipment (including cans)	271.48	.115
Liability insurance	9.50	.004
Utilities	280.80	.119
Miscellaneous	51.87	.022
Packaging supplies, except cans	272.06	.115
Total	1,478.52	.626

1/ Weighted by average monthly volumes received.

Table 19.--Butter-condensed skim milk plant: Major expense items, estimated weighted average cost per day and per hundredweight of raw milk received, New York-New Jersey milkshed, 1958 1/

Expense item	Cost of item per day	Cost of item per cwt. of raw milk
	Dollars	Dollars
Labor	494.45	0.210
Building	70.14	.030
Equipment (including cans)	285.13	.121
Liability insurance	9.99	.004
Utilities	176.55	.075
Miscellaneous	47.36	.020
Packaging supplies, except cans	38.24	.016
Total	1,121.86	.476

1/ Weighted by average monthly volumes received.

Table 20.--Butter-cottage cheese plant: Major expense items, estimated weighted average costs per day and per hundredweight of raw milk received, New York-New Jersey milkshed, 1958 1/

Expense item	Cost of item per day	Cost of item per cwt. of raw milk
	Dollars	Dollars
Labor	461.51	0.196
Building	51.68	.022
Equipment	224.07	.095
Liability insurance	12.10	.005
Utilities	87.72	.037
Miscellaneous	63.72	.027
Packaging supplies	445.64	.189
Total	1,346.44	.571

1/ Weighted by average monthly volumes received.

Table 21.--Cream-condensed skim milk plant: Major expense items, estimated weighted average costs per day and per hundredweight of raw milk received, New York-New Jersey milkshed, 1958 1/

Expense item	Cost of item per day	Cost of item per cwt. of raw milk
	Dollars	Dollars
Labor	451.35	0.192
Building	64.82	.028
Equipment (including cans)	288.46	.122
Liability insurance	10.79	.005
Utilities	188.33	.080
Miscellaneous	44.40	.019
Packaging costs, except cans	4.51	.002
Total	1,052.66	.448

1/ Weighted by average monthly volumes received.

Table 22.--Cream-cottage cheese plant: Major expense items, estimated weighted average costs per day and per hundredweight of raw milk received, New York-New Jersey milkshed, 1958 1/

Expense item	Cost of item per day	Cost of item per cwt. of raw milk
	Dollars	Dollars
Labor	446.79	0.190
Building	52.66	.022
Equipment (including cans)	235.41	.100
Liability insurance	12.71	.005
Utilities	88.03	.037
Miscellaneous	61.72	.026
Packaging supplies, except cans	432.37	.184
Total	1,329.69	.564

1/ Weighted by average monthly volumes received.

Table 23.--Ice cream mix-nonfat dry milk plant: Major expense items, estimated weighted average costs per day and per hundredweight of raw milk received, New York-New Jersey milkshed, 1958 1/

Expense item	Cost of item per day	Cost of item per cwt. of raw milk
	Dollars	Dollars
Labor	534.18	0.227
Building	92.85	.039
Equipment (including cans)	311.63	.132
Liability insurance	15.33	.006
Utilities	251.38	.107
Miscellaneous	48.28	.020
Packaging supplies, except cans	172.57	.073
Total	1,426.22	.604

1/ Weighted by average monthly volumes received.

Table 24.--Ice cream mix-condensed skim milk plant: Major expense items, estimated weighted average costs per day and per hundredweight of raw milk received, New York-New Jersey milkshed, 1958 1/

Expense item	Cost of item per day	Cost of item per cwt. of raw milk
	Dollars	Dollars
Labor	504.71	0.214
Building	65.13	.028
Equipment (including cans) 2/	320.38	.136
Liability insurance	15.68	.007
Utilities	174.09	.074
Miscellaneous	44.67	.019
Total	1,124.66	.478

1/ Weighted by average monthly volumes received.
2/ Plant uses no packaging materials except cans.

Table 25.--Ice cream mix-cottage cheese plant: Major expense items, estimated weighted average costs per day and per hundredweight of raw milk received, New York-New Jersey milkshed, 1958 1/

Expense item	Cost of item per day	Cost of item per cwt. of raw milk
	Dollars	Dollars
Labor	503.51	0.214
Building	74.50	.032
Equipment (including cans)	309.44	.131
Liability insurance	14.61	.006
Utilities	115.97	.049
Miscellaneous	69.06	.029
Packaging supplies, except cans	338.69	.144
Total	1,425.78	.605

1/ Weighted by average monthly volumes received.

Comparisons with Other Studies

One advantage of statistical studies utilizing accounting data (as opposed to the method of synthesis used in this study) is that they do provide the investigator with an opportunity for testing the reliability of component parts and, hence, give some idea of the reliability of the final results (2). One of the deficiencies of the synthetic approach to cost analysis is that once results are obtained there is no statistical method of testing their reliability. This deficiency does not, however, invalidate synthesized cost studies since it is often possible to check results with other sources. Such comparisons serve to test the reasonability of the data so synthesized and to give some assurance that important cost components have not been inadvertently omitted. Several comparisons of this sort are made in the following paragraphs.

Kosikowski indicates that in a study of 15 New York cheese factories conducted in 1953, average processing costs amounted to 6.75 cents per pound. 35/ On the assumption that changes in the wholesale price index (1947-49 = 100) reflect changes in processing costs, the processing cost (adjusted to 1958 cost rates) for Cheddar cheese as computed by Kosikowski would amount to 7.26 cents per pound. This is .48 cent per pound less than costs of 7.74 cents per pound developed for the model cheese plant (table 16).

Rowe indicates plant costs of 4.34 cents per pound for a plant processing an average of 1,569,443 pounds of Cheddar cheese annually, and 4.35 cents per pound for a plant processing an average of 1,013,760 pounds annually (21, p. 17). This study was conducted in Oregon and covered accounting data for 1941-48. Again, assuming that movements in the index of wholesale prices (1947-49 = 100) reflect the increase in processing costs, 1958 costs for the Oregon plants would amount to 5.94 and 5.96 cents per pound. This difference appears to be considerable; however, it might be explained in part by variations in building requirements and costs, regional differences in labor costs, and the fact that the Oregon cheese plants were not qualified to ship milk for bottling.

The Milk Dealers Association of Metropolitan New York reported, for seven cream-nonfat dry milk plants in 1950, a net processing cost of 73.3 cents per hundredweight of milk processed (24). When this figure is adjusted to be comparable with the model plant data (eliminating feeder plant costs, hauling charges, and plant loss), the resulting cost amounts to approximately 48.3 cents per hundredweight processed. 36/ A further adjustment for price changes using the wholesale price index (1947-49 = 100) yields a processing cost of 55.9 cents per hundredweight for the reporting plants. On the other hand, the processing cost of 59.9 cents per hundredweight for the model plant contains certain expense items which were not included as a net cost of manufacturing by the reporting plants. These items, namely package costs and investment costs (interest on investment), amount to approximately 13 cents per hundredweight in the model plant. The model plant costs adjusted for comparability amount to 46.9 cents per hundredweight, or 9 cents per hundredweight less than

---

35/ Kosikowski, Frank. Testimony for Class III hearing, N. Y. Federal Milk Market Order. 1954 (unpub., mimeo.).

36/ For a treatment of feeder plant costs, hauling costs, and plant loss as components of plant costs, see footnote 17.

processing costs encountered by the reporting plants. Since the average volumes processed in the reporting plants are roughly comparable to those of the model plant (62.9 million pounds annually versus 72 million), reasons for this cost difference must be sought in variation in cost rates or physical input rates. For example, depreciation costs for the model plant exceeded those of the reporting plants by approximately 2 cents per hundredweight; labor rates averaged $1.27 per hour in the reporting plants, against a weighted average cost of $1.77 per hour for processing labor in the model plant. 37/ Although these variations may be wholly or partially compensated for by the price adjustment, differences in labor efficiency or plant organization would still result in variations in processing costs between the model plant and the reporting plants.

Processing costs for the model butter-nonfat dry milk plants may be compared with costs developed in the Northwest butter-nonfat dry milk study (25). These costs ranged from 74 cents to 48 cents per hundredweight received. Costs for a butter-nonfat dry milk plant comparable in size to the model plant (2,568 hundredweight per day versus 2,356 hundredweight for the model plant) amounted to 48 cents per hundredweight received. For the model plant, these costs amounted to 63 cents per hundredweight received (table 19). Costs for a smaller plant in the Northwest study (1,606 hundredweight per day) amounted to 54 cents per hundredweight. Costs in the Northwest study were based on 1946 prices. Thus, following the previous assumption that changes in the index of wholesale prices (1947-49 = 100) reflect changes in processing costs over the time period considered, the new costs (adjusted to the 1958 level) became 67.6 cents per 100 pounds received for the larger plant and 76 cents per 100 pounds received for the smaller. The adjusted processing costs in the larger Northwest plant are 4.6 cents per hundredweight higher than comparable costs developed in the model plant. For the smaller Northwest plant, this difference is 13 cents per hundredweight received.

The purpose of these comparisons is to test the reasonableness of cost data for the model plants. The costs for the model plants agreed with results of other studies (after appropriate adjustments, and with one exception) within 5 to 9 cents per 100 pounds of milk processed. Considering that compensations for differences in building requirements and costs, wage rates, labor efficiency, and prices were not entirely possible, the measure of agreement is well within the range of costs that probably exists among individual firms within the milkshed.

37/ The average rate includes fringe benefits and shift differentials.

Table 26.--Receiving station: Contractors' itemized estimate of building costs, New York-New Jersey milkshed, 1953

Item	Number of units	Cost: Per unit	Cost: Total
		Dollars	Dollars
Excavation for footer	85 cu. yds.	3.00	255
Concrete footer	19 cu. yds.	40.00	760
Exterior walls, 8" block	1,840 blocks	.80	1,471
Interior walls, 6" block	1,628 blocks	.60	977
Concrete floor, 5" reinforced mesh	2,750 sq. ft.	1.00	2,750
Quarry tile floors	1,000 sq. ft.	2.00	2,000
Asphalt tile	520 sq. ft.	.50	260
Built-up roof	25 squares	38.00	950
Roof, 2" concrete plank	2,500 sq. ft.	.90	2,250
Coping	240 lin. ft.	.75	180
Ceiling, $\frac{1}{2}$" fiberboard	520 sq. ft.	.35	182
Plaster work	222 sq. yds.	3.00	666
Lath, fiberboard, strapped to joists	2,000 sq. ft.	.30	600
Insulation, 2" glass fiber	2,500 sq. ft.	.15	375
Millwork	---	---	1,110
Painting	---	---	750
Subtotal	---	---	15,536
Electricity	---	---	1,779
Heating	---	---	1,500
Plumbing	---	---	1,800
Allowance for error and contingency plus contractors' fees	---	---	4,879
Total	---	---	25,494

Table 27.--Cheddar cheese plant: Contractors' itemized estimate of building costs, New York-New Jersey milkshed, 1953

Item	Number of units	Cost: Per unit	Cost: Total
		Dollars	Dollars
Exterior walls, 8" block	6,133 blocks	0.80	4,904
Interior walls, 6" block	1,853 blocks	.60	1,112
Excavation for footers	193 cu. yds.	3.00	579
Concrete footers	43 cu. yds.	40.00	1,720
Concrete floor, mesh reinforced	9,610 sq. ft.	1.00	9,610
Quarry tile	1,000 sq. ft.	2.00	2,000
Asphalt tile floors	876 sq. ft.	.50	438
Steel joists	15 tons	400.00	6,000
Roofing	94 squares	38.00	3,572
Planks, 2" concrete	9,360 sq. ft.	.90	8,424
Insulation, 2" glass fiber	9,360 sq. ft.	.15	1,404
½" fiberboard	876 sq. ft.	.35	307
Plaster	943 sq. yds.	3.00	2,829
Lath strapped to joists	7,884 sq. ft.	.30	2,365
Coping	464 lin. ft.	.75	348
Insulation, coldroom, 4"	2,200 sq. ft.	.25	550
Asbestos board, coldroom	1,600 sq. ft.	.40	640
Refrigerator doors	2 doors	250.00	500
Subtotal	---	---	47,302
Electricity	---	---	3,603
Heating	---	---	4,256
Plumbing	---	---	2,760
Allowance for error and contingency plus contractors' fees	---	---	6,230
Total	---	---	64,151

Table 28.--Receiving station: Equipment requirements, installed cost, estimated life, and annual depreciation, New York-New Jersey milkshed, 1958

Item and description	Installed cost	Estimated life	Annual depreciation 1/
	Dollars	Years	Dollars
Can conveyors, complete, with drives, units, and turns	6,850	15	457
Weighing tank, 750 lb., 2 compartments	4,365	12	364
Receiving vat, 2,000 lb., stainless steel	1,560	20	78
Scale, 1,000 lb., stainless steel	1,187	15	79
Sample cabinet, capacity 240 8-oz. bottles	1,045	15	70
Vacuum sampler, 2-compartment	535	15	36
Can washer, 12 cans per minute	7,150	14	511
Plate cooler, 50,000 lb. per hr., 80 plate	7,420	15	495
Milk pump, 60,000 lb. per hr., centrifugal, 5 hp	483	14	35
Milk pump, $\frac{1}{2}$ hp., centrifugal	239	14	17
Wash sink, 2-compartment, and pipe sink and rack	545	15	37
Ice builder, 15,000 lb. ice storage capacity	3,877	15	258
Compressor, 20 hp., mounted on ice builder	3,162	15	211
Storage tanks (2), on scales, 6,000 gal., with agitator	18,430	20	922
Steam generator, 56 b.hp.-E	6,676	20	334
Water and fuel feed systems, and hot water system, complete	682	15	45
Oil storage tank, 5,000 gal., steel	700	15	47
Sanitary lines and fittings, stainless steel	721	10	72
Laboratory equipment	200	10	50
Office equipment	1,000	10	100
Total	66,827	---	4,218

1/ It is assumed that none of the equipment items listed have any salvage value at the end of their estimated life.

Table 29.--Cheddar cheese plant: Equipment requirements, installed cost, estimated life, and annual depreciation, New York-New Jersey milkshed, 1958

Item and description	Installed cost	Estimated life	Annual depreciation 1/
	Dollars	Years	Dollars
Conveyors, complete, with drive units and turns	6,850	15	457
Weighing can, 750 lb., stainless steel	4,365	12	364
Drop tank, 2,000 lb.	1,560	20	78
Scale, 1,000 lb.	1,187	15	79
Sample cooler, 240 8-oz. bottles	1,045	15	69
Pump, 50,000 lb. per hr. speed	483	14	35
Can washer, 12 cans per minute, return line	7,150	14	511
Wash tank, 11 ft. H.S.S. with rotor brush	644	15	43
Cooler, plate, 50,000 lb. per hr.	7,420	15	495
Storage tanks:			
2 tanks, 4,000 gal.	14,490	20	725
1 tank, 3,000 gal.	6,340	20	317
Preheater, with 2-hp. circulating pump and air control, 33,000 lb. per hr.	2,544	10	254
Cheese vats:			
5 vats, 15,000 lb. each	18,705	20	935
2 vats, 10,000 lb. each	4,776	20	239
Cheese presses (5), double row, 20 ft.	7,475	14	534
Curd mills (2), 12 in. 3-knife with portable stand	1,480	14	106
Whey separators (2), 11,000 lb. per hr. each	12,404	15	827
Whey tanks (4), 5,000 gal., steel	2,800	15	187
Whey pasteurizer, 100-gal. vat type stainless steel	1,095	20	55
Whey pump, 3 hp. positive, capacity 22,000 lb. per hr.	2,041	16	128
Cold storage compressor, 10 hp.	2,500	15	167
Air compressor, 3/4 hp.	355	14	25
Steam generator, 92 boiler hp.	9,025	20	450
Ice builder, 15,000 lb.	3,877	15	252
Compressor, 15 hp., mounted on ice builder	2,875	15	192
Wax machine, steam heating element, $\frac{1}{4}$-hp. motor	590	20	30
Sanitary lines and fittings, stainless steel	3,435	10	344
Miscellaneous: Cheese hoops, starter processor, curd knives, cans, shovels, gate valves, cheese trucks, tables, etc.	35,945	---	3,306
Subtotal, plant equipment	163,456	---	11,204
Laboratory equipment:			
Glassware	250	5	50
Miscellaneous	500	10	50
Office equipment: Furniture, typewriter, adding machine, fan, water cooler	1,375	10	138
Subtotal, laboratory and office	2,125	---	238
Total: Plant, laboratory, and office equipment	165,581	---	11,442

1/ It is assumed that none of the equipment items listed have any salvage value at the end of their estimated life.

Table 30.--Cream-nonfat dry milk plant, separation center: Equipment requirements, installed cost, estimated life, and annual depreciation, New York-New Jersey milkshed, 1958

Item and description	Installed cost	Estimated life	Annual depreciation 1/
	Dollars	Years	Dollars
Positive milk pump, 44,000 lb. per hr., 7-½ hp., variable speed	2,875	10	288
Plate heat changer, 44,000 lb. per hr., complete with hot water circulating unit and air controls	2,320	10	232
Separators (5), 11,000 lb. per hr., white enamel finish with magnetic starter	31,010	10	3,101
Spare separator motors (2)	756	14	54
Spare bowl	3,100	10	310
Pipe rack	120	15	8
Wheeled parts branch	95	15	6
Wash tank with ¼-hp. motor and brush	644	15	43
Chain hoist and truck, stainless steel table	550	20	28
Separator parts washer and rinser with ¼-hp. motor	495	15	33
Sanitary lines	1,205	10	121
Total	43,170	---	4,224

1/ It is assumed that none of the equipment items listed have any salvage value at the end of their estimated life.

Table 31.--Cream-nonfat dry milk plant, cream pasteurizing center: Equipment requirements, installed cost, estimated life, and annual depreciation, New York-New Jersey milkshed, 1958

Item and description	Installed cost	Estimated life	Annual depreciation 1/
	Dollars	Years	Dollars
H.T.S.T. 2/ system, complete with holding tube, regeneration positive pump, surge tank, controls, air compressor, 6,000 lb. per hr.	16,241	15	1,083
C.I.P 3/ system, 2-hp. pump on dolly, complete	575	14	41
Cream storage tanks:			
(3) 1,000 gal. each	13,335	20	666
(1) 1,500 gal.	5,065	20	253
Sanitary lines	893	10	89
Total	36,109	---	2,132

1/ It is assumed that none of the equipment items listed have any salvage value at the end of their estimated life.
2/ High temperature short time.
3/ Cleaning-in-place.

Table 32.--Cream-nonfat dry milk plant, raw cream sales center: Equipment requirements, installed cost, estimated life, and annual depreciation, New York-New Jersey milkshed, 1958

Item and description	Installed cost	Estimated life	Annual depreciation 1/
	Dollars	Years	Dollars
Cream cans (2,165)	21,650	6.3	3,437
Platform scale, 125 lb. capacity	860	15.0	57
Can-filling valve, stainless steel, with shield	246	14.0	17
Conveyor, gravity, from city can room to cooler	600	15.0	40
Can washer, 2/ rotary, 4 cans per minute	3,310	12.0	275
Can truck	86	5.0	17
Sanitary lines	648	10.0	65
Total	27,400	---	3,908

1/ It is assumed that none of the equipment items listed have any salvage value at the end of their estimated life.

2/ For washing "city cans" used for cream and condensed milk shipped under New York City regulations.

Table 33.--Cream-nonfat dry milk plant, condensed milk processing center: Equipment requirements, installed cost, estimated life, and annual depreciation, New York-New Jersey milkshed, 1958

Item and description	Installed cost	Estimated life	Annual depreciation 1/
	Dollars	Years	Dollars
Skim-milk storage tanks:			
3 tanks, 5,000 gal., insulated, 96' x 161'	25,500	20	1,275
1 tank, 6,000 gal., insulated	9,215	20	461
Skim-milk pump with 1-hp., 3-phase motor	403	14	29
Vacuum pan, double effect, capacity 13,600 lb. per hr.	43,000	20	2,150
Hot wells (2)	4,000	20	200
Vapor and steam preheater	4,431	15	295
Level controls	2,200	15	147
Condensed-milk storage tank, 1,000 gal.	4,445	20	222
Sanitary lines	1,451	10	145
Total	94,645	---	4,924

1/ It is assumed that none of the equipment items listed have any salvage value at the end of their estimated life.

Table 34.--Cream-nonfat dry milk plant, dry milk spray-processing center: Equipment requirements, installed cost, estimated life, and annual depreciation, New York-New Jersey milkshed, 1958

Item and description	Installed cost	Estimated life	Annual depreciation 1/
	Dollars	Years	Dollars
Wash rack	145	10	15
Drier (spray) including high-pressure pump, 1,200 lb. per hr.	51,000	15	3,400
Tube heater, 3,000 lb. per hr.	3,490	15	233
Powder cooler	4,180	20	209
Y-bagger	350	15	23
Moisture test equipment	155	10	15
Platform scales (2)	1,870	15	125
Barrel carts (2)	41	12	3
Pallet lift	6,103	12	509
Pallets (400)	4,068	10	407
Sack sewers (2)	1,625	15	108
Warehouse trucks (2)	250	5	50
Sanitary lines	293	10	29
Total	73,570	---	5,126

1/ It is assumed that none of the equipment items listed have any salvage value at the end of their estimated life.

Table 35.--Cream-nonfat dry milk plant, dry milk roller-processing center: Equipment requirements, installed cost, estimated life, and annual depreciation, New York-New Jersey milkshed, 1958

Item and description	Installed cost	Estimated life	Annual depreciation 1/
	Dollars	Years	Dollars
Skim pumps:			
3/4 hp.	321	14	24
1 hp.	403	14	29
Tube heater	3,500	15	233
Wash tank	145	10	15
Pulverizer and elevator (2)	1,200	15	80
Powder rolls (2)	34,000	15	2,266
Barrel shaker	200	10	20
Sanitary lines	410	10	41
Total	40,179	---	2,708

1/ It is assumed that none of the equipment items listed have any salvage value at the end of their estimated life.

Table 36.--Cream-nonfat dry milk plant, utilities center: Equipment requirements, installed cost, estimated life and annual depreciation, New York-New Jersey milkshed, 1958

Item and description	Installed cost	Estimated life	Annual depreciation 1/
	Dollars	Years	Dollars
Steam			
Boilers (2), 250 hp., with condensation pump, boiler controls, and oil feed	32,300	20	1,616
Oil storage tank, 99,000 gal.	13,630	20	682
Total	45,930	---	2,298
Refrigeration			
Compressor, coldroom, 10 hp.	3,000	20	150
Compressor, sweet water, 20 hp.	5,500	20	275
Sweet water system, 15,750 lb. ice builder	5,255	20	263
Cooling tower, 750 tons	32,000	10	3,200
Evaporative condenser, 30 tons	2,200	10	220
Total	47,955	---	4,108

1/ It is assumed that none of the equipment items listed have any salvage value at the end of their estimated life.

Table 37.--Dairy-product processing plants, general service equipment center: Equipment requirements, installed cost, estimated life, and annual depreciation, New York-New Jersey milkshed, 1958 1/

Item	Installed cost	Estimated life	Annual depreciation 2/
	Dollars	Years	Dollars
Shop:			
Portable electric drill	96	10	10
Bench vise	81	15	5
Acetylene torch	228	9	25
Electric welder	611	11	56
Anvil	41	20	2
Air compressor	366	15	24
Tube and die set	305	12	25
Pipe threader	91	12	8
Paint sprayer	143	8	17
Pipe reamer	44	5	9
Small electric grinder	91	10	9
Large electric grinder	143	12	12
Wheelbarrow	44	12	4
Small tools	1,730	5	346
Drill press	305	15	20
Reseating tools	152	8	19
Wood table saw	152	2	76
Metal table saw	1,180	5	236
Chain hoist	71	12	6
Spare equipment:			
Positive milk pump	1,730	10	173
Regular milk pumps (3)	1,830	10	183
Positive milk pump head	661	10	66
Motors (4), 3 hp.	611	15	41
Motors (2), 5 hp.	366	15	24
Motor, 10 hp.	244	15	16
Personal convenience:			
Lockers (40)	1,320	15	88
Benches (6)	61	12	5
Chairs and sofas (2)	504	10	51
Medicine chests (2)	82	10	8
Total	13,283	---	1,564

1/ Walker, S. A. (25).
2/ It is assumed that none of the equipment items listed have any salvage value at the end of their estimated life.

Table 38.--Dairy-product processing plants, office equipment center: Equipment requirements, installed cost, estimated life, and annual depreciation, New York-New Jersey milkshed, 1958 1/

Item	Installed cost	Estimated life	Annual depreciation 2/
	Dollars	Years	Dollars
Office:			
Billing machine	4,883	25	195
Calculators (4)	4,883	15	325
Adding machines (6)	3,662	10	366
Desks and tables (10)	2,339	15	156
Chairs (14)	427	10	43
Typewriters (4)	1,180	12	98
Safe	1,525	30	51
Time clock	357	10	36
Filing cabinets (8)	1,057	15	70
Lighting and miscellaneous	1,018	12	85
Storage cabinets (15)	916	30	31
Cash register	966	15	64
Postal scale	20	10	2
Check protector	305	12	25
Record binders (9)	275	20	14
Stencil machine	509	15	34
Addressing machine	1,323	20	66
Water cooler	255	10	26
Intercommunication system	611	10	61
Posting trays (2)	305	25	12
Check writer	559	12	47
Total	27,375	---	1,807

1/ Walker, S. A. (25).
2/ It is assumed that none of the equipment items listed have any salvage value at the end of their estimated life.

Table 39.--Dairy-product processing plants, laboratory equipment center: Equipment requirements, installed cost, estimated life and annual depreciation, New York-New Jersey milkshed, 1958 1/

Item	Installed cost	Estimated life	Annual depreciation 2/
	Dollars	Years	Dollars
Laboratory:			
Centrifuges (2), capacity 36 bottles each	529	10	53
Methylene blue set	611	10	61
Electric water heater	305	15	20
Acidity tester	255	10	26
Sediment guns (4)	325	5	65
Torsion balance scales (2)	346	20	17
Hotplate	50	10	5
Salt titration set	40	15	3
Acid dispenser	40	12	3
Trays and hot water bath	3,052	12	254
Glassware	2,441	3	814
Majonnier tester	4,273	40	107
Bottle washer	173	10	17
Sterilizer	457	15	31
Incubator	489	15	33
Miscellaneous	1,832	5	366
Total	15,218	---	1,875

1/ Walker, S. A. (25).
2/ It is assumed that none of the equipment items listed have any salvage value at the end of their estimated life.

LITERATURE CITED

(1) Baum, E. E., Riley, R. D., and Weeks, E. E.
1954. Economies of Scale in the Operation of Can and Tank Milk Receiving Rooms, with Special Reference to Western Washington. Wash. State Col., Tech. Bul. 12. May.

(2) Black, Guy
1955. Synthetic Method of Cost Analysis in Agricultural Marketing Firms. Jour. Farm Econ. 36:270-279.

(3) Boles, James N.
1958. Economies of Scale for Evaporated Milk Plants in California. Hilgardia 27(21). Oct.

(4) Bressler, R. G.
1942. Economies of Scale in the Operation of Country Milk Plants with Special Reference to New England. New England Res. Council on Mktg. & Food Supply. June.

(5) ______
1958. Pricing Raw Product in Complex Milk Markets. Agr. Econ. Res. 10(4):113. Oct.

(6) Brewster, J. M.
1954. Comparative Economies of Different Types of Cottonseed Oil Mills and Their Effects on Oil Supplies, Prices, and Returns to Growers. U. S. Dept. Agr., Mktg. Res. Rpt. 54. Feb.

(7) Carlson, Sune
1939. A Study on the Pure Theory of Production. Kelley & Millman, Inc., New York.

(8) Carter, R. M., Brundage, K. P., and Bradfield, Alec
1951. Labor and Equipment Use in Milk-Receiving Plants. Vt. Agr. Expt. Sta., Bul. 563. Sept.

(9) Conner, M. C., Webster, F. C., and Owens, T. R.
1957. An Economic Analysis of Model Plants for Pasteurizing and Bottling Milk. Va. Agr. Expt. Sta., Bul. 484. June.

(10) ______, Spencer, Leland, and Pierce, C. W.
(n.d.) Specifications and Costs for a Milk Pasteurizing and Bottling Plant. N. E. Reg. Pub. 16. Va. Agr. Expt. Sta., Bul. 463.

(11) Farrall, A. W.
1942. Dairy Engineering. New York, N. Y.

(12) Frazer, J. R., Nielson, V. H., and Nord, J. D.
1952. The Cost of Manufacturing Butter. Iowa Agr. Expt. Sta., Bul. 389.

(13) French, C. E., Wood, G. B., and Manhart, V. C.
1952. Labor Utilization in Receiving Rooms of Indiana Milk Plants. Ind. (Purdue) Agr. Expt. Sta., Bul. 576. July.

(14) Juers, L. E., and Koller, E.
1956. Costs of Drying Milk in Specialized Drying Plants. Minn. Agr. Expt. Sta., Bul. 435. June.

(15) Kolmer, L., Homme, H. A., and Ladd, G. W.
1957. Spray Drying Costs in Low-Volume Milk Plants. Iowa State Col., Spec. Rpt. 19. Sept.

(16) Market Administrator's Bulletin.
1957. 1956 Annual Report. New York-New Jersey Milk Marketing Area. Mkt. Admin. Bul., Vol. 17, No. 2.

(17) New York State College of Agriculture.
1958. Comparative Cost and Efficiency Factors in the Operation of Milk Manufacturing Plants in the New York Milkshed. Dept. Agr. Econ., Ithaca, N. Y. (Mimeo.)

(18) New York State Department of Agriculture and Markets.
1957. Statistics Relative to the Dairy Industry in New York State.

(19) Owens, T. R., and Butz, W. T.
1957. Specifications and Costs for Processing Operations in Small Market Milk Plants. Pa. Agr. Expt. Sta., Bul. 625. Aug.

(20) Page, C. M., and Walker, S. A.
1953. Building Designs for Dairy Processing Plants. Idaho Agr. Expt. Sta., Bul. 297. June.

(21) Rowe, G. A.
1952. Economics of Cheese Manufacturing in Tillamook County, Oregon. Oreg. Agr. Expt. Sta., Bul. 529. Dec.

(22) United States Bureau of Reclamation.
1945. Columbia Basin Joint Investigations. Agr. Processing Indus., Prob. 24.

(23) United States Department of Commerce.
1957. Survey of Current Business. Business Statis. Suppl.

(24) Vial, E. E.
1953. Class III Price Hearing, October 19 to November 24, 1953. Milk Dealers' Assoc. of Metropolitan N. Y., Inc., Membership Letter No. 76.

(25) Walker, S. A., Preston, H. J., and Nelson, G. T.
1953. An Economic Analysis of Butter-Nonfat Dry Milk Plants. Idaho Agr. Expt. Sta., Res. Bul. 20. June.