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The University of Minnesota
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IN CO-OPERATION WITH

UNITED STATES DEPARTMENT OF AGRICULTURE,
BUREAU OF AGRICULTURAL ECONOMICS

Economic Aspects of Creamery Organization

John D. Black and Edward S. Guthrie
Division of Agricultural Economics

UNIVERSITY FARM, ST. PAUL

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ILLUSTRATIONS

ECONOMIC ASPECTS OF CREAMERY ORGANIZATION

By JOHN D. BLACK AND EDWARD S. GUTHRIE[1]

This bulletin deals more especially with the problems of organization of creameries as distinguished from the problems of management. Of the three phases of organization, namely, economic organization, financial organization, and business organization, it considers the first. Its conclusions should be of value to some operators and managers of creameries and some members of creamery organizations, in helping them to establish efficient creamery enterprises or re-organize existing enterprises along more efficient lines; but the bulletin in its present form is intended primarily for specialists in the field of marketing and dairy manufacture.

SOURCES OF DATA

The data in this bulletin are partly from official sources, such as the records of the Minnesota Dairy and Food Department,[2] but mostly from a special survey made of 102 Minnesota creameries. In most of the tables the data from only 88 of these 102 creameries are used.

THE STATE

On January 1, 1920, Minnesota had 1,229,000 cows two years old and over, classified as "kept primarily for milk," ranking third after Wisconsin with 1,795,000, and New York with 1,482,000. Per 1000 acres of land in farms, Minnesota with 41 ranks after Wisconsin with 81, New York with 72, New Jersey with 57, Pennsylvania with 50, Michigan with 42, and the New England States taken as a group with 50. Per 1000 acres of improved land in farms, Minnesota ranks after the same states, but with only 57 as against 144 for Wisconsin, 113 for New York, 75 for Pennsylvania, and 66 for Michigan. In 1919, with relatively low butter prices, approximately fifteen per cent of the average gross income of Minnesota farms was from dairy products.[3] For a normal year, 18 per cent is about right. As to milk production per cow, Minnesota ranks below all the New England States, all the North Atlantic States, and all the North Central States. The estimates obtained by the Bureau of Crop Estimates in June, 1920,

[1] Dr. Guthrie did the field work on this study during the summer and fall of 1920, while on sabbatical leave from Cornell University.

[2] The authors wish to thank the staff of the Dairy and Food Department for their very great courtesy and excellent co-operation; also R. C. Potts of the Bureau of Agricultural Economics, and C. H. Eckles and J. R. Keithley for their help in outlining the project and preparing the results for publication; also A. J. McGuire, general manager of the Minnesota Co-operative Creameries Association, Inc.

[3] This can be only a rough approximation, as the Census Bureau did not tabulate all the data on farm receipts for 1920.

indicate that 33.2 per cent of all of the cattle of Minnesota were Shorthorn, as compared with 29.8 per cent for the dairy breeds. (Holstein, 19.3 per cent.) In Wisconsin, 16 per cent were Shorthorn, as compared with 72.2 per cent for the dairy breeds. In New York, 89.1 of the cattle were of the dairy breeds. In Minnesota, 13.8 per cent of the cattle were "nondescript" or "scrubs," in Wisconsin 7.0 per cent, in New York 5.9 per cent.

There is undoubtedly a tendency toward the dairy breeds and more dairying in many parts of Minnesota; but the 1920 census was not taken in such a way as to show it.

In 1920 the creameries of Minnesota made 139,230,000 pounds of butter as compared with 95,668,000 pounds in 1910. Butter made on farms in the same period decreased from 35 to 20 million pounds; and butter sold from farms from 18 to 4 million pounds. Cheese production in the same period increased only from 3,800,000 to 3,848,000 pounds. Thus by turning nearly all its surplus milk into butter, Minnesota has become the leading butter state in the Union.

In 1920, there were 830 creameries in Minnesota, 642 of which were co-operative. The co-operative creameries made 67 per cent of all the factory-made butter, the centralizers 24 per cent, and the other proprietary creameries 10 per cent. The co-operative creameries are gradually gaining upon the proprietary creameries, as in 1914 the co-operatives made only 62 per cent of the butter.

In 1920, the creameries received 168 million pounds of milk and 390 million pounds of cream. Thus more than 90 per cent of all the butterfat was delivered as cream. A considerable portion of the milk received by creameries is resold as market milk. Milk receipts are still rapidly declining.

Minnesota, however, has such a variety of systems of farming that its dairying must really be analyzed by districts. In Figure 1 and Figure 2 the state is divided into 8 districts. Figure 1 also shows the location of all creameries and cheese factories. Tables I and II give the principal data for each district. The southern dairy section and the Red River Valley represent the two extremes. In the southern dairy section, the creameries in 1919 averaged 125,000 pounds of butterfat per creamery, received 58.3 cents per pound for their butter, and paid their patrons 66.8 cents per pound for butterfat. Nearly 4000 pounds of butterfat were delivered to the creamery per square mile of territory, an average of 120 pounds per cow. In the Red River Valley, the creameries averaged only 63,000 pounds of butterfat, received only 54 cents per pound for butter, and paid their patrons only 58.7 cents per pound for butterfat.

Additional facts concerning each of these sections are as follows:

Section 1. Southern dairy section.—Less than half of farm receipts from sale of crops; and more than half of livestock receipts from cattle. Corn acreage 20 per cent of total. Cash crops are spring wheat and barley. Hogs in combination with dairying. Many Holstein herds.

Section 2. Central dairy section.—From 50 to 65 per cent of farm receipts from crops, from spring wheat mostly in the southwest, and potatoes around the Twin Cities and to the north. Livestock receipts mostly from cattle, frequently of dairy types; but some from hogs, especially in McLeod and Kandiyohi Counties.

Section 3. Intermediate dairy section.—Mostly Shorthorn cattle. Large receipts from spring wheat to the north and oats and barley in other counties. Corn and hogs to the southwest.

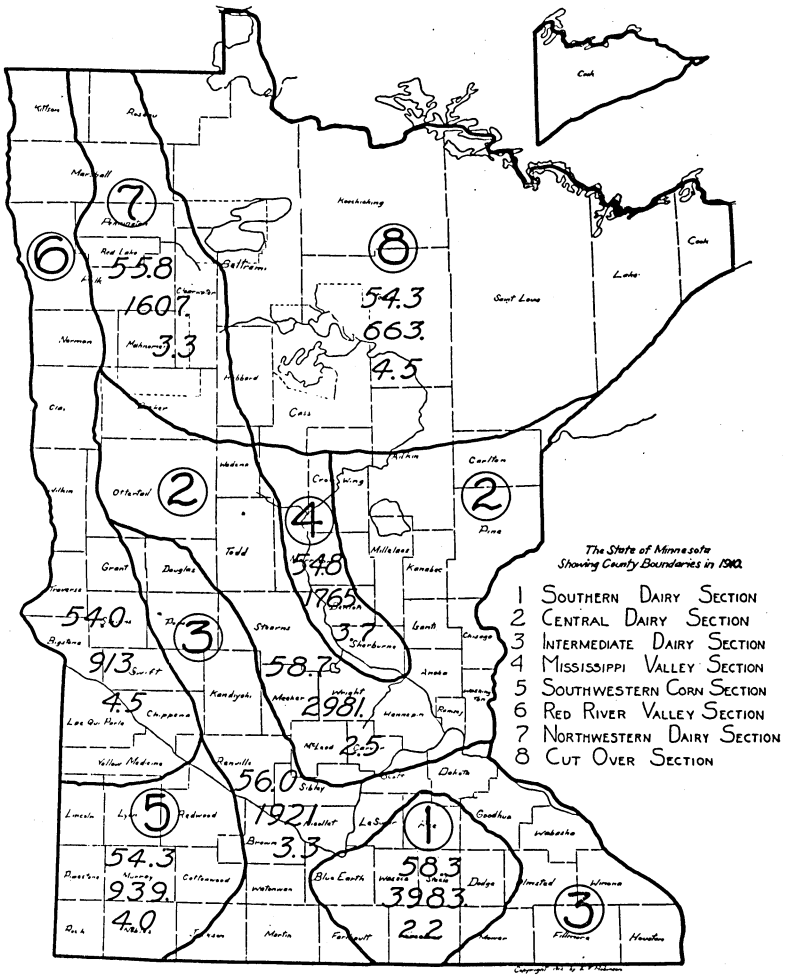

Fig. 2. Minnesota by Dairy Districts

Upper figures—Average price received for butter. Middle figures—Butterfat delivered per square mile. Lower figures—Average rank of creameries by quality of cream delivered. Quality of cream and quantity are closely associated; also quality of cream and price received for butter.

Section 4. Mississippi Valley.—Dairying in combination with potatoes, rye, and small grains on sandy lands. Dairy receipts an important source of income.

Section 5. Southwestern corn section.—Corn and hogs. Oats and barley near the Dakota line. Beef cattle.

Section 6. Red River Valley.—Three-fourths of receipts from sale of crops, mostly spring wheat and potatoes. Beef cattle mostly, and not many of them.

Section 7. Northwestern dairy section.—Relatively new country, much drained land. Hay an important crop. Dairying of high order considering the newness of the region.

Section 8. Cut-over section.—Hay principal crop. Potatoes, timber products, outside labor, and dairy products the principal sources of income. Creameries small and far between.

It should be apparent from the foregoing that it is useless to talk of dairying in Minnesota, taking the state as a whole. The same is true in large part for creameries. This is shown by Table III, which gives certain data for the 88 creameries analyzed in this bulletin. First, the cream received differs greatly in quality,[4] that coming from the Red River Valley and cut-over district actually averaging a condition halfway between "Sour and Old" and "Fairly Sour and Old," and that from the southern dairy section averaging about "Fairly Good." The score of the butter on hand at the time of the survey ranged from 88.5 in the cut-over district to 92.5 in the southern dairy section.

TABLE IV

RELATION OF QUALITY OF CREAM TO QUALITY OF BUTTER

Type of cream	Rank	Number of creameries receiving mostly	Butter score*	Average price received for butter in 1919†	Average output
				Cents	
Sour and old.....	5	16	89.6	54.1	140,000
Fairly sour and old..	4	10	89.4	54.7	149,000
Fair	3	34	91.1	56.6	242,000
Fairly good.....	2	10	92.8	57.8	251,000
Good	1	18	92.8	57.9	270,000

* Butter on hand at time of survey.

† Some of the difference in price for the different grades is due to the fact that the creameries receiving poor cream are small and are likely to have relatively poor buttermakers. (See page 16.)

It will be noted that these 88 creameries average about a third larger than the state average (see Table II). Their expenses per pound of butter are therefore somewhat lower. As to the price received for butter, however, they are nearly 2 cents under the average. Of the 14 creameries included in the survey but not included in the tables, 6 are proprietary creameries whose financial records were so incomplete that their data could not be used. The co-operative creameries usually keep better records.

[4] See Table IV for classes of cream.

FACTORS OF EFFICIENCY

The ultimate test of the efficiency of a creamery is the price it pays for butterfat. Figure 3 shows an extreme range—30 to 49 cents for 291 Minnesota creameries in 1921. No doubt some of the extreme cases are due to irregularities in the records, but making allowance for this, there is still a range, excluding irregular cases, of 16 cents, or 38 per cent. Fifteen cents more or less for butterfat will probably mean the difference between profit and loss in dairying on two thirds of the dairy farms of the state. Part of this 15 cents is of course due to differences in the cream delivered. But enough of it can be ascribed to the creamery that we are justified in saying that the creamery alone is one of the largest factors in the success of dairying, and it is highly important that it be properly organized. Even 10 cents less a pound for butterfat means 14 million dollars for the farmers of Minnesota. The purpose of this bulletin is to present the causes of these variations.

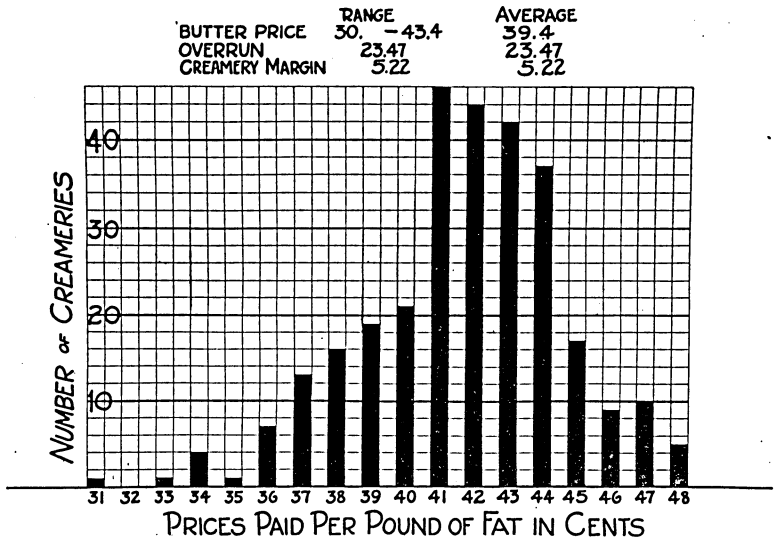

Fig. 3. Range in Prices Paid per Pound of Butterfat for 291 Minnesota Creameries as Reported in 1921

The ordinary range is from 34 to 49 cents; the five extremely low prices are probably due to errors in the creamery records.

There are three immediate reasons for these variations. These are differences in prices received for butter, differences in cost of manufacture and preparation for market, and differences in overrun. Figures 4, 5, and 6 show the ranges for these three things. The range in prices received for butter is the most important factor. Most of the creameries in 1921 received between 35 and 41 cents per pound

for their butter, but 16 out of 290 received more than 41 cents and 23 out of 290 less than 35 cents. Figure 7 shows that if there were no differences in overrun or creamery costs[5] per pound, butter price would still produce a range, excluding irregular cases, of 13 cents per pound of butterfat.

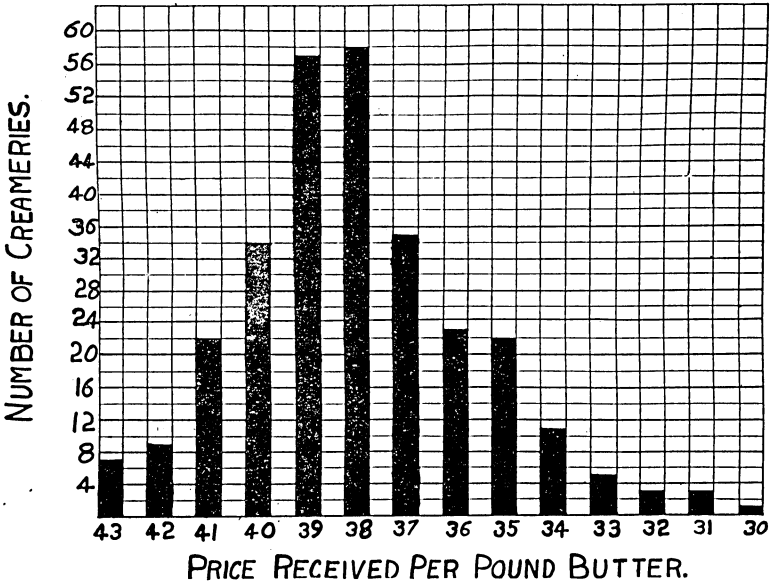

Fig. 4. Ranges in Net Prices Received per Pound of Butter for 88 Minnesota Creameries
The ordinary range in prices received for butter is 11 cents—5 cents less than the range in butterfat prices.

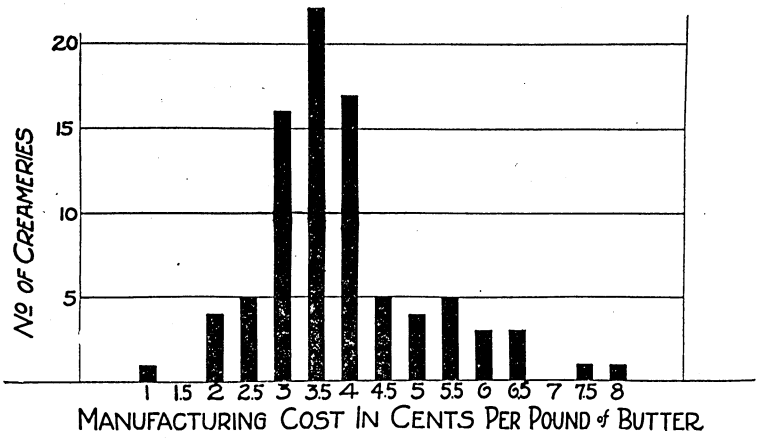

Fig. 5. Range in Manufacturing Costs per Pound of Butter for 88 Minnesota Creameries

[5] Really "margins," as profits and patronage dividends are combined with costs.

Next in importance are the differences in creamery costs shown in Figure 5. The ordinary range for the 88 creameries covered in the survey is from 2 to 7 cents per pound of butter. (Extreme costs are due in most cases to irregularities in the records.) If prices for butter and overrun were the same for all creameries, differences in creamery costs, as shown by Figure 8, would still make a difference, excluding irregular cases, of 9 cents a pound of butterfat.

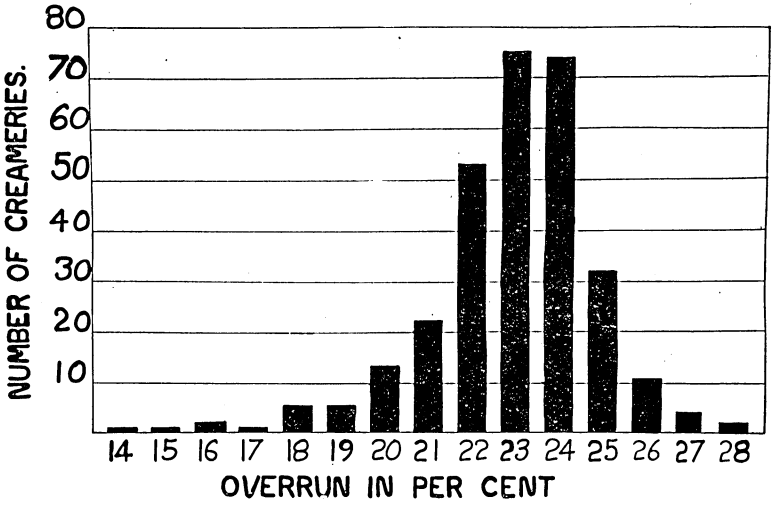

Fig. 6. Ranges in Over-run for 301 Minnesota Creameries

The over-runs, at least over 24 and under 20, are not true over-runs, but are due to errors in tests and weights and mistakes in creamery records.

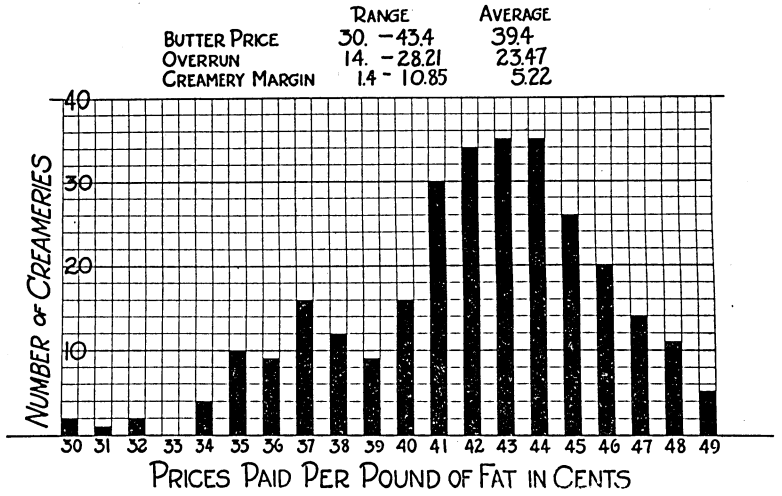

Fig. 7. Relation of Price Received for Butter to Prices Paid for Fat

If all creameries had the same over-run of 23.47, and the same margins, there should still be an ordinary range of 36 to 48 cents in prices paid for butterfat.

The ordinary range in overrun, as shown by Figure 6, is from 20 to 26 per cent. If butter prices and creamery cost were the same for all creameries, there would still be a difference, excluding irregular cases, of 3 cents per pound of butterfat, due to overrun variations (see Fig. 9).

Range in butter prices.—The principal cause of variations in butter prices is the quality of the cream delivered. Table IV shows that the 18 creameries receiving "Good" cream on the day of the visit were making butter scoring 3.2 points higher than that made by the 16 creameries delivering "Sour and Old" cream; and that they sold their year's make of butter for nearly 4 cents more per pound.[6] The possible range due to differences in cream, according to Table V, was 6 cents.

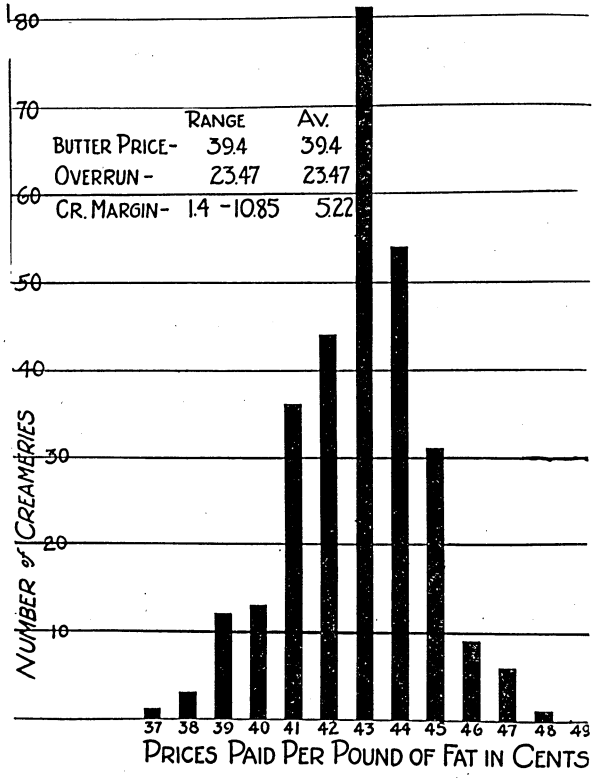

Fig. 8. Relation of Creamery Margins to Prices Paid for Fat

If all creameries received the same prices for butter and had the same over-run, there would still be an ordinary difference of 8 cents in prices paid for butterfat, due to difference in costs or margins.

[6] The question arises as to how good a sample one day is of the whole year in a matter of this kind. The chances are that there is no great variation from day to day in quality of cream received, and there is much less variation from season to season than is ordinarily supposed. As for quality of butter, there may be a variation of two or even three points in the score, but there is likely to be no more than a point of difference. Moreover, there are enough creameries in each group to make it probable that error of sampling will be offset.

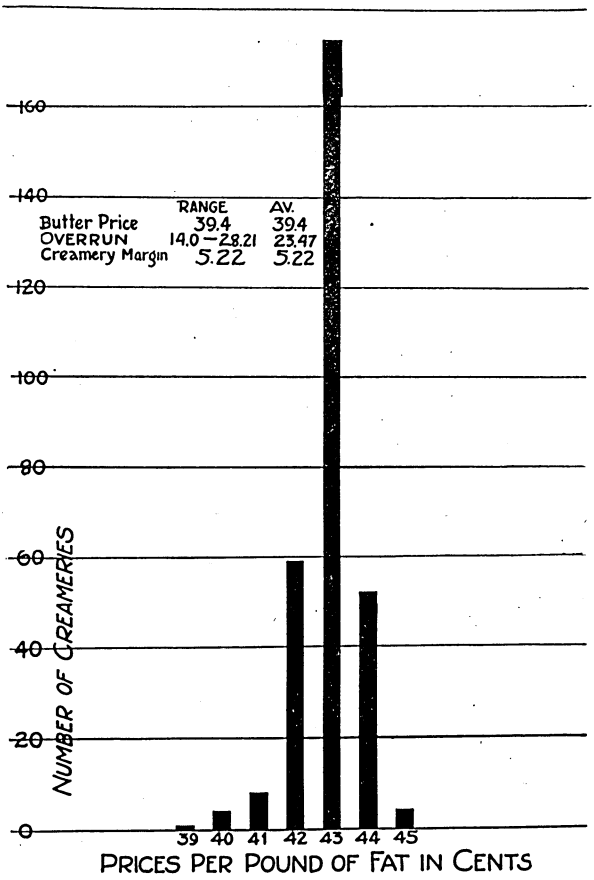

Fig. 9. Relation of Over-run to Prices Paid for Fat

The ordinary effect of differences in over-run is only 3 cents, as compared with 8 cents for costs (Fig. 7) and 13 cents for prices of butter (Fig. 8).

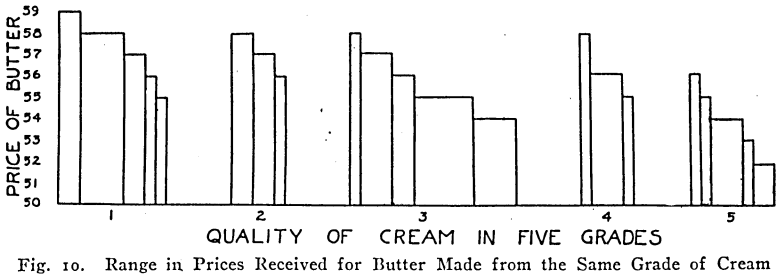

Fig. 10. Range in Prices Received for Butter Made from the Same Grade of Cream

No. 1 or "Good" cream made butter that ranged in price from 55 to 59 cents; and No. 5 or "Sour" cream made butter that ranged from 52 to 57 cents. Thus, although the quality of butter declines with the quality of the cream, there is considerable range in the quality of butter for each grade of cream. (The width of the bars indicates the relative number of creameries.)

One can not know, however, whether the low prices for butter made from poor cream were not partly due to the poor ability of the butter-makers employed in such creameries. The 6 cents is therefore only a rough estimate.

Figure 10 shows, however, that creameries receiving the same grade of cream on the day of the visit did not all receive the same average price for their butter for the year. For example, the 28 receiving "Good" cream received prices ranging from 55 to 59 cents a pound; and the 16 receiving "Sour and Old" cream received prices ranging from 52 to 57 cents a pound. Some of these differences are no doubt due to mistakes in grading cream, or to the fact that the cream delivered on the day of the visit was not a fair sample for the whole year. But making allowance for these possible errors, there is still a range of about 6 cents to be accounted for.

One explanation is the difference in time of year when the butter was sold. Figure 11 gives the monthly range in prices for New York Extras for two four-year periods. Creameries delivering only 51 per cent of their cream in the six summer months, in 1919 received for the same grade of butter 1.7 cents more per pound than those delivering 70 per cent of their cream in the summer. This is a factor in average annual butter prices which is frequently overlooked.

Another cause for differences in butter prices received is freight costs. On a car consisting of 300 tubs of butter (18,900 pounds) the freight cost to New York at present is $364.54; for the same butter

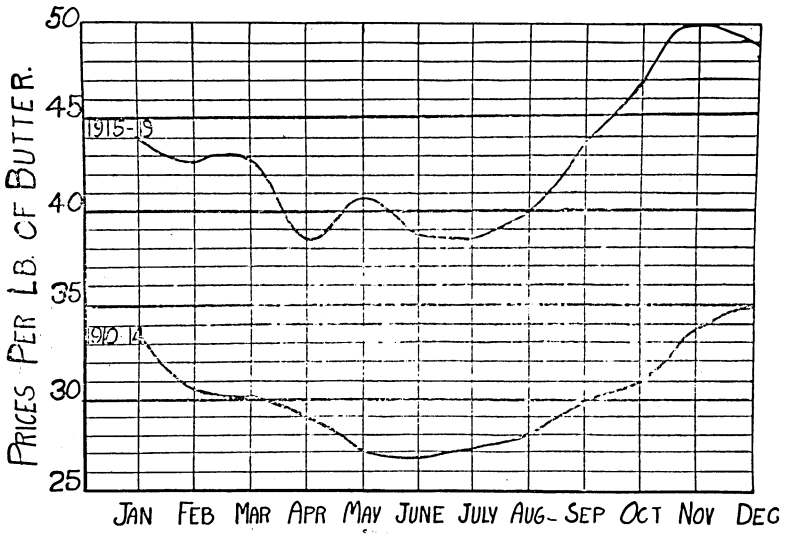

Fig. 11. Monthly Ranges in Prices for New York Extras

Both of these periods are periods of rising prices, but especially the 1915-19 period; hence the December averages are considerably above the January averages.

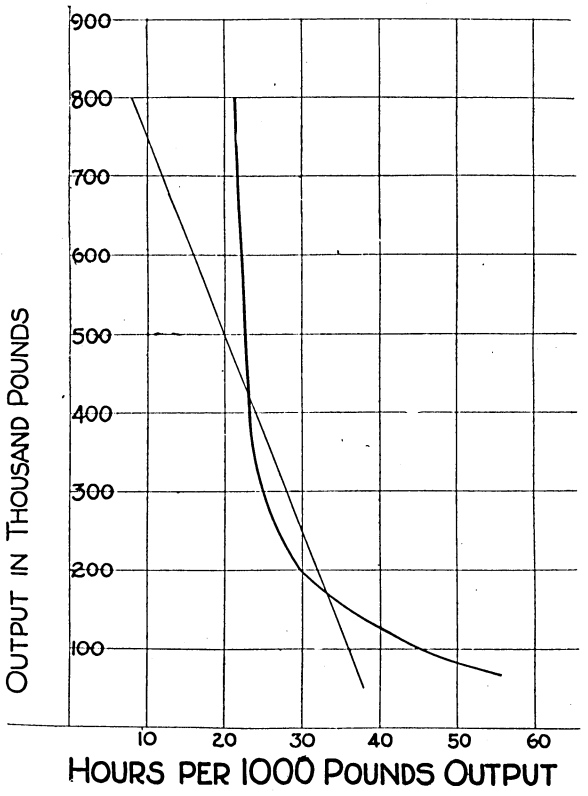

Fig. 12. Relation of Output to Labor and Management Time

For 100,000-pound creameries, the average rate is about 45 hours per thousand; for 500,000-pound creameries, about 23 hours per thousand. The average rate of decrease, indicated by the straight line, is 4.5 hours for each additional 100,000 pounds of output; but the curved line shows that it is very rapid under 200,000 pounds, up to the point where the time of one buttermaker is fully utilized.

Method of using curve.—Locate on the vertical scale the point which represents the output of butter in your creamery. Extend a horizontal line from this point across the diagram till it crosses the curve. Drop a vertical line from this point until it crosses the horizontal line at the bottom of the diagram on which the scale of hours is indicated. The point where the base line is crossed represents the prevailing number of hours per 1000 pounds of output for creameries with your output.

shipped at "less than carload" rates, it is $543.12. This is a difference of not quite a cent a pound (0.94 cent).

Another factor in differences in prices is skill and judgment in choosing a market and a commission firm. These, however, are relatively unimportant. More important are the differences in prices charged patrons for butter, differences in prices at which butter is sold locally, differences in packing the butter, whether in prints or tubs, etc.

There still remains an estimated difference of 2.3 cents of the total range of 10 cents per pound to ascribe to the buttermaker himself and his plant and equipment. As already explained, we can not be sure that some of this is not due to the fact that the poorer butter-

makers did not have as good cream to work with as the better buttermakers. Altho we have made an allowance for differences in quality of cream, we may not have allowed for all of it, as some may be so identified with poor buttermaking as not to be apparent. Even if we allow only 2 cents a pound for differences in buttermaking and plant and equipment, it amounts to $2500 for an average output of 125,000 pounds. This point will be discussed later.

Table V can, of course, be only an estimate, because one does not know to what extent the various causes reinforce or run counter to each other.[7] Any one of the causes could reasonably have been as significant as indicated in the first column as "possible range," or less significant than indicated in the second column as "actual range."

Can the range in butter prices be reduced?—The principal factor in quality of cream is the frequency of its delivery. Many farmers in Minnesota can not afford to deliver more frequently—the extra price received for fresher cream will not pay for the extra cost of hauling oftener. This is the case on farms a long way from creameries and with few cows. The condition is prevalent in the Red River Valley, the southwestern corn section and the cut-over section, and on many

TABLE V

ESTIMATED RANGE IN AVERAGE ANNUAL RATES RECEIVED FOR BUTTER IN 1919 WHICH WAS DUE TO SEVERAL CAUSES

Causes	Possible range*	Share in actual range†
	Cents	Cents
Quality of cream	6.0	4.0
Skill in buttermaking, and plant equipment	4.0	2.3
Seasonal variations in receipts	2.0	1.7
Marketing methods and costs	3.0	2.0
Total range	15.0	10.0

* This means that if some of the creameries receiving the poorest cream had also the poorest buttermakers and equipment, the most expensive marketing methods, and lowest relative cream receipts in winter; and some of those receiving the best cream had exactly the opposite of the above in all three particulars, the difference in price received for butter would have been 15 cents.

† This means that because some of the creameries with poor cream had fair to good buttermakers, and vice versa, and so for the other three factors, the actual range between highest and lowest was only 10 cents (see Figure 4) excluding irregular cases.

farms in the intermediate dairy section. Unless the farmers keep more cows, it is foolish in most cases to urge them to deliver more frequently. We can be thankful that they are delivering at all—not long ago they were making butter on the farm and selling their butterfat in that way. In twenty years there has been a decrease from 22 million to 4 million pounds of butter sold from farms in Minnesota.

Nor can we urge the farmers in all sections of the state to keep more cows. It is likely that corn, hogs, and beef cattle will always

[7] The data were not in such shape in this case as to make possible a multiple correlation analysis.

take precedence over dairying in the corn belt and in southwestern Minnesota because the earth has much more potential dairy-farming territory than corn-and-hog territory. This is evidenced by the fact that corn and hog prices have increased more rapidly than butter and cheese prices in the last twenty years. Dairy farming is likely to increase, however, in the small-grain regions north of the corn belt, partly because livestock is needed to improve the farm organization in this territory, partly because the growth of population will call for more dairy products, and partly because there is as much available wheat and oat land in the world as dairy farming land. There is also a twilight zone between the corn belt and the small-grain region where the "corn, hog, and dairy cattle" combination is likely to be further developed, as it has been under similar circumstances in southeastern Wisconsin and northeastern Illinois. Also as the land is gradually cleared in the cut-over section, there will be more cows and more creameries within reach.

Therefore there is hope for improvement in the quality of the cream in many parts of Minnesota as time goes on, merely as the result of an increase in dairying and more frequent deliveries.

The quality of the cream can also be improved by better sanitation and more cleanliness in handling the milk and cream, and better care of the cream while it is awaiting delivery. Grading the cream may also prove effective under some circumstances.

The next important way to reduce the range in butter prices is to get better buttermakers. Small weak creameries can not ordinarily hire high-class buttermakers—the larger creameries with better quality of cream outbid them. The trouble is that there are not enough high-class buttermakers to go around. There has already been great improvement, however, and there is sure to be more in the future. The way out is to train more buttermakers; and especially to select more carefully the men who are trained.

Probably a little can be done in improving the quality of the butter by looking after the equipment carefully and keeping it in better condition.

We shall always have seasonal variations in cream receipts because we shall always have differences in systems of farming in Minnesota.

The only other way to reduce the range in butter prices is therefore to standardize marketing practices and price policies. Some things along this line are feasible; for example, combining shipments will equalize freight costs somewhat; but freight costs will always be a little higher in northwestern than in southern Minnesota. Likewise there is no reason why all creameries should have the same price policy for local sales and sales to patrons.

We can conclude, therefore, that the range in price received for butter can be reduced considerably by improving the buttermakers; to some extent by taking better care of the cream; to a greater extent, but more slowly, by improving the quality of the cream along with more dairying and more frequent deliveries; and to some extent by shipping in carload lots. Perhaps the range of 10 cents can in time be reduced to 5 or 6 cents, but it will take a long time to do it—the next ten years may make a difference of 2 or 3 cents.

Range in overrun.—Of the three factors determining the price the farmer receives for his butterfat, overrun is the least important. The ordinary range is from 20 to 26 per cent, but two-thirds comes between 22 and 24 per cent.

The range in overrun is probably due principally to four things: (1) Varying amounts of moisture, salt, and other ingredients in the butter, (2) variations in losses of butterfat in handling and churning, (3) variations in reading the butterfat test of the cream, and (4) variations in weighing the cream when delivered. According to Table VI, under-reading the butterfat test of 30 per cent cream by 0.2 per cent, which is about the average under-reading when readings are in half-per cents and always read down, will increase a "true overrun" of 23 to 23.82 per cent; and under-reading the same cream 0.4 per cent will increase a "true overrun" of 23 to 24.66 per cent.

TABLE VI

EFFECT ON OVERRUN OF UNDER-READING BUTTERFAT TEST OF 30-PER CENT CREAM*

Butterfat reading	Overrun					
	Per cent	Per cent	Per cent	Per cent	Per cent	Per cent
Correct reading.....	20.00	21.00	22.00	23.00	24.00	25.00
1 per cent below.....	20.40	21.40	22.41	23.41	24.41	25.41
2 per cent below.....	20.80	21.81	22.82	23.82	24.83	25.83
3 per cent below.....	21.21	22.82	23.23	24.24	25.25	26.26
4 per cent below.....	21.62	22.63	23.65	24.66	25.67	26.68
5 per cent below.....	22.03	23.05	24.06	25.09	26.10	27.11

*The method of calculation is as follows: 100 pounds of cream testing 30 per cent will make 36 pounds of butter at 20 per cent overrun. ($36 \div 30 = 120$.) If the test is read 29.9, then the overrun will read 20.40. ($36 \div 29.9 = 120.40$.)

According to Table VII, under-weighing a 5-gallon can of 30 per cent cream by 0.2 pound will increase a true overrun of 24 per cent to 24.62; and an underweighing of 0.4 pound will increase it to 25.25.

Losses in the creamery probably vary from less than one per cent of the butterfat delivered, for very large creameries, to more than 3 per cent for small creameries with careless workmen. Minnesota Bulletin 177 gives 1.4 per cent for the Albert Lea creamery. This is equivalent to an overrun of 1.75. Of this, about one per cent was churn loss and 0.75 mechanical losses in vats, heaters, pasteurizers, etc.

TABLE VII

EFFECT ON OVERRUN OF UNDER-WEIGHING CREAM*

Weighing method	5-gallon unit	8-gallon unit	10 gallon unit
	Per cent	Per cent	Per cent
Correct weight	23.00†	23.00	23.00
0.2 pound below	23.62	23.38	23.31
0.4 pound below	24.24	23.77	23.62

* Assumptions: true overrun of 23 per cent, and cream test of 30 per cent.

† 5 gallons = 40 pounds which at 30 per cent test = 12 pounds of butterfat which at 23 per cent overrun = 14.76 pounds of butter. But 39.8 pounds at 30 per cent test = 11.94 pounds of butterfat. 14.76 ÷ 12 = 123; 14.76 ÷ 11.94 = 123.62.

Minnesota and federal statutes require butter to contain 80 per cent of butterfat, and less than 16 per cent of moisture. Eighty per cent butterfat means an overrun of 25 per cent, counting no mechanical losses. Every creamery would profit if it could exactly attain the 15.9+ per cent of moisture; but this is so difficult as to be impracticable. If the buttermaker aims at 15.5 per cent, the product obtained will probably vary from 15 to 16 per cent, but will practically always be this side the limit. If he aimed at 15.9+ per cent, the product would frequently exceed the limit.

About the same thing is true for salt. A product with more than 3 per cent of salt in it will surely be too salty for most markets; hence it pays better to try for a little less.

If one-half per cent of the possible 16 per cent of moisture is not incorporated in the butter, and only 2.5 per cent of salt, the true overrun, assuming no churn losses and the like, will be 23.75 per cent. Butterfat losses will reduce this probably by 2 per cent. Yet the average overrun of the 301 creameries in Figure 6 was 23.47, and 48 per cent of them had an overrun of more than 23.75.[8] Most of the overruns of more than 23.75 are likely to be due partly or entirely to the under-testing and under-weighing presented above. This is surely true of the overruns of more than 24.50, which include nearly 30 per cent of the 301 creameries. The 140 creameries with overruns of more than 23.75 average 1.05 per cent too high. If creameries with overruns of more than 23.75 per cent under-test and under-weigh, there is no reason for believing that many creameries with overruns of 21 and 22 per cent may not under-test and under-weigh also, this under-testing and under-weighing merely serving to conceal the fact that they are not getting enough moisture or salt into the butter or that they have high churn losses. The under-reading of tests and weights does not really rob the patrons of any of their returns—it merely gives them a higher price per pound of butterfat for proportionately fewer pounds. The real evil involved is that it conceals real losses from moisture deficiencies and handling and churning.

[8] Average for all creameries in the state in 1920 was 23.14, according to the reports of the State Dairy and Food Department.

Range in creamery costs.—The third factor in range in price paid for butterfat is the cost of manufacturing the butter and preparing it for market. As already stated, the ordinary range in creamery costs is from 2 to 7 cents per pound of butter. Figure 5 shows that nearly two-thirds of the creameries have costs between 2.75 and 4.25 cents, and the remainder are spread out evenly over the rest of the range from 2 to 7 cents. It is the purpose of this bulletin to analyze in detail this range in costs and the reasons for it. This will furnish the basis for an analysis of the economic organization of creameries. For each creamery covered in the survey complete financial records were obtained, as well as estimates of the distribution of time of labor and management. The floor space of each creamery was measured and an inventory taken of the plant and equipment. A cost accounting system for creameries was devised and the data for each of the 88 creameries were put through this system separately. Thus there resulted 88 separate sets of accounts showing 88 separate labor, space, equipment, and other costs per pound of butter; likewise 88 separate receiving, babcock-testing, churning, and other process costs per pound of butter. These costs vary greatly. The variations have been analyzed and the factors responsible for them have been determined wherever possible.[9]

It should be made clear at this point that the purpose of this analysis is not to determine costs. Costs have been introduced merely as a means to the end of discovering economy in creamery organization. Costs in themselves have little value for such a purpose—it is only when they are analyzed in combination with other organization facts that useful conclusions can be derived.

CLASSIFICATION OF COSTS

Table VIII presents the classification of costs used in this analyzis, together with a summary of the results. The costs analyzed are the costs of converting the raw materials (cream and milk) into a finished product packed and ready for the market. No cost of the raw materials is to be considered. What is paid the patrons for butterfat is considered as a result rather than as a cost. A co-operative creamery is an institution for marketing butterfat. It is as successful as the

[9] The method of partial and multiple correlation analysis was used wherever it promised results. The combining of accounting and statistical methods in this way in a cost study promises many valuable results. Only by the survey method is it ordinarily possible to bring together enough cost records at any one time to allow statistical analysis of results, and then the question arises as to whether the survey method does not introduce so many errors in the original data as to vitiate the results. This study throws considerable light on this question. In many ways, creameries lend themselves especially well to such a study. Creamery plants are similar in type and methods. Ordinarily only one product is turned out. Also co-operative creameries, especially, must keep reasonably good records. On many points, however, the data are inadequate or biased. The bias in some cases can be partly eliminated by statistical methods. In other cases, detailed daily cost records will be needed.

returns to the producers for a given grade of cream are high. While this analysis does not exactly fit the 8 proprietary creameries included in the tables, the error introduced is very slight.

The costs are first classified as "Elementary Costs," and finally as "Process Costs."[10] The sum of all elementary costs equals the sum of all process costs. The first classification divides all costs into the elements of production—site, buildings, equipment, labor, management, supplies, and miscellaneous. The second classification principally divides all costs into the following processes: receiving, babcock-testing, preparation for churn, churning, preparation for market, record keeping, and correspondence. Hauling, sidelines, and extra space are really separate from the main and current business of the creamery, and hence are classed as separate costs. Buttermilk and skimmilk disposal should in most creameries be included as one of the regular creamery costs.

Between the elementary and process costs are six intermediate costs. These represent re-combinations of the elementary costs which are themselves distributed to the process costs. Power cost, for example, represents a combination of building, equipment, labor and management, and supplies and miscellaneous costs. It enters as a cost into all the manufacturing costs.

Table VIII also gives the average per creamery and per 1000 pounds of output for each of the elementary, intermediate, and process costs. The purpose of this table is to show the relative importance of the various costs, and for purposes of such a comparison, the average is the most usable index. The averages per 1000 pounds of output are included here merely for economy of space and convenience of reference in later pages. Average costs per unit of output have little significance in themselves—it is variations in cost that are significant, and these will be presented in the pages following.

Of the four elementary costs, Supplies and Miscellaneous is the largest. This is because it includes the large items of coal and electricity, tubs and boxes, ice and salt. Labor and Management costs, representing nearly a third of all creamery costs, will, however, be found to offer the principal reasons for variations in costs.

Of the process costs, preparation for market is high partly because of the cost of tubs and boxes, and partly because of the labor of packing.

[10] Cost accountants will note that this classification is different from "Prime Costs." The concept of prime costs is based on the technic of cost accounting method and not upon the fundamentals of the economic organization of an enterprise.

TABLE VIII

CLASSIFICATION OF CREAMERY COSTS

Elementary Costs

Item	Per creamery		Per 1000 pounds of butter
	Amount	Per cent of total	
Building and site	$1092	11.7	$4.68
Equipment	929	9.9	3.98
Labor and management	3085	32.9	13.21
Supplies and miscellaneous	4267	45.5	18.28
Total	$9373	100.0	$40.15

Intermediate Costs

Item	Per creamery	Per 1000 pounds of butter
Power	$1184	$5.08
Water	145	0.62
Cold storage	599	2.57
Storage of supplies	131	0.56
Cleaning	545	2.34

Process Costs, Etc.

Item	Per creamery		Per 1000 pounds of butter
	Amount	Per cent of total	
Process costs			
Receiving	$714	7.7	$3.06
Babcock-testing	482	5.1	2.07
Preparation for churning	1347	14.4	5.76
Churning	1418	15.1	6.07
Preparation for market	3541	37.5	15.06
Record keeping and correspondence	811	8.6	3.48
Buttermilk and skimmilk disposal	13	0.1	0.06
Extra space	127	1.4	0.54
Hauling	25	0.3	0.11
Sidelines	89	0.9	0.38
General maintenance	271	2.9	1.16
General management or overhead	562	6.0	2.40
Total	$9373	100.0	$40.15

Ultimate Costs

All Cost Items

	Cents
Per pound of butter	4.02
Per pound of butterfat	4.96

Excluding Sidelines, Hauling, and Extra Space

Per pound of butter	3.91
Per pound of butterfat	4.84
	Pounds
Average output of butter	233,304
Average input butterfat	188,963
	Per cent
Average percentage overrun	22.73

In the following analysis, the unit in which costs are expressed is pounds of butter rather than pounds of butterfat. The average cost per pound of butter of the 88 creameries is 4.02 cents; and the average cost per pound of butterfat is 4.96 cents. The relation between these two costs of course depends solely upon the amount of overrun, which in this case is 22.73. Since the overrun is different in different creameries, the relation between costs of butter and butterfat will vary. The range of the 88 creameries will therefore be somewhat different on the two bases.

The reasons for using butter as the unit in place of butterfat are (1) The buttermaker customarily thinks in terms of pounds of butter; (2) most manufacturing plants compute costs in terms of output rather than input; and (3) the errors of under-testing and under-weighing in many creameries make butterfat a less reliable measure than butter. On the other side of the question it may be said (1) that the co-operative principle that such enterprises as creameries are service enterprises which take the farmer's product and process it and dispose of it at cost, would require costs to be figured in terms of the unit in which the farmer sells his product, in this case, butterfat; and (2) that the most important factor in overrun is the amount of moisture and salt added to the butterfat. Thus there are strong arguments on both sides, and for some purposes the results should no doubt be expressed both ways.

ELEMENTARY COSTS

Each of the four elementary costs will now be analyzed separately. Many of the items included in this analysis are based on estimates. None of the results are therefore to be taken as highly accurate. Ordinarily no conclusions will be stated in which the error of estimates makes the results doubtful; or if they are stated, the degree of probable error will be indicated.

LABOR AND MANAGEMENT

Labor and management costs include all salaries and wages paid except for special labor hired for such work as draying, filling the icehouse, painting, repairs to the plant and equipment, and the like. These are included under "Supplies and Miscellaneous."

Later in the bulletin, labor is separated from management, and record-keeping and correspondence are separated from other forms of labor. In this first analysis, however, all are combined.

The employees of a creamery may be classified as in Table IX and Table XIII. In Table XIII each creamery is considered as having one buttermaker or head buttermaker. He is frequently described as "buttermaker-manager" or "operator." These 88 creameries in addition employ 11 men who are designated as managers, 64 full-time

helpers (in some cases these are trained or experienced buttermakers), 19 part-time helpers, 67 secretaries, and 7 bookkeepers; 23 have salaried treasurers, and 63 have salaried directors.

The analysis of labor and management costs is taken up in three stages, (A) the time requirement (hour as unit) per 1000 pounds of butter, (B) the rate of pay per unit of time, and (C) the product of A and B, that is, the labor and management cost per 1000 pounds of butter. If it takes 30 hours of labor and management to make 1000 pounds of butter, and the rate of pay is 40 cents per hour, then the labor and management cost is $12.

TABLE IX

HOURS OF LABOR PER YEAR OF YEAR-ROUND CREAMERY EMPLOYEES, BY NUMBER OF HELPERS

Employees	No helper (28)*	One helper (40)*	Two or more helpers (20)*	All creameries (88)*
Buttermakers	3249	3351	3130	3352
Helpers	....	2714	2754	2733
Secretaries	702	1024	1356	997
Bookkeepers	822	1980	1731	1664
Managers	1342	1206	1984	1555
Directors	98	108	180	119
Treasurers	120	173	180	169

* Number of creameries.

Hours.—Table IX shows the average hours per year of the year-round employees. Most of the employees except buttermakers and full-time helpers have other employments. This is true of most of the managers. In this table, the 88 creameries are put into 3 groups according to the number of "helpers" employed. (Creameries with part-time helpers are put in the group into which they fit most nearly.) For full-time employees, the hours are about the same for all groups, but for part-time employees, such as secretaries, directors, and the like, the increase in hours is very marked.

The buttermakers' hours average least in the largest creameries because some of them do not quite need all the helpers they have. In the group of 28 with no helpers, are some creameries so large that one buttermaker must put in very long hours to handle the work, but more which do not keep one buttermaker fully employed, with the result that the hours for such creameries are somewhat below the average.

The ordinary range in buttermakers' hours is from 2900 to 3600 per year, but 20 buttermakers gave estimates of over 3600 hours per year and 10 estimated over 4000 hours per year. The evidence shows that several of these estimates were too high. The error arose from the fact that many buttermakers put in a good share of their working hours in and around the creamery, whether really at work or not, and the tendency is to include all these hours as working time. (The same

difficulty is experienced in farm cost accounting.) Only 7 buttermakers worked less than 2700 hours per year.

The ordinary range for full-time helpers is from 2700 to 3300 hours. Table IX, however, includes a large number who were not really employed full-time the year around. Eight worked more than 3300 hours per year.

The salaries per year for full-time men increase somewhat with the hours worked per year, or vice versa. Each $100 additional salary of buttermakers, however, represents an average of only 42 more hours of work per year, a little less than one hour per week. For full-time helpers, there seems to be no relation between hours of work and salary. (In making this analysis all part-time workers were eliminated—of course such workers receive wages in accordance with the time they work.) Buttermakers therefore do not receive appreciably higher salaries merely because they work longer hours. There are special cases, to be sure, in which the work to be done is heavy for one, but not enough for a helper, and a buttermaker is given an extra salary for handling the work alone.

Hours per 1000 pounds of butter.—Table X shows the range in hours per 1000 pounds of butter. The average for the 88 creameries is 30.7 hours, and the ordinary range from 20 to 45 hours. As already explained, this average is somewhat high because of over-estimated hours; the error, however, is surely less than two hours per 1000 pounds and probably less than one hour.

TABLE X

RANGE IN HOURS OF LABOR AND MANAGEMENT PER 1000 POUNDS OF BUTTER

Hours per 1000 pounds of butter	No. of creameries in group	Average of group
		Hours
Under 20	8	17.0
20 to 25	21	22.7
25 to 30	18	27.3
30 to 35	15	32.3
35 to 45	13	38.8
Over 45	12	51.5
All creameries	88	30.7

Figure 12 shows, however, that the hours per 1000 pounds of butter decrease markedly with output. In general, every 100,000 pounds of output is accompanied by an average decrease of 4.5 hours of labor and management per 1000 pounds of butter. This average is expressed by the straight line. But an average line does not fit the facts very well, as the decrease is very slight, being for creameries between 400,000 and 800,000 pounds of output at the rate of only 0.3 hour per 100,000 pounds. But between 50,000 and 150,000 pounds, the

decrease is at the rate of 60 hours per 100,000 pounds. Thus a curved line bending sharply around 200,000 pounds of output describes much more accurately than the straight line the relation between output and time requirement of labor and management. The manager of any creamery can determine from this curved line what his hours per 1000 pounds of output should be, unless there are some other causes operating.

The reason for the very slight saving in labor and management with increase in output after from 300,000 to 400,000 pounds is reached, is partly that cheaper help, working less rapidly, is hired for some of the ordinary work, such as packing butter and cleaning, and partly that from this point on nearly all operations are performed with a full load, and increasing output simply increases by so much the scope and number of operations. Under 300,000 pounds, churns, ripeners, power plants, etc., are run at less than full capacity, yet require about as much time as they would if run at full capacity. In the smallest creameries, even the buttermaker has to put in much time when he is not fully occupied.

Seasonality of milk flow.—The receipts of the heaviest month of the year determine in many cases the amount of help hired, for it is not always practicable to hire extra labor for part of the year. Only 19 of 88 creameries employ part-time help (other than for management, bookkeeping, and the like). One would expect, therefore, to find the creameries with heavy summer receipts and light winter receipts using more labor. The 15 creameries receiving over 12 per cent more milk in the heavy months of the year than in the light months, after allowance was made for difference in output, used two hours more of labor for each 1000 pounds of butter than the 12 creameries receiving less than 7 per cent more butter in the heavy than in the light months. This is a difference of more than 6 per cent.

Convenience of arrangement.—At the time of the survey, the creameries were roughly classified into three groups as to convenience of arrangement. Table XI shows the results of this classification. At 42 cents per hour, the conveniently arranged creameries saved $2.23 per 1000 pounds of butter, or $445 for a 200,000-pound creamery, over the very inconveniently arranged creameries.

TABLE XI

RELATION OF CONVENIENCE OF ARRANGEMENT TO LABOR

Arrangement	No. in group	Hours per 1000 lbs.*
Convenient	15	28.7
Somewhat inconvenient	55	30.4
Very inconvenient	21	34.0
All creameries	88	30.7

* After allowance was made for differences in output.

Rates per hour.—The rate per hour for each employee was obtained by dividing annual salary by hours per year; and average rates per hour for each creamery by dividing the annual payroll (excluding salaries of treasurers and directors) by total hours of labor and management per year.[11] Table IX gives hours per year for different classes of employees. Table XII gives annual salaries by classes of employees; Table XIII, by classes of employees in different combinations; and Table XIV, the rates per hour in the different combinations. The salaries of buttermakers increase with the size of the labor force and output of creameries for all groups with enough creameries to give a good average. For the 8 creameries with no helper, the average is $1669; for 13, each with a part-time helper, $1742; for 22, each with a full-time helper, $1726;[12] for 8, each with two full-time helpers, $1806. All but 19 of the buttermakers covered in the survey received salaries between $1400 and $2100. The lowest salary for the buttermaker was $1000; and the highest was $4000. Nine received salaries under $1400, and 10 salaries over $2100. Between $1400 and $2100 the distribution is very even, 9 receiving from $1400 to $1500, and 9 from $2000 to $2100, and about the same number for each wage interval between. Managers' salaries are very erratic, ranging from $1300 to $1600 for several part-time men, to $4000 for one full-time man. Several others were over $2100.

Where managers are full-time men, either doing little but look after the business details, as in the very large creameries, or combining this with buttermaking, their salaries are larger than those of buttermakers. In such cases buttermarkers' salaries are likely to be reduced, sometimes to the level of experienced helpers.

Salaries of first helpers also increase consistently from $742 for one helper with no secretary to $908 for one helper with a secretary, and $1185 for two helpers with a secretary. In the largest creameries the second helper draws as large a salary as the first helper. Salaries of secretaries and bookkeepers likewise increase regularly. Most of the salaries of helpers are between $700 and $1200, only 6 receiving

[11] If the question of cost by seasons was involved, or of different products using labor at different seasons, this method would be objectionable, for some of the labor and equipment of a creamery is required mostly for the early summer months of heavy receipts. However, there is no question of alternatives here, for a creamery has no choice except to take the cream when it comes.

There is, however, one serious objection to this method, namely, that it does not give a correct distribution of labor and management costs to different processes. In large creameries, men of different degrees of skill and experience are employed at different rates to do the receiving, churning, cleaning, packing of butter, record-keeping, etc.; in the smaller creameries, one man may do all of these at one contract rate. The salary rate in such a case is really a combination of rates for different tasks; but it does not appear so in the contract, and there is no very satisfactory way of making the separation.

[12] In many cases the helper is really a second buttermaker, in which case both receive about the same salary.

more than $1200, and 7 less than $700. Those receiving $1200 and more of course have had experience or training as buttermakers, or both. Those receiving the lowest salaries are either boys or, in a few cases, part-time helpers.

These are the salaries prevailing in 1919. There has been both an increase and a decrease in the salary level since then.

Reduced to rates per hour, buttermakers' earnings do not increase in general with the size of the creamery—longer hours in the larger creameries apparently offset the slight increase in salary. The ordinary range is between 40 and 70 cents an hour, and the extreme range 30 and 92 cents an hour. Ten are receiving less than 40 cents an hour, and 13 over 70 cents an hour.

TABLE XII

AVERAGE ANNUAL SALARY AND FORMS IN WHICH IT IS RECEIVED

Employing	No. of creameries employing	Cash salary	Perquisites	Total
Buttermaker	88	$1634	$115	$1749
Helpers (full time)	60	991	...	991
Helpers (part time)	24	98*	...	98*
Secretaries	66	357	3	360
Bookkeepers	16	662	...	662
Managers	18	1420	40	1450

* Per month.

First helpers' salaries average 31.2 cents per hour as compared with 54 cents for buttermaker-operators. It will be noted that when second helpers are employed, the first helpers receive considerably higher pay than when only one helper is employed. The rates for first helpers increase as the size of the business increases, from 23.7 cents an hour to 28 cents, then to 34.5 cents when a second helper is taken on, and finally to 46.8 cents when a third helper is taken on. The rate when one helper alone is employed averages 27.6 cents an hour. If second helpers where two are employed and third helpers where three or more are employed are averaged with these, the rate is 28.3 cents an hour. The average of rates for first helpers when a second helper is employed combined with rates for second helpers when three or more are employed, is 36.7 cents an hour. Averaged on this basis, which more nearly represents the facts, the rates range as follows: 46.8, 36.7, and 28.3 cents. The ordinary range in helpers' salaries is from 25 to 40 cents an hour, but 8 receive less than 25 cents per hour.

Bookkeepers are paid higher rates when they do the secretary's work than when a secretary is employed in addition. However, in the case of the 8 creameries having both bookkeepers and secretaries, 4 listed as secretaries are also bookkeepers, and those listed as bookkeepers are really bookkeepers' assistants. The average rate for bookkeepers, 51.6

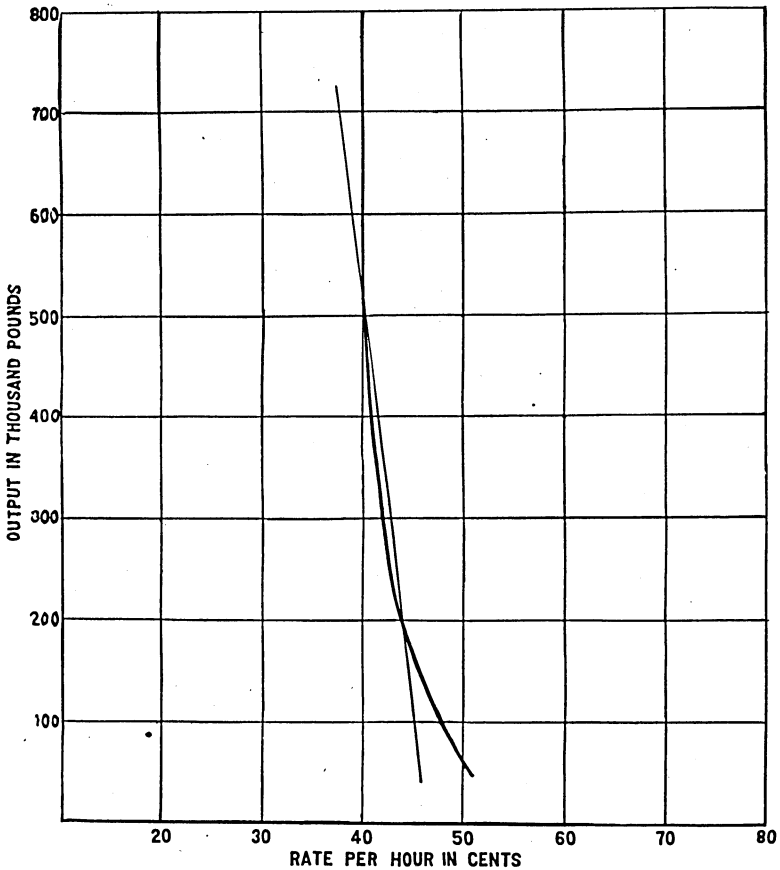

Fig. 13. Relation of Output to Rate per Hour for Labor and Management

The average rate per hour is about 48 cents for 100,000-pound creameries, and about 40 cents for 50,000-pound creameries. The average rate of decrease, indicated by the straight line, is 1.2 cents per hour for each additional 100,000 pounds of output. The actual decrease, however, is according to the curved line, and much more rapid under 250,000 pounds than above this point.

cents per hour, is therefore too low (probably 2 cents), and the average rates for secretaries, 46.8 cents per hour, is too high (probably 0.6 cent). Buttermakers and bookkeepers are therefore paid at about the same rate, and secretaries at a somewhat lower rate.

TABLE XIII

SALARIES OF CREAMERY EMPLOYEES IN VARIOUS COMBINATIONS (Blanks indicate none employed.)

Average ouput in pounds of butter	No. in group	Average annual payroll											Cost per pound of butter
		Total	Buttermakers	Managers	Secretaries	Book-keep-ers	First helper—full time	Second helpers—full time	Others—full time	Part-time helpers*	Directors*	Treasurers*	
													Cents
87,638	5	$1679	$1679	....	....	....	....	....	...	...	...	...	1.92
133,280	16	1974	1669	....	$219	....	....	....	...	...	$70	$16	1.48
140,826	3	2774	2230	....	....	....	....	....	...	$486(4)†	56	...	1.97
146,554	3	2812	1872	....	....	....	$742	....	...	...	135	43	1.92
148,004	4	3040	1739	$1202	....	....	....	....	...	...	72	27	2.05
177,562	13	2614	1742	....	305	....	....	....	...	516(13)†	62	18	1.47
181,637	3	2702	2130	....	212	$273‡	....	....	...	...	50	37	1.49
256,525	22	3147	1726	....	411	....	908	....	...	...	76	26	1.23
326,000	1	4948	1754	1564	....	....	1500	....	...	...	130	...	1.52
177,661	1	4574	2050	....	....	600	1200	....	...	500(1)†	224	...	2.57
383,140	8	4495	1806	....	506§	....	1185	$877	...	...	60	37	1.17
475,514	3	4863	1497	1738	539	....	789	....	...	...	152	148	1.02
623,250‖	5	7639	1635	1187¶(3)†	800(2)†	1050(3)†	1191	1118	$903(9)†	367(1)†	147	112	1.22

* Calculated as the amount paid per creamery for part-time helpers, directors, treasurers.

† Numbers in parentheses indicate number employed in the given group of creameries.

‡ One of these also calls himself a manager.

§ Two of these are classed as bookkeepers, and in two cases the salary is divided between a bookkeeper and a secretary.

‖ Of these 5 creameries, 3 had managers, 2 had secretaries, 3 had bookkeepers, and 4 had 10 extra helpers in all, one being employed part time.

¶ Two of these managers worked on a part-time basis.

TABLE XIV

RATES PER HOUR OF CREAMERY EMPLOYEES UNDER DIFFERENT COMBINATIONS

Average pounds of butter made	No. of creameries	Average rate per hour									
		Operator	Manager	Secretary	Bookkeeper	First helper	Second helper	Third helper	Part time helpers		
									6 months	4 months	3 months
		Cents	Cents	Cents	Cents	Cents	Cents	Cents	Cents	Cents	Cents
87,638	5	55.4	...	...	...	...	...	...	...	...	...
132,280	16	54.0	...	4.74	...	...	...	...	...	...	...
146,554	3	51.2	...	...	...	23.7	...	...	...	...	...
148,004	4	53.6	48.3	...	...	...	...	...	...	...	...
140,826	3	58.1	...	...	...	...	...	...	41.9	26.1	...
177,562	13	52.0	...	42.1	...	...	...	...	25.1	20.8	18.9
181,637	3	54.6	...	...	58.6	...	...	...	...	...	...
256,525	22	56.0	...	48.5	...	28.0	...	...	...	...	...
326,000	1	58.0	107.9	...	...	48.6	...	...	...	...	...
177,661	1	55.0	...	...	...	32.1	...	...	26.8	...	...
335,246	8	51.9	...	50.0	34.4	34.5	27.8	...	...	...	...
475,514	3	48.6	85.8	44.9	...	25.6	...	...	...	...	...
623,289	5	57.8	40.3	46.3	54.3	46.8	40.3	30.5	23.7	...	...
Average all creameries		54.0	58.5	46.8	51.6	31.2	32.6	30.5	27.6	22.6	18.9

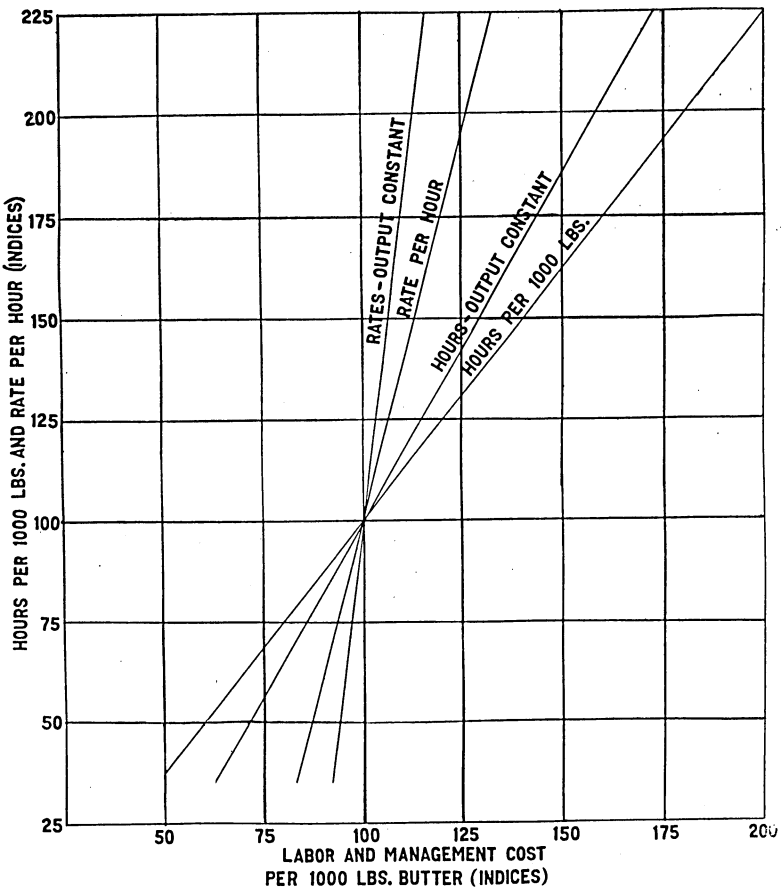

Fig. 14. Relation of Hours and Rate per Hour to Labor and Management Cost

In this diagram rates per hour have been reduced to percentages or indices of the average rate per hour; and similarly hours per thousand, to percentages of average hours per thousand; and the same for labor and management cost per thousand. Only in this way can the effects of rates per hour and hours per thousand be compared. Taking creameries as they are, it appears that rates per hour 50 per cent above the average are accompanied by a 13 per cent higher labor and management cost; whereas hours per thousand 50 per cent above the average are accompanied by a 40 per cent higher labor and management cost. The other set of lines shows that if creameries all had the same output, the effects would be much less pronounced.

The rate given for managers, 58.5 cents, is not an average for real managers, it includes the rates for men bearing that title whose services are of a very miscellaneous nature. And where the manager has this work as a sort of avocation, he may put in time out of all proportion to his salary. The range is from 32 cents an hour to $1.08.

Table XV gives the range in rate per hour by creameries. It is as much due to averaging salaries of high- and low-priced employees in one creamery as it is to difference in salary levels in different creameries. Table VII shows this conclusively—in the creameries with two

or more helpers, the average rate per hour is 40.7 cents as compared with 49.9 cents in the creameries with no helpers. Thus one of the economies of larger output is that it permits division of labor and hiring of cheaper help for the work requiring less skill. The same result appears in Figure 13. The straight line, which represents the average for all outputs, indicates a decrease of 1.2 cents per hour for each 100,000 pounds increase in output. According to this ratio, 500,000-pound creameries would be hiring labor 5 cents less per hour than 100,000-pound creameries. The curved line, however, which fits the facts better than the straight line, indicates that for creameries under 250,000 pounds, the rates increase rather rapidly with decrease in output.

TABLE XV

RANGE IN RATES PER HOUR FOR LABOR AND MANAGEMENT BY CREAMERIES

Groups	No. in group	Average rate for group
Cents		Cents
Under 30	9	27.9
30 to 35	6	32.6
35 to 40	14	37.8
40 to 45	24	42.3
45 to 50	11	47.3
50 to 55	8	52.2
55 to 60	7	56.3
Over 60	9	66.7
All creameries	88	43.1

By using this curve in the manner previously explained, any manager can determine what average rate per hour he should be paying for labor for a creamery with his output, other things being the same.[13] If his labor is costing him at a higher rate, he will find in many cases that he is using too high a proportion of the higher-class labor. Of course, as will be indicated later, he may be getting a quality of product which more than makes up for the extra cost per hour.

As already explained, rates per hour do not increase quite in proportion to salaries, as the more highly paid men work 42 more hours per year for each addditional $100 of salary. This means that employees receiving $2000 for a year's work, on the average work 210 more hours than employees of the same type receiving $1500 per year.

Labor and management cost per pound of butter.—Table XVI shows the range in cost of labor and management per 1000 pounds of butter. The extreme range, not shown in the table, is from $8 to $31. The average is $13.20. As already explained, labor and management cost per 1000 pounds of butter is the product of the number of hours multiplied by the rate per hour. It varies, therefore, with both these factors. Figure 14 shows these variations graphically.

[13] Assuming the same salary level as in 1919.

TABLE XVI

RANGE IN LABOR AND MANAGEMENT COST PER 1000 POUNDS OF BUTTER

Groups	No. in group	Average for group
Under $10	12	$8.80
$10 to 13	29	11.60
13 to 16	19	14.30
16 to 19	10	17.10
19 to 22	8	20.50
Over 22	10	27.50
All creameries	88	$13.21

After correction was made for the errors of overestimates,[14] it was found that a difference of 10 per cent in the rate per hour, other things being the same, is accompanied by a difference of only 2 per cent in labor and management cost; while a difference of 10 per cent in number of hours is accompanied by a difference of 18 per cent in labor and management cost. This is indicated in the diagram by the greater slope of the line for hours per 1000 pounds of butter. Reduced to a unit basis, a difference of 10 cents per hour, other things being the same, accompanies a difference of only 62 cents per 1000 pounds, and a difference of 10 hours per 1000 pounds of butter accompanies a difference of $3.45 per 1000 pounds. This can only mean that the higher rates of pay, for various reasons, are accompanied by fewer hours per 1000 pounds of butter, and conversely, the more hours by lower rates of pay. This is evident from Figure 15, which shows that especially the creameries with average rates under 50 cents per hour, average more hours per 1000 pounds of output. This must be due to the greater capacity and efficiency of the more highly paid workmen.

The most important of the other things not the same is output. If creameries were all of the same size, the results would be less pronounced, for as already pointed out (Figures 12 and 13), the creameries with the lowest number of hours per unit of output are likely to be the largest ones, and these also have the lowest rates per hour. Figure 14 shows how much less the effect of the number of hours and rates per hour would be if the creameries were all of the same size.

Figure 16 shows the variations in labor and management cost with output, the heavy straight line expressing the average relation between them, and the curved line the particular relation for any given output. Other things being the same, labor and management costs per unit of output for a creamery of any given output should be as indicated by the curved line. The cost per unit decreases very little above 300,000 pounds. On the average, 100,000 pounds of additional output accompanies labor and management costs lower by $2.24 per 1000

[14] The error of overestimate, as near as could be determined, represented an understatement of 2.05 cents in the rate per hour for each 100 hours overstatement of hours.

pounds. A little of this decrease is due to the lower rates per hour of the large creameries—if rates per hour were the same, the decrease would be $2.06 per thousand instead of $2.24. If, however, hours per thousand were the same for all outputs, the decrease would be only $1.33 in place of $2.24. The lighter lines in Figure 16 illustrate this.

Table XIII gives average labor and management cost according to the different combinations of employees. An economical combination is the buttermaker-manager, secretary, and two full-time helpers. This gives the 8 creameries an average cost of $11.70 per 1000 pounds of butter. Another economical combination is buttermaker-manager, secretary, and one full-time helper, at $12.30 per 1000 pounds of butter for the 22 creameries. The 13 creameries with part-time helpers made 44,280 pounds more butter per year than the 16 with no helpers, but the payroll cost was $640 more per year, which was almost proportional to the increase in butter output, resulting in costs of $14.70 as compared to $14.80 per 1000 pounds. The creameries with neither helpers nor

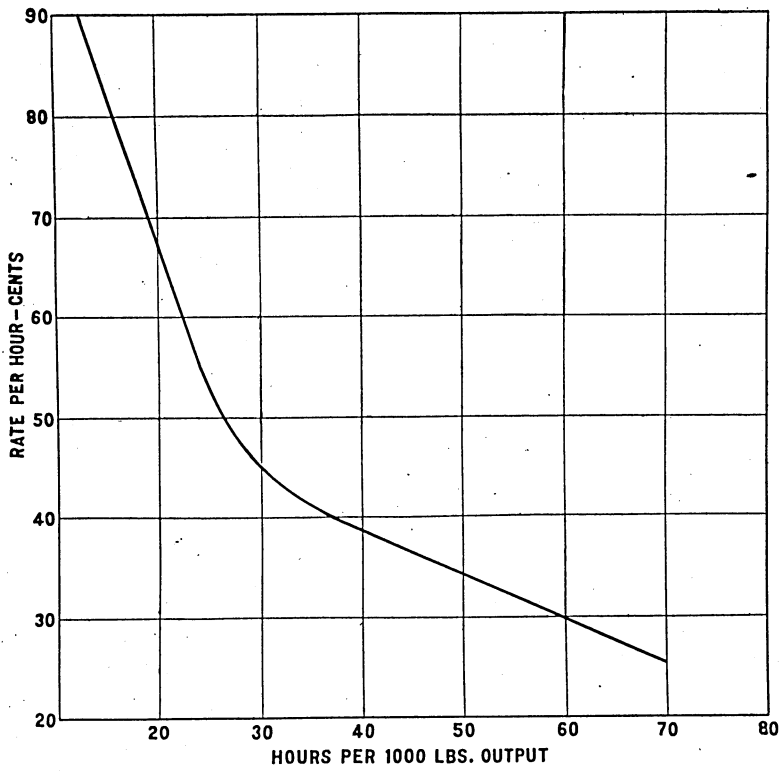

Fig. 15. Relation of Rates per Hour to Labor and Management

The low rates per hour are accompanied by a high number of hours per thousand pounds of output. The low rates arise from putting in long hours to poor advantage, and from the low salaries paid inexperienced slow workers.

secretaries had a labor and management cost of $19.20 per 1000 pounds of butter. This is because of the small output of butter.

The creameries with managers have high labor and management costs per pound of butter if the creameries are relatively small. This is because the creamery has two highly paid employees. The 3 creameries, however, making an average of 475,000 pounds of butter and having both buttermaker and manager, have the lowest cost of any. This arrangement is very similar to a buttermaker-manager and two full-time helpers, and the costs are about the same. The buttermaker in one case is about the same as the first helper in the other case, and receives very little more salary. Such creameries are really large enough to have managers.

Separation of labor and management cost.—Table XVII shows the distribution of labor and management cost between labor, record keeping and correspondence, and management. The term "labor" as here used refers to the labor, mostly manual, of receiving, churning, and the like.[15] The proportion of management cost increases as more help is taken on, and the proportion of labor cost decreases. Part of the reason for the increase in the proportion of management cost is higher rates of pay, and for the decrease in the proportion of labor cost is lower average rates of pay, because part of the labor is low-priced. The percentage of total hours devoted to labor is only one half per cent less for creameries with two or more helpers than for creameries with no helpers. The percentage of total hours devoted to record keeping and correspondence decreases with output, but the rates are somewhat higher. Reduced to a unit basis, the lower the labor and management cost per pound of butter, the smaller the proportion of it which is labor, and the more of it which is management and record keeping and correspondence. This is because the larger creameries have lower costs and more management.

The separating of the three classes of work in a creamery was of course difficult. In only the largest creameries are managers hired to do managing only. The buttermaker-manager does much of his managing incidentally; he makes his plans while he is packing butter or figuring over his accounts. Management is directing other men at labor. As a part of this, or necessary to it, is included organizing the business, laying out the work, buying and selling, hiring, borrowing money, negotiating with patrons, travel, correspondence, and the interpretation of records and study of conditions necessary to the foregoing.

[15] The only excuse for using the term "labor" here is the want of a better one.

TABLE XVII

DIVISION OF COST BETWEEN DIFFERENT TYPES OF WORK IN CREAMERIES OF DIFFERENT CLASSES

	No helpers		One helper		Two or more helpers		All creameries	
	Average cost	Per cent	Average cost	Per cent	Average cost	Per cent	Average cost	Per cent
Labor	$1481	75.9	$2165	73.2	$3500	71.0	$2150	73.0
Record keeping and correspondence	348	17.8	556	18.8	932	18.9	575	18.6
Management	123	6.3	237	8.0	499	10.1	260	8.4
Total	$1952	100.0	$2958	100.0	$4931	100.0	$3085	100.0

Time spent by the manager in actual correspondence and record keeping, however, was separated out. Record keeping was defined to include the bookkeeping and work upon the records. The recording of weights, tests, and the like was counted as labor at the various processes.

Labor, according to Table XXII, represents 73 per cent of the labor and management cost, record keeping and correspondence 18.6 per cent, and management 8.4 per cent.

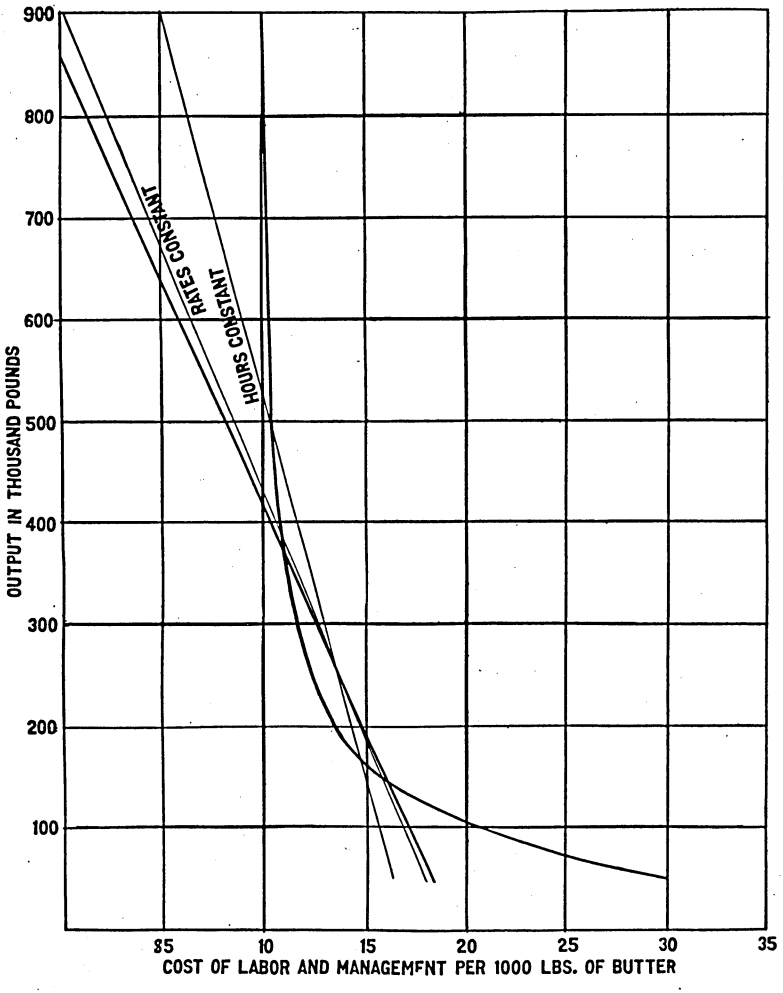

Fig. 16. Relation of Output to Labor and Management Cost

These curves should be read exactly as explained for Fig. 14. The cost per thousand for 100,000-pound creameries averages $21; for 300,000-pound creameries, $12, that is, reading from the curved line. The straight lines express the average effect of output on cost. If the larger creameries paid as high rates as the smaller creameries, the effect of output would be somewhat less; and if they used the same number of hours per thousand, it would be a great deal less.

When labor is analyzed in detail, as were labor and management combined in the preceding pages, labor costs vary with output at the average rate of $2.04 per 100,000 pounds of output in place of $2.24 for labor and management combined; with each ten cents additional rate per hour at the rate of 86 cents per 1000 pounds of butter, in place of 62 cents for labor and management combined; and with each ten hours additional per 1000 pounds of butter at the rate of $4.30 in place of $3.45 for labor and management combined. Table XVIII shows that the labor cost per 1000 pounds of butter is $9.60, representing 22.9 hours at 42.1 cents per hour.

TABLE XVIII

RANGE IN LABOR COST PER 1000 POUNDS AND RELATION TO OTHER COST FACTORS

Groups	No. in group	Average for group	Labor per 1000 lbs.	Labor cost per hour	Output
			Hours	Cents	Lbs.
Under $7.50	16	$6.40	16.6	38.5	429,403
$7.50 to 9.00	15	8.30	19.5	42.7	269,917
9.00 to 10.50	20	9.50	23.7	40.2	211,591
10.50 to 12.50	12	11.20	24.9	45.0	192,517
12.50 to 14.00	6	13.10	28.5	46.1	128,567
Over 14.00	19	19.10	43.3	44.0	118,431
All creameries	88	$9.60	22.9	42.1	233,304

This means that a 10 per cent higher labor rate in the various creameries, taking other conditions as they are, is accompanied by a 3.8 per cent higher labor cost; and 10 per cent more labor hours by 10.2 per cent higher labor cost. Table XVIII gives the ordinary range in labor costs.

Table XIX shows that when the creameries are grouped according to the number of helpers, the hours per 1000 pounds output are nearly the same, but that the rates are much lower for the creameries with helpers.

TABLE XIX

LABOR PER CREAMERY CLASSIFIED ACCORDING TO NUMBER OF HELPERS

	No. of helpers (28)*	One helper (40)	Two or more helpers (20)	All creameries (88)
Output, pounds	125,898	225,077	400,231	233,305
Labor hours	2830	5384	8800	5348
Labor cost	$1481	$2165	$3500	$2250
Labor cost per 1000 pounds of butter	$11.80	$9.60	$8.70	$9.60
Labor hours per 1000 pounds of butter	22.5	23.9	22.0	22.9
Labor cost per hour, cents	52.3	40.2	39.8	42.1

* Number of creameries.

To the above management cost must be added the salaries paid to directors and treasurers, averaging $89 per creamery for the 88 creameries, as indicated in Table XX. Only 23 of the 88 paid salaries to their treasurers, and only 63 to their directors.

TABLE XX

SALARIES OF TREASURERS AND DIRECTORS

	No helpers		One helper		Two or more helpers		All	
	No. of creameries	Salary paid	No. of creameries	Salaries paid	No. of creameries	Salaries paid	No. of creameries	Salaries paid
Number paying salary to treasurer	6	$300	13	$1073	4	$679	23	$2072
Average per treasurer receiving salary	..	50	..	83	..	175	..	90
Number of creameries paying directors	27	2386	28	3238	8	1144	63	5768
Average per creamery paying salaries to directors	..	88	..	116	..	143	..	107

Table XXI shows the increase in payroll, including salaries of treasurers and directors for the 88 creameries, according to output. This table should be useful in determining the reasonableness of the payroll for any size of creamery. It must be remembered that this payroll is on a 1919 basis. Table XXII also shows the direct distribution of labor cost to intermediate and process accounts. The labor element in power, general maintenance, and cleaning is later redistributed to receiving, testing, and the other final process accounts, so that the total labor element in these final process accounts is greater than here indicated.

TABLE XXI

RELATION OF PAYROLL TO OUTPUT

Butter output	No. in group	Total payroll	Butter output	Payroll per 1000 pounds
Pounds			Pounds	
Under 100,000	10	$1976	73,788	$26.78
100,000 to 150,000	19	2371	127,353	18.62
150,000 to 200,000	17	2748	184,394	14.90
200,000 to 250,000	15	2889	215,224	13.42
250,000 to 300,000	10	3503	274,471	12.76
300,000 to 400,000	5	4018	331,792	12.11
400,000 and over	12	5862	541,543	10.82
All creameries	88	$3186	233,304	$13.65

TABLE XXII

DISTRIBUTION OF LABOR AND MANAGEMENT COST

Accounts to which distributed	Per creamery		
	Amount		Per cent of total
Labor	$2250		73.0
Power	$176	5.7	
General maintenance	50	1.6	
Receiving	427	13.9	
Testing	278	9.0	
Preparation for churn	156	5.0	
Churning	307	9.9	
Preparation for market	464	15.0	
Cleaning	348	11.4	
Sidelines	43	1.4	
Record keeping and correspondence	575		18.6
Management (overhead)	260		8.4
Total	$3085		100.0

SPACE COST

Space cost includes building cost and site cost. Together, these constitute 11.7 per cent of the total cost of operating creameries. Building cost is 93 per cent of the total. Building cost and site will be discussed separately and then combined.

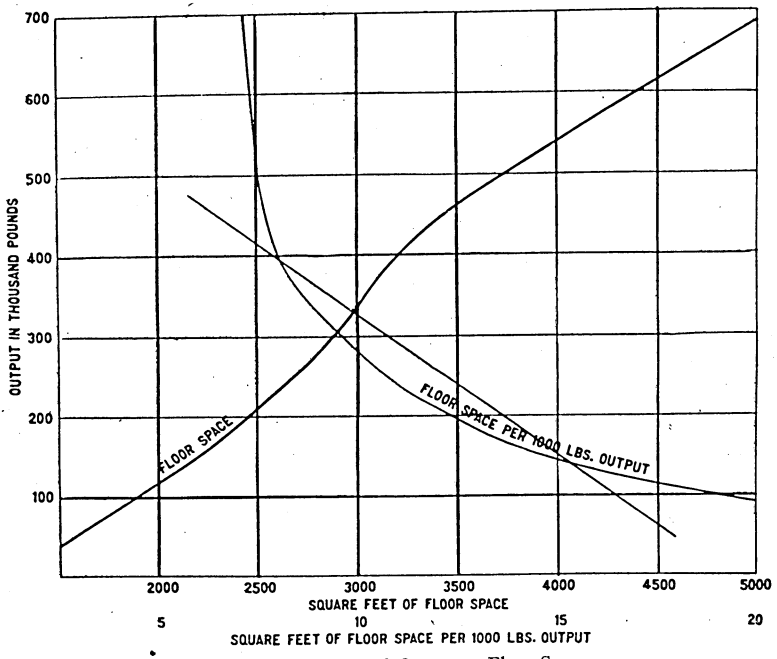

Fig. 17. Relation of Output to Floor Space

Building cost per 1000 pounds of butter may be considered as the product of the number of square feet of floor space times the annual cost per square foot of this floor space. Site cost can be similarly reckoned as ground space instead of floor space; however, in reducing site cost to a cost basis, it was calculated on a floor space basis so that it could be combined with building cost.

Floor space.—The ordinary range in floor space as given in Table XXIII is from 1500 to 3500 square feet. Only 7 out of 88 were over 3500 square feet. The largest creamery included in the survey had 5493 square feet of floor space and the smallest, 705 square feet. Figure 17 shows the relation of output to floor space. For the group of creameries with outputs between 250,000 and 400,000, there is a relatively smaller increase in floor space with output. This is because of the bunching at this point of quite a number of creameries that are running at or above full capacity. Above this point is an increasing number of new creameries built larger than needed at present.

The curve in Figure 17 can not be used as an altogether safe guide as to the size of creamery needed for a given output, because there are more creameries running either over or under capacity at different points on the curve. In general, however, it indicates that floor space increases with output at the rate of about 450 square feet for each 100,000 pounds of output, starting from 1900 square feet for 100,000 pounds.

The other curve in Figure 17 expresses the same relation in terms of floor space for 1000 pounds. It shows that the efficiency of use of space increases rapidly only up to about 300,000 pounds. One important reason, however, that efficiency does not increase more rapidly with the larger outputs is that there are more oversize creameries in these groups. The three creameries with floor space of over 4000 square feet have a very high degree of utilization.

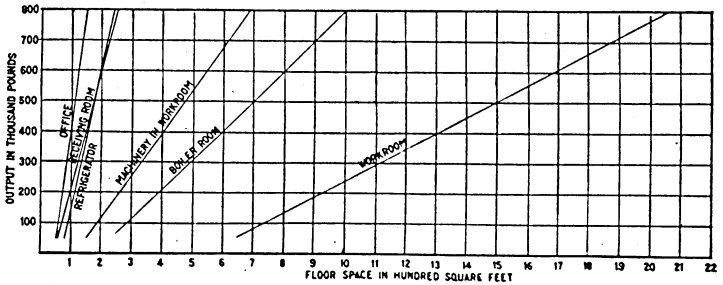

Fig. 18. Floor Space by Departments and Output

Figure 18 shows the division of floor space between departments of the plant for creameries of different outputs. Table XXIV gives the average for 65 creameries, and also readings from Figure 18 for creameries of 100,000, 300,000, and 500,000 pounds. Similar readings for any other output can be made from the diagram. Space for the storage of ice and supplies has been omitted because many creameries have neither, or perhaps store their supplies upstairs.

The figures for boiler-room space combine creameries using and those not using electric power. As will appear later, creameries with electric power average only 35 square feet less floor space than those using no electric power. It is likely, however, that if creameries built in the first place to use electric power could have been segregated, there would have been a greater difference. As it is, boiler-room floor space varies greatly between creameries from 10 per cent to over 23 per cent of the total floor space. The proportion of the total floor space is larger in the smaller creameries than in the larger ones.

TABLE XXIII

RANGE IN FLOOR SPACE OF 88 MINNESOTA CREAMERIES

Floor space	No. of creameries	Butter output in 1919
Sq. ft.		Lbs.
Less than 1500	6	149,900
1500 to 2000	17	152,700
2000 to 2500	22	229,700
2500 to 3000	25	262,500
3000 to 3500	12	292,800
3500 and over	6	302,500

TABLE XXIV

FLOOR SPACE FOR CREAMERIES OF VARIOUS SIZES, SQUARE FEET*

Output	Office	Receiving room	Refrigerator	Boiler room	Machinery work room	Workroom space
Lbs.						
100,000	55	70	90	285	185	740
300,000	85	120	135	495	320	1060
500,000	115	170	170	700	430	1500
Average of 65 creameries	75	95	120	410	280	930

* Not including space for storage of ice and of supplies.

Office space is also very irregular. For example, the office floor space for the creameries with outputs between 400,000 and 500,000 varies from 30 to 300 square feet. The proportion of office space increases with the larger creameries. This is because the larger creameries are likely to have more business in proportion to their output than the smaller ones.

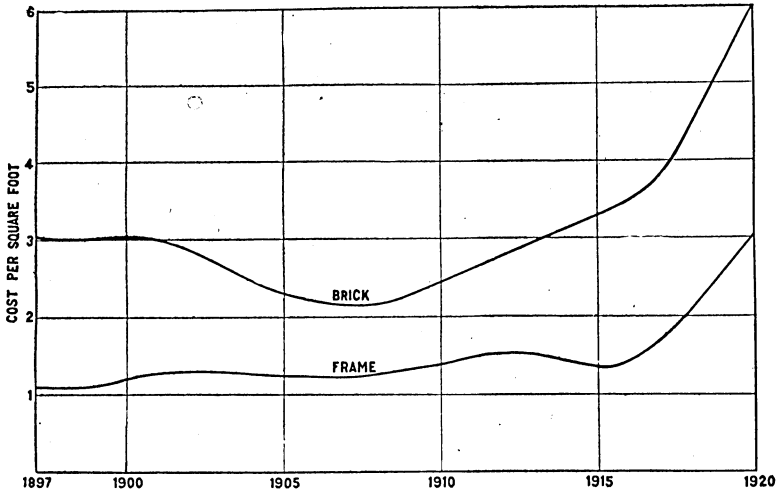

Fig. 19. Building Cost per Square Foot, 1897 to 1920

The data are based on the buildings actually erected in these years combined with the Bureau of Labor data on the costs of building materials and labor. They are, of course, only approximations.

The proportion of space actually occupied by machinery decreases with output; a creamery with 500,000 pounds output has about two per cent less of its total space actually occupied by machinery than a 100,000-pound creamery. The proportion of space in the workroom, however, increases with the size of the building. This can only mean more work space around equipment, more passageway or more extra space. The proportion of refrigerator space decreases slightly with output, but this is partly because more of the larger creameries are using ice machines.

There is clear evidence that much space is wasted in many creameries in departments of the plant which are larger than need be. On the other hand, many plants have departments which are cramped for room merely because of poor planning.

Convenience of management of the plant is also a factor in utilization of space. In the more convenient plants, less space is wasted in passageways and in work space around machinery. A group of 22 creameries indicated as "inconvenient," after making allowance for difference in output, used 1.8 more square feet per 1000 pounds of butter than the group of 16 "convenient" creameries. This 1.8 square feet is 16.5 per cent of the average.

One important factor in floor space and cost is extra space for expansion of business. It was difficult to determine this, because what might be extra space is frequently used up by leaving more space around the equipment. Only when unused space was unoccupied was it counted. On this basis, 56 of the 88 creameries had extra space as indicated in Table XXV. This extra space makes the relation between output and floor space somewhat irregular.

TABLE XXV

EXTRA SPACE FOR EXPANSION, SQUARE FEET

Groups	No. in group	Average for group		Average cost	
		Per creamery	Per 1000 pounds butter	Per creamery	Per 1000 pounds butter
Sq. ft.					
Less than 100	16	68	0.33	$39	$0.19
100 to 200	19	151	0.19	98	0.32
200 to 300	12	255	1.34	108	0.57
300 to 400	5	358	1.96	192	1.05
400 to 500	..	...	...	...	...
Over 500	4	820	1.95	625	1.49
All creameries	56	216	0.88	$127	$0.52

Other factors affecting the utilization of space are seasonality of milk receipts, efficiency of labor and management, and proportion of butterfat received as milk and cream. The creameries receiving over 11 per cent more of their annual milk supply during their heaviest month than during their lightest month, after full allowance was made for difference in output, used on the average 5.5 more square feet per 1000 pounds of butter than the creameries receiving less than 8 per cent more of their milk supply in their heaviest than in their lightest month.

TABLE XXVI

VARIATION IN FLOOR SPACE PER THOUSAND POUNDS OUTPUT, SQUARE FEET

Groups	No. in group	Average of group	Output
Under 6	7	4.5	521,611
6 to 10	26	7.9	309,522
10 to 13	16	11.7	119,982
13 to 18	23	15.0	171,883
18 to 22	10	20.4	127,316
22 and over	9	29.9	89,850
All creameries	91	10.8	230,011

Because of the combination of all the foregoing factors, there is a wide range in the utilization of space. Table XXVI shows that even the ordinary range is from 6 to 22 square feet per 1000 pounds of output.

Creamery sites.—Table XXVII shows the size of the building sites occupied by 80 creameries classified as to whether located in cities, villages, or the country. In cities, an ordinary city lot is most commonly used; in villages, a half-acre; and in the country, a half-acre or an acre.

TABLE XXVII

SIZE OF LOT OCCUPIED BY 80 MINNESOTA CREAMERIES

Size of lots in fractions of acres	Number of creameries occupying lots of varying sizes in			
	Cities	Villages	Country	Totals
Three	..	2	..	2
Two	1	1	..	2
Between one and two	1	5	2	8
One	3	5	6	14
Between one and one half	1	7	1	9
One half	1	11	5	17
Between one half and one quarter	4	4	..	8
One quarter	6	4	..	10
Under one quarter	6	4	..	10

Building cost per square foot of floor space.—Table XXVIII shows that interest on investment is the largest expense connected with the creamery building, constituting 50.5 per cent of the total. The various expenses were computed as follows:

Interest.—Interest was computed at the prevailing rate on similar investments in the locality. The rates used were 6 per cent for 4 creameries and 7 per cent for 84 creameries. An attempt was made to value buildings on the basis of cost of construction at the time of the survey, less depreciation to that date. It was only partly successful. The average original cost of construction of the 88 creamery buildings was $7304. If they had been constructed in 1920, they probably would have cost $12,890. The depreciation on this basis would have been

$3530, making the 1920 valuation $9360. The depreciation on the original cost basis of $7304 would have been $2008, making the 1920 valuation $5296. The actual valuation obtained was $7400, which is almost exactly half-way between the two.[16] Interest was based on this $7400 valuation.

As will appear later, this was an unsatisfactory method of computing interest charges. Interest should have been based on the average value per year throughout the life of the building, in other words, one half of the present cost of reproduction. According to the method used, brick buildings, because only one-seventh depreciated, have a much higher interest charge in proportion to their present value than the frame buildings which are three-fourths depreciated.

Taxes.—The actual taxes paid were included. Income taxes should not properly have been charged to real estate, but it was impossible to make the separation in the annual reports of the creameries, and besides very few creameries paid income taxes.

TABLE XXVIII

DIVISION OF ANNUAL EXPENSES CONNECTED WITH 88 CREAMERY BUILDINGS

Items of expense	Average expense		Per cent of total building expenses
	Per creamery	Per 1000 pounds of butter	
Taxes	$113	$0.49	11.1
Insurance	32	0.13	3.0
Interest	515	2.21	50.5
Depreciation	263	1.13	25.9
Maintenance	97	0.42	9.5
All building expense	$1020	$4.38	100.0

Insurance.—The insurance was computed by using the rate per year. Most of the creameries of the state are insured in the Mutual Creamery and Cheese Factory Fire Insurance Company of Minnesota. The schedule of rates on policies in this association is as follows:

> Sec. 3. A premium of one per cent of the amount of insurance applied for shall be paid by the applicant on class A and B risks: 65 per cent of the A rate on class C risks and 50 of A rate on class D risks. The classification is as follows:
>
> Class A, wooden buildings equipped with steel stacks.
>
> Class B, wooden buildings equipped with brick stacks.
>
> Class C, buildings of stone, brick or concrete with wooden shingle roofs, equipped with brick or concrete chimney and stacks.
>
> Class D, buildings of stone, brick or concrete walls, the roofs of which are covered with fire proof material and equipped with brick or concrete chimney and stacks.

[16] This discrepancy may be simply because in periods of rising prices our notions of building costs are sure to lag; or it may include a considerable recognition of the obsolescence surely present.

In the levying of an assesssment the rate on class B shall be 80 per cent of the rate on class A and the rate on class D 50 per cent of the rate on class A.

Depreciation.—Annual depreciation was computed by dividing the 1920 valuation of the building by its estimated life. The estimated life of a building was based on general estimates for the various types of construction, modified to fit the particular condition of the different buildings at the time of the visit. The estimated life of the brick buildings was most commonly 50 years; of the ordinary frame structure, from 20 to 30 years, the range being 15 to 45 years, depending largely on the care received; of concrete buildings, from 30 to 50 years; and of hollow-tile creameries, 50 years. There were a few combination brick and frame structures. The average life of these buildings was 27 years. These estimates represented the combined judgment of creamery architects, creamery operators and officers, and the man making the survey.

Maintenance.—This includes the annual cost of labor, materials, etc., for repairs and renewals, such as painting and roofing. Labor is usually a larger item than materials.

The ordinary range in annual cost per square foot of the creamery building and site combined is indicated in Table XXIX. This cost is sixteen times as much per square foot, and eighteen times as much per creamery, for the 20 highest creameries as for the 10 lowest. The extreme range per creamery is from $80 to $3240, and per square foot, from 3 to 95 cents.

TABLE XXIX

RANGE IN ANNUAL SPACE COST

Groups	No. in group	Average for group			Annual space cost per creamery		
		Building	Site	Both	Building	Site	Both
Cents square foot		Cts. sq. ft.	Cts. sq. ft.	Cts. sq. ft.	Sq. ft.	Sq. ft.	Sq. ft.
Less than 10	2	4.8	0.0	4.8	$106	$00	$106
10 to 20	12	14.6	1.0	15.6	347	24	371
20 to 30	15	23.4	1.9	25.3	605	43	647
30 to 40	13	32.8	2.2	35.0	722	45	767
40 to 50	16	43.3	1.8	45.1	1115	56	1172
50 to 60	10	51.8	4.0	55.8	1262	96	1358
Over 60	20	70.3	5.8	76.1	1820	148	1968
All	88	40.7	2.9	43.6	$1020	$72	$1092

Part of the reason for this extreme range is difference in the cost of the creamery site. Table XXX shows the variation in site cost. The extreme range for purchased sites is from less than half a cent to ten cents per square foot of floor space. In addition, thirteen of the sites were either donated or leased for a nominal consideration. On the other hand, one creamery with an output of 106,000 pounds

paid $5000 for its site; and a creamery with an output of 482,000 paid $8000 for its site. Eleven sites cost $200 or over. Tables XXXI and XXXII show the relation of site cost to type of community in which located. Creameries with locations in cities usually keep site cost within reasonable bounds by building on either one or two lots.

TABLE XXX

VARIATION IN ANNUAL COST OF SITE

Groups	No. in group	Average for group	Average cost per 1000 pounds of butter
Cents per square foot		Cts. per sq. ft.	Cents
None	13	None	0.0
0 to 1	17	0.87	9.1
1 to 2	27	2.24	4.0
2 to 3	10	3.66	52.7
3 to 4	5	5.29	50.2
4 to 5	3	6.87	63.4
5 and over	7	10.96	120.1
All	82	2.88	30.9

The average annual site cost is $72 per creamery. It consists of $67 of interest plus $5 of taxes. The attempted basis of valuation was cost to purchase at land prices in 1920, but, as in the case of buildings, this was only partly accomplished. The average first cost of the sites, as given in Table XXXI, was $1193. The average valuation obtained was $1720. The interest rate applied ranges from 2 to 5 per cent, being 4 per cent in most cases. The average was 3.9 per cent. These rates represent the prevailing ratios, as nearly as can be estimated, between prevailing annual net incomes from land and valuations in 1920. The ratios between net incomes and values of farm lands in Minnesota in 1919, as derived from the 1920 census schedules by C. R. Chambers, of the United States Department of Agriculture, ranged mostly from 2 to 4. The ratios for land in cities and villages are usually around 4.

TABLE XXXI

FIRST COST OF SITE FOR MINNESOTA CREAMERIES

Location	First cost of site
Country	$227
Village (edge of)	623
Village (center of)	1447
City (edge of)	1612
City (center of)	2316
All creameries	$1193

The extreme range in annual building cost alone per square foot of floor space is from 3 to 90 cents, and the ordinary range is from 15 to 75 cents. The value of the building is of course the principal determiner of annual building costs; the other determinants are rate

of depreciation and cost of maintenance. The wide range in valuations can not escape producing a wide range in annual space costs. Two buildings were valued at $500 each, one at $35,000, and one at $29,110. This range is of course due to two things, high original cost, and small amount of total depreciation because of the newness of the buildings.

TABLE XXXII

FIRST COST PER ACRE OF SITES FOR MINNESOTA CREAMERIES

Location	Average cost per acre
Country	$710
Village or city (population)	
0 to 499	2340
500 to 999	2045
1000 to 1999	5809
2000 to 2999	6885
3000 to 3999	2564(2 only)
4000 and over	7142

Table XXXIII shows this relation in detail. The high construction cost of the brick and tile buildings and their newness gives a relatively high annual interest charge. Lower depreciation and maintenance costs offset only a little. The higher cost of construction largely offsets the longer life, so that depreciation is only 2.9 cents less per foot for brick than for frame buildings. The brick buildings in 1920 averaged only 7.1 years old, and the frame buildings 18 years old. The first effect of this is that the brick buildings were therefore built under a higher price level than the frame buildings. An attempt is made to correct for this in Table XXXIV. Figure 19 shows the changes in creamery building costs per square foot from 1897 to 1920. The figures are estimates based partly on actual creamery costs and partly on prices of building material and labor as published by the United States Bureau of Labor.[17] All were reduced to a 1914 price level basis, this being a better base year for such a comparison than 1920. The brick buildings, if all were built in 1914, would have cost $913 less, or 33 cents (11 per cent) less per square foot; and the frame buildings $582 more, or 29 cents (21 per cent) more per square foot. Making allowance for this, the interest and depreciation charges on brick buildings would be 31.4 cents per square foot instead of 35.3. And the interest charge and depreciation charge on frame buildings would be 19.3 cents per square foot instead of 16.4. The maintenance charge would be similarly affected, because it is largely proportional to first cost. Thus, annual space costs on brick buildings would be reduced probably to 43 cents; and on frame buildings, raised to about 32 cents.

[17] One of the principal difficulties connected with these data is the apparent improvement in the quality of the construction, especially of brick buildings, in recent years. This was corrected for, but inadequately.

TABLE XXXIII

RELATION OF DEPRECIATION, INTEREST, AND MAINTENANCE COSTS BY TYPE OF CONSTRUCTION

Type of construction	No. of creameries	Construction cost per square foot	Annual building cost per square foot	Percentage of annual building cost due to			Annual cost, per square foot		
				Depreciation	Interest	Maintenance	Depreciation	Interest	Maintenance
			Cents				Cents	Cents	Cents
Brick	50	$3.50	47.7	18.4	55.6	11.3	8.8	26.5	5.4
Frame	25	1.40	28.4	41.2	20.0	25.3	11.7	5.7	7.2
Brick and frame	5	2.47	34.8	31.3	37.4	19.5	10.9	13.0	6.8
Concrete	4	2.04	30.9	20.4	50.5	14.6	6.3	15.6	4.5
Tile	4	3.36	47.3	16.9	59.2	10.8	8.0	28.0	5.1
All creameries*	88	$2.84	40.7	23.6	47.7	14.5	9.6	19.4	5.9

* Averages weighted by size of buildings.

TABLE XXXIV

AGE, COST, AND TYPE OF CONSTRUCTION OF 88 CREAMERIES

Type of construction	No. of creameries	Average age of buildings	Average cost			
			Per creamery		Per square foot*	
			When built	If built in 1914	When built	If built in 1914†
Brick	50	7.1	$9825	$8908	$3.50	$3.17
Frame	25	18.0	2810	3392	1.40	1.69
Brick and frame..	5	12.4	5650	4058	2.47	2.68
Concrete	4	12.3	4573	6142	2.04	1.81
Tile	4	6.0	8625	7735	3.36	3.01
All	88	10.7	$7304	$7207	$2.88	$2.56

* Averages weighted by size of buildings.
† Adjustments made on basis of Figure 20.

The second effect is that according to the system of valuation used the interest charge on brick buildings is based on a value depreciated by only 7.1 years, or 14.2 per cent, whereas frame buildings are based on a value depreciated 18 years, or 72 per cent. If interest charges for brick buildings had been based on an average of 50 per cent depreciation from the values obtained in the survey, the average would have been $420 per creamery, or 15.0 cents per square foot. For frame buildings, the comparable figures would have been $243 per creamery, or 12.1 cents per square foot.

If these two effects are eliminated, the comparable figures for building costs would be as follows: brick, 31.5 cents per square foot; frame, 38.4 cents per square foot.

The maintenance costs given in Table XXXIII must not be accepted as at all accurate. There is reason for believing that they are all too high. It was difficult to secure good estimates as to most of the items of cost included.

It is probably true that brick buildings provide cheaper space than frame buildings, provided the brick creamery buildings do not become obsolescent long before they are worn out. As already pointed out, rapid changes are taking place in the whole organization of the creamery business, and no doubt many brick creamery buildings will go out of use long before the 50 years of estimated life is past.

Providing cheap space, however, is by no means the sole objective in planning a creamery—a fraction of a cent more due to the quality of the cream received or butter made would easily pay the additional cost.

TABLE XXXV

COST OF CONSTRUCTION BY TYPE OF BUILDING AND SIZE

Floor-space	No. of creameries	Cost of construction per square foot				
		Brick (50)*	Frame (25)	Concrete (4)	Tile (4)	Brick and frame (5)
Sq. ft.						
Less than 1500	6	....	$1.68	....	....	....
1500 to 2000	17	$2.89	1.41	$2.10	$2.87	$2.91
2000 to 2500	22	2.32	1.77	1.88	5.81	3.44
2500 to 3000	25	3.15	1.35	2.12	....	1.38
3000 to 3500	12	3.91	....	....	2.72	....
3500 to 4000	3	4.94	0.99	....	....	....
4000 to 4500	2	5.88	....	....	....	....
4500 and over	1	5.64	....	....	....	....
All creameries†	88	$3.50	$1.40	$2.04	$3.36	$2.47

* Number of buildings.

† Average weighted by size of buildings.

Table XXXV shows the interesting fact that apparently construction cost per square foot of brick buildings increases with the size of the building. Most of this is due to the fact that the larger buildings were erected more recently and are also of better construction. With frame buildings, the opposite tendency prevails.

Space costs (building and site), when reduced to an annual cost per square foot basis, show no correlation whatever with output, that is, they are the same for creameries with large output as for creameries with small output.

The ordinary range in construction costs per square foot of brick creameries, as given in Table XXXV, except for six expensive creameries recently built, is from $1.50 to $4 when the costs are all reduced to the 1914 price level; and the ordinary range in annual space cost from 25 to 51 cents per square foot.

TABLE XXXVI

VARIATIONS IN CONSTRUCTION COSTS OF BRICK CREAMERIES

Groups (construction cost when built)	No. in group	Average cost per square foot of construction		Annual space cost per square foot	
		When built	If built in 1914	When built	If built in 1914
				Cents	Cents
Less than $2	10	$1.42	$1.52	22	24
$2 to $3	9	2.56	2.73	44	45
3 to 4	14	3.57	3.34	46	43
4 to 5	11	4.41	3.70	63	51
5 to 6	..	....	....	..	..
6 to 7	3	6.48	4.18	78	49
Over 7	3	7.31	7.45	85	87
All creameries	50	$3.50	$3.17	48	43

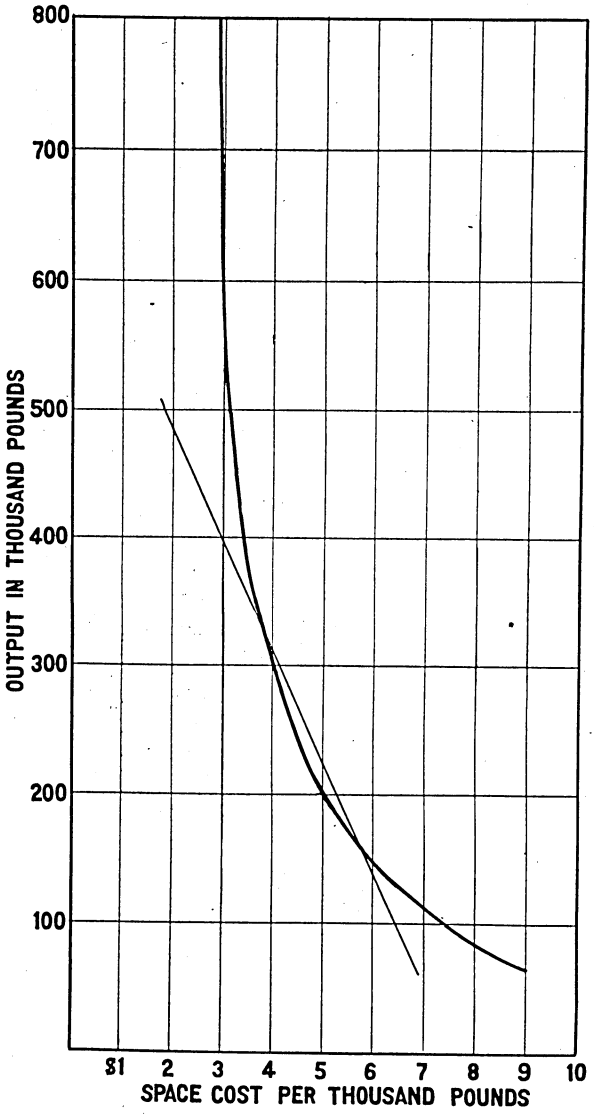

Fig. 20. Relation of Space Cost to Output

Most of the saving in space cost with larger output comes under 300,000 pounds.

TABLE XXXVII

VARIATIONS IN ANNUAL COST OF BUILDING SPACE PER 1000 POUNDS OF BUTTER

Group	No. in group	Average of group	Average per creamery
$1 to $2	14	$1.48	$503
2 to 3	17	2.75	462
3 to 4	14	3.50	908
4 to 5	9	4.63	1186
5 to 6	9	5.40	1437
6 to 7	5	6.68	1260
7 to 8	6	7.65	1795
8 to 9	4	8.49	1148
9 to 10	6	9.53	1491
10 and over	4	13.85	1878
All creameries	88	$4.38	$1020

Space cost per 1000 pounds butter.—While 15 creameries have building costs of less than $2 per 1000 pounds of butter, according to Table XXXVII, 4 have building costs over $10 per 1000 pounds of butter. The highest cost, $15.35 per 1000, is for a creamery with 3136 square feet of floor-space costing $18,000 to build, making only 131,000 pounds of butter in 1919. The lowest cost, $1.16 per 1000, is for a creamery with 2530 square feet of floor-space costing $8000, making 544,000 pounds of butter in 1919. The average for 88 creameries is $4.38 per 1000 pounds of butter.

TABLE XXXVIII

VARIATION IN ANNUAL SITE COST PER 1000 POUNDS OF BUTTER

Groups	No. in group	Average for group	Average output
Cents		Cents	Lbs.
None	13	None	243,000
0 to 10	13	6.1	291,000
10 to 20	17	12.5	273,000
20 to 30	16	24.6	196,000
30 to 50	14	40.2	211,000
50 to 60	5	67.0	191,000
60 and over	10	111.5	185,000
All	88	30.9	233,300

Site cost per 1000 pounds of output has an ordinary range, according to Table XXXVIII, between 10 and 15 cents per 1000. The highest site cost, $2.85 per 1000, is for a creamery making only 106,000 pounds of butter in 1919 which paid $5000 for its site. The next highest, $1.11 per 1000, is for a creamery making 110,000 pounds in 1919 which paid $2000 for its site. The next highest, 92 cents per 1000, is for a creamery making 482,000 pounds in 1919 which paid $8000 for its site. The average is 30.9 cents per 1000. This combined with $4.38 gives a total space cost of $4.68 per 1000.

The cost of "extra space" in creameries, according to Table XXV (see p. 17) is 52 cents per 1000 pounds. Thus it is a more important element of cost than site.

TABLE XXXIX

FIRST COST OF SITE PER 1000 POUNDS OF BUTTER

Groups	Number of creameries			
	City	Village	Country	All
Donated	..	2	4	6
Lease	2	2	2	6
Less than $2	2	11	4	17
$2 to $4	5	11	1	17
4 to 6	7	8	..	15
6 to 8	2	5	..	7
8 to 10	2	1	..	3
10 to 12	1	2	..	3
12 to 14	..	1	..	1
14 to 16	3	1	..	4
$16 and over	3	1	..	4
All creameries	27	45	11	83

Table XXXIX expresses first cost of site as a ratio to output in 1919. Four creameries paid for their site $16 or over for each 1000 pounds of output from their plant. The average is $5.05 for all creameries, $7.65 for creameries located in cities, $4.65 for creameries located in villages, and 80 cents for creameries located in the country. These figures may indicate when the purchase price of a site is out of proportion to the volume of business.

Space cost per 1000 pounds of butter varies principally with output and with its two components, namely, square feet per thousand, and annual cost per square foot, both of which have been analyzed above. Figure 20 shows how space cost per 1000 pounds of butter varies with output. On the average, each additional 100,000 pounds of output, taking the creameries as they are, that is, other things not being equal, means $1.14 less annual space cost (25.5 per cent) per 1000 pounds of output, as indicated by the straight line. From 100,000 to 300,000 pounds, however, the decrease is at the rate of $1.68 per 1000 for each 100,000 pounds, as indicated by the curved line. This curve for output and space cost represents a combination of the significant curve for utilization and output (Fig. 17), and the lack of correlation between cost per square foot and output mentioned on page 55.

Figure 21 shows how space cost per 1000 pounds of butter varies with annual cost per square foot and with square feet per 1000 pounds output, with building values and interest based as in this analysis. If space cost per 1000 pounds were exactly proportional to cost per square foot, 10 cents additional cost per square foot would mean $1.08 additional space cost per 1000 pounds of output ($0.10×10.84=$1.084).

Figure 21 shows, that the actual average increase is $1.30. For creameries with space costs over 50 per cent above the average, however, the space cost per pound of butter increases much more slowly (see accompanying curved line). If space cost per 1000 pounds were proportional to the number of square feet per 1000 pounds, then one additional square foot per 1000 pounds would mean an increase in cost of 4.36 cents per 1000 pounds of butter ($4.36 \times 1 = 4.36$). Figure 21 shows that the actual increase is only 2.83 cents. The reason for this is that the poorest utilization of space (most square feet per 1000 pounds) usually occurs in creameries where cost per square foot is lowest.[18] The accompanying curved line shows that the increase in space cost with square feet per 1000 was at first more rapid than the average and then less rapid. Taking creameries as they are, cost per square foot is obviously having more effect than utilization of space on the unit space costs of a creamery.

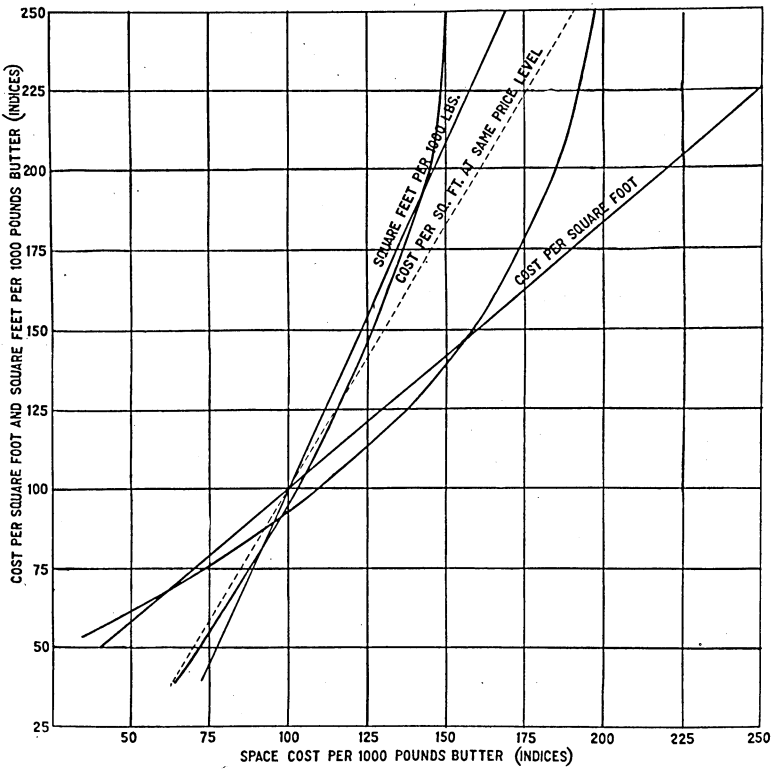

Fig. 21. Relation of Space Cost to Output

Annual cost per square foot affects space cost more than the utilization of space; but this would be much less true if all valuations and interest charges were on the same basis. The curved lines express the relationships in more detail than the straight or average lines.

[18] Inverse correlation.

When this analysis is made for brick and frame creameries separately, it appears that cost per square foot affects space cost 35 per cent more for frame creameries than for brick creameries. This is because there is a wider range in value of frame buildings. On the other hand, utilization of space affects space costs 140 per cent more for brick buildings than for frame buildings. This is because the frame buildings are old and are likely to be used to capacity, whereas many of the new brick buildings were built much larger than present receipts warrant.

As above explained, the method used of valuing buildings and charging interest is subject to serious criticism for the purposes in question. Those in charge of creamery organizations are interested in what space costs will be and how they will be affected by building costs at the prevailing price level, not at the price level which happened to prevail when the building was constructed. They are interested in the interest cost over the whole period of use of the building, and not in the interest on only that portion of the building which is not yet worn out. Handling valuations and interest in this way also destroys a large part of the correlation that should exist between output, cost, and the other factors. Were this study to be repeated, therefore, all values would be reduced to a common basis and interest would be based on a 50 per cent depreciation. The attempt to do this subsequently as part of the analysis has been only partly successful. The dotted straight line in Figure 21 shows costs per square foot on this basis increasing space costs per thousand at the rate of 65 cents for each 10 cents additional cost per square foot, in place of $1.30 on the first-cost basis. Most of the pronounced effect of cost per square foot is therefore due to the method of handling valuations and interest.

EQUIPMENT COST

Under equipment was included the boiler and engine, churns, vats, starter cans, Babcock testers, office desks, typewriters, and all major articles. Such items as thermometers, brushes, and pails were charged as materials under supplies and miscellaneous. Table XL shows that the total annual cost of equipment of 88 creameries in 1919 averaged $929, or leaving out sidelines and hauling, $886. Only 6 do hauling, and only 15 have important sideline equipment. The equipment for preparation for churning and that for churning have the highest annual cost. Equipment costs will be analyzed in more detail under process costs.

Table XLI shows that depreciation, maintenance, and interest costs are about equal and make up 92.6 per cent of the total.

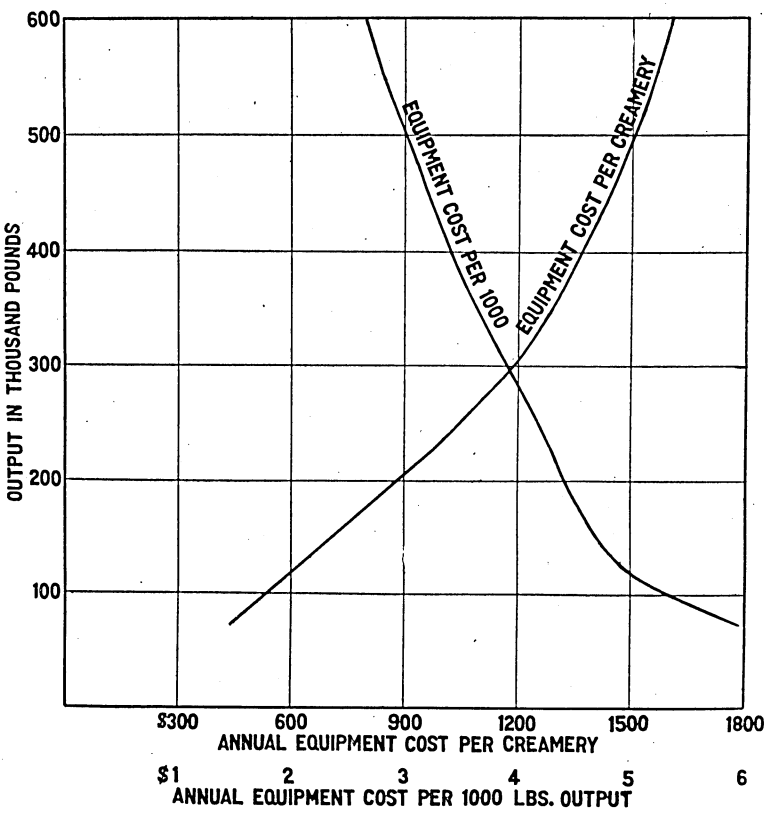

Fig. 22. Relation of Equipment Cost to Output

Equipment costs per thousand decrease rapidly up to the point of full utilization of minimum-sized equipment, and less rapidly from then on.

Interest and depreciation were determined on the same basis as for buildings. The valuations, as near as can be determined, average about half way between cost when purchased and cost in 1920 less depreciation to date. The equipment averaged 30 per cent worn out at the time of the survey. The average value for equipment per creamery was $4050. The cost of equipment new in 1920 was estimated at $5800. This depreciated 30 per cent would make a total depreciation of $1750, or $407 per year. The actual cost of the equipment new in 1920 would probably have been between $6000 and $7000. The interest rate was practically the same as for buildings, 7 per cent in most cases. The estimates of life of equipment were made by the creamery operator, in the first instance, but were verified when possible from other sources, such as creamery supply houses. The average for all equipment combined was 14.4 years. All important renewals were analyzed separately from general depreciation wherever possible. Labor and materials are the principal items in maintenance cost.

Taxes and insurance were handled as for buildings.

Table XL shows the equipment costs directly charged to the different processes. Power, water, and cold storage are of course later redistributed to the remaining processes. Preparation for churning and churning are the two largest items in equipment cost.

TABLE XL

DISTRIBUTION OF EQUIPMENT COSTS BY PROCESSES

Process	Average equipment cost per creamery	Per cent of total equipment cost
Receiving	$54	5.7
Babcock testing	15	1.6
Preparation for churning	271	29.2
Churning	167	18.0
Record keeping and correspondence	49	5.2
Preparation for marketing	39	4.2
Cold storage	114	12.3
Power	135	14.5
Water	20	2.2
General maintenance	9	1.0
Skimmilk and buttermilk disposal	13	1.4
Hauling	25	2.7
Sidelines	18	2.0
All processes	929	100.0

TABLE XLI

ELEMENTS OF EQUIPMENT COST (EXCLUDING SIDELINES AND HAULING)

Items of expense	Average expense		Per cent of total equipment expense
	For creamery	Per 1000 pounds of butter	
Interest	$267	$1.15	30.1
Taxes	49	0.21	5.5
Insurance	17	0.07	2.0
Depreciation	407	1.75	45.9
Maintenance	146	0.63	16.5
All equipment expense	$886	$3.81	100.0

Range in equipment costs.—The range in annual equipment costs is from $300 to $2100. Eight creameries have equipment costs over $1500, twenty-six over $1000, and fifteen under $500. The range per 1000 pounds of butter was from $1.38 to $9.63, ten having costs under $3 per 1000, and eight over $6 per 1000. The average annual cost of equipment per 1000 pounds of output was $3.98; or, excluding hauling and sidelines, $3.81.

The analysis of reasons for variations in equipment cost should follow the same lines as that for building cost. The variations can be said to be due to variations in the annual cost of the equipment and in the utilization of the equipment. Reduced to more definite

terms, the annual cost, let us say, of churning equipment is equal to the product of annual cost per 100 pounds of churn capacity times the output of the creamery for each 100 pounds of churn capacity. The following analysis of churn equipment is introduced merely as an example of the form of analysis. If equipment costs are to be analyzed thoroly, a study must be made for each item of equipment separately, as the various items of equipment have no common unit of size. Just as labor has been measured in hours and space in square feet, so churns must be measured in one way, Babcock testers in another, and ripeners in another. The only possible common unit of measurement is value or cost; and using this unit covers up exactly what one wishes to show.

TABLE XLII

VARIATIONS IN CHURN CAPACITY

Capacities	No. of creameries	Butter output, in 1000's	
		Average	Range
Lbs.		Lbs.	Lbs.
One churn			
500	1	69	69
600	2	95	95
700	3	71	41 to 96
800	8	145	44 to 256
900	8	113	75 to 134
1000	28	171	59 to 245
1200	1	554	554
Two churns			
1400	3	144	140 to 148
1500	5	199	190 to 215
1600	2	325	207 to 433
1700	9	217	135 to 293
1900	2	338	307 to 361
2000	12	453	347 to 886

Table XLII shows that churn capacity and output are very poorly matched in the various creameries. For example, one creamery with an output of 59,000 is using a 1000-pound churn; and another with an output of 256,000 is using only an 800-pound churn. A 1200-pound churn is turning out 554,000 pounds, and a 1700-pound churn capacity, only 135,000 pounds. These misfits are due to various causes, chief of which are the following: extra capacity provided for expansion which has not yet come; extra heavy peak-load requirements in May and June, with low receipts in the fall and winter. Or sometimes where two churns are used one is old and used only at peak-load periods. The creameries with relatively small churn capacity get along by churning every day and sometimes two or even three times a day during flush periods. Those at the other extreme churn every other day in the winter, or even less often, and must run their churns under

capacity much of the time. Table XLIII shows that the outputs of the 91 creameries represent an average of only 167 full churn loadings. The extreme range is from 55 to 453, and 4 have an average of only 70 full churn loads.

TABLE XLIII

VARIATIONS IN NUMBER OF FULL CHURN LOADINGS WITH OUTPUT*

Groups (output)	Number in group	Average for group
Lbs.		Lbs.
Under 100	11	69
100 to 150	20	128
150 to 200	18	170
200 to 300	25	238
Over 300	17	385
All	91	167

* Assuming that cream could be held until the churn could be filled each time.

Table XLIV shows how churn capacity increases with output in the 91 creameries used in this particular analysis. The average churn capacity of the 91 creameries is 1240 pounds, or 5.3 pounds for each 1000 pounds of annual output. The extreme range is from 2.0 pounds per 1000 for a creamery with 491,000 pounds of output with a 1000-pound churn, to 18.2 pounds for a creamery with 44,000 pounds of output and an 800-pound churn. Fifteen of the 91 have less than 5 pounds, and 8 have more than 10 pounds, per 1000 pounds of output. Under 200,000 pounds of output, the decrease in churn capacity per 1000 pounds of output is rapid, but above this point it is much slower. This is because a 1000-pound churn can handle 200,000 pounds of output in most cases, but it can not conveniently handle much more. Only 7 creameries under 200,000 pounds have more than 1000 pounds capacity, and only 10 over 200,000 pounds are getting along with 1000 pounds capacity.

TABLE XLIV

VARIATIONS WITH OUTPUT IN CHURN CAPACITY PER 1000 POUNDS OUTPUT

Groups (output)	No. in group	Average output	Average capacity	Capacity per 1000 pounds output
Lbs.		Lbs.	Lbs.	Lbs.
Under 100	11	72,800	780	10.7
100 to 150	20	128,900	1060	8.2
150 to 200	18	184,500	1090	5.9
200 to 300	25	240,000	1230	5.1
300 and over	17	480,000	1800	3.7
All	91	233,000	1240	5.3

The other factor in churn equipment cost is the annual cost per unit of churn capacity. The principal factor in this is the first cost of the churn. The oldest churn in use at the time of the survey was

bought in 1910, and 8 were installed in 1912. Between 1912 and 1920, the price of churns doubled. The valuation given at the time of the survey was based partly on these varying prices depreciated to date. Interest and depreciation changes are based on these valuations. This results in a wide range in annual costs per unit of capacity.

The rate of depreciation is also a factor in the cost. The average time since the purchase of all the churns was 4.4 years. The average estimated life was 8.6 years. These estimates check closely, for over a period of time and in an industry which is in a stable condition, the estimated life should be twice the average age of the churns now in use. The range in estimated life was from 5 to 12 years, 7, 8, and 10 years being named most frequently. No correlation was discovered between estimated life and output per churn capacity. The variations seem to be due mostly to differences in upkeep and in the judgment of the operators as to the probable life of the churn. The extreme range in churn cost was from $9 per 100 pounds churn capacity for a 1000-pound churn bought in 1913, with an estimated life of twelve years, to $34 per 100 pounds capacity for an 800-pound churn bought in 1919, with an estimated life of five years. The average was $21 per 100 pounds capacity.

Reduced to the basis of annual cost, the ordinary range is from 60 cents to $2 per 1000 pounds of output. The highest cost, $3.10, is for a creamery making 75,000 pounds of butter in 1919 which bought a 900-pound churn that year. The average was $1.08 per 1000.

A change from 5.3 pounds of churn capacity per 1000 pounds of output, the average, either upward or downward one pound would, taking other circumstances as they are, have increased or decreased churn equipment costs by 25 cents per 1000. A change in cost per 100 pounds of churn capacity from $21, the average, either upward or downward by $1, would, other things being as they are, have increased or decreased churn equipment costs 20 cents per 1000. This means that variations in cost of the churn were three times as responsible for the differences in churn equipment costs as the differences in utilization of the churn. This is because of the wide range in valuations due to the wide variations in price paid for churns from 1912 to 1920. In normal times, the various makes of churns sell at about the same price; hence any differences would be due to differences in rate of depreciation and upkeep, or in cost per unit of capacity with different sized churns. Utilization would therefore be relatively much more significant in normal times, or if the churns had been valued on a common basis.

On an output basis, the range in churn cost is from $1.75 per 1000 for the smallest 10 creameries to 75 cents for the largest 10 creameries.

The decrease in cost is at a rate increasing somewhat rapidly below 250,000 pounds of output.

If a similar analysis were made for each item of equipment, similar results would be obtained. In each case, it would be discovered that utilization varied, and in consequence, the resulting equipment cost; and likewise the annual cost per unit of capacity would vary, depending, however, owing to the method of valuation used, largely upon prices paid at different price levels, and also upon rate of depreciation, upkeep cost, etc. The range in utilization varies, of course, with different items of equipment. In general the smaller the unit and the sooner it wears out, the better the utilization, as this makes it possible to fit sizes better to volume of business.

Figure 22 shows variations with output of annual equipment cost per creamery and per 1000 pounds of butter. At 500,000 pounds output, the equipment cost is $3 per thousand, or $1500 per creamery; at 200,000 pounds output, it is $4.40 per thousand, or $880 per creamery. The savings in equipment cost with output are considerable, but not so much as for labor and management or for buildings and space. This is because much of the equipment is in small units, making possible a better adjustment of capacities.

According to the valuations obtained in the survey, the value of equipment in 1920 was $4050 per creamery, as compared with $7400 for buildings. This equipment represented 35.4 per cent of the value of plant and equipment. If each had been depreciated to the same extent, however, say 30 per cent, the figure would have been 36.1 instead of 35.4. It is 4 per cent higher for brick buildings than for frame buildings. These figures are merely averages, of course, and do not fit any particular plant at any time. The figure 36.1 per cent given above ought not to be very far from the average ratio between investment in buildings and equipment at any equal stage in depreciation. In a new creamery, however, the equipment will depreciate more rapidly than the plant (3.5 times as fast as for brick buildings) so that the ratio of value of equipment to value of buildings will constantly decline till the equipment begins to be replaced.

SUPPLIES AND MISCELLANEOUS CASH EXPENSES

As already explained, this is the largest classification of expense items in 1919, constituting 45 per cent of the total expenses of a creamery. Table XLV lists the most important items in their relative importance. The relative importance of these items will of course change as prices change.

TABLE XLV

ITEMS INCLUDED UNDER SUPPLIES AND MISCELLANEOUS CASH OUTLAYS

Items	Average cost per creamery 1919	Per cent of total cost
Tubs and boxes	$1875	43.9
Fuel and electric power	755	17.7
Drayage	190	4.5
Liners and circles	180	4.2
Salt	135	3.2
Stationery	80	1.9
Color	60	1.4
Paraffin	50	1.2
Washing powder	40	0.9
Acid	35	0.8
Oil	35	0.8
Tub tins	25	0.6
Light	20	0.5
Miscellaneous	787	18.4
Total	$4267	100.0

Included in miscellaneous are such items as the following: ice, water, ammonia, starter culture, wrappers, repairs, glassware, brushes, thermometers, cotton waste, boiler compound, telephone, printing, advertising, and membership fees in creamery organizations. Ice is the largest expense in this miscellaneous group, and was not listed separately because many of the creameries have ice machines. Similarly, many of the creameries supply their own water. Starter culture averaged $20 for those creameries using it. Wrappers are used in greatly varying proportions by different creameries. The average was $60 for those using an appreciable quantity of them.

The range in costs for this group of expenses is from $12 to $34 per 1000; but all except a few of the costs come between $14 and $26 per 1000 pounds. The average is $18. It will be realized that this figure is somewhat higher than now prevails because the costs of most supplies have fallen considerably. There is also a considerable margin of error in these figures due to the difficulty of getting accurate estimates of opening and closing inventories for the various supply accounts.

The principal reason for the variations in supplies and miscellaneous is in the fuel and electric power cost, which shows a considerable range between creameries according to output and as to whether steam or electric power is used; also according to the type of fuel used. The expense for tubs, boxes, wrappers, etc., also varies somewhat according to the method of packing the butter. The drayage cost varies according to the distance from the shipping point. The prices at which supplies were purchased varied somewhat also. On the whole, the large creameries seem to have bought most cheaply.

Figure 23 shows the variation in cost of supplies and miscellaneous with output. Above 150,000 pounds of output, the increase is noticeably less rapid. Economies in the use of fuel and buying of supplies probably account for this. Such expenses as tubs, wrappers, salt, color, and the like, making up 57.2 per cent of the total, except for economies in buying, must increase in proportion to output. The curve in Figure 23 therefore represents a combination of expenses both proportional and less than proportional to output.

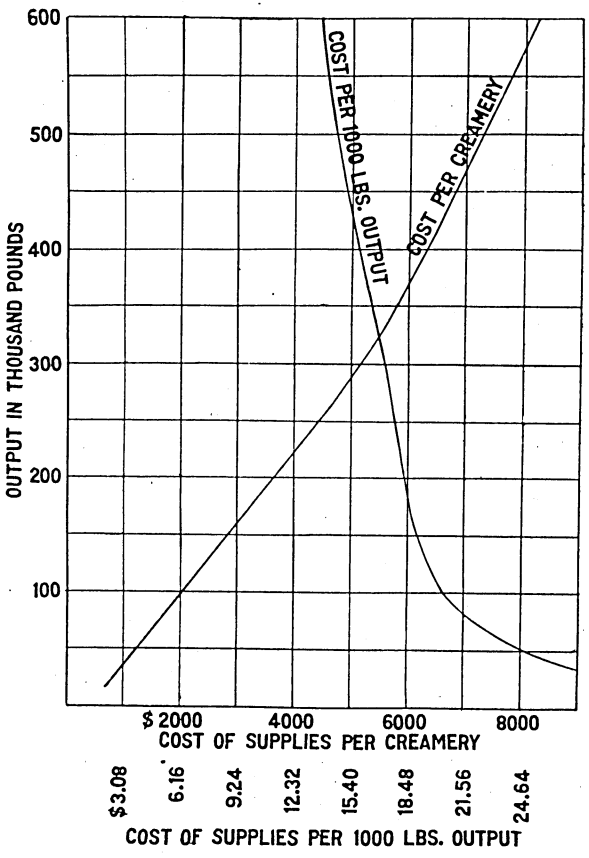

Fig. 23. Relation of Cost of Supplies to Output

Most of the decrease in cost of supplies with output is to be attributed to fuel and ice. Apparently creameries under 100,000 are wasteful of both. All of the rest of supplies are nearly proportional to output.

The direct distribution of supplies and miscellaneous cost is indicated in Table XLVI. The charge to power account was of course later redistributed to testing and other final processes; and the same for water, general maintenance, cleaning, and miscellaneous.

Following is a list of the supplies and miscellaneous items and the accounts to which they are charged:

Testing	Acid, glassware
Preparation for churn	Starter culture, milk powder
Churning	Color, salt, about one third of charge to hauling supplies
Power	Fuel, electric power, hauling fuel, oil, cotton waste, boiler compound
Cold storage	Ice, ammonia, calcium chloride
Preparation for market	Tubs and packages, liners and circles, wrappers, tub tins, paraffin, freight and drayage, about two thirds of hauling supplies.
General maintenance	Labor on repairs, thermometers, etc.
Cleaning	Washing powder, brushes
Water	Water
Heat and light	Heat and light
Miscellaneous	Sidelines; special repairs charged directly to space or equipment, etc.

TABLE XLVI

DISTRIBUTION OF SUPPLIES AND MISCELLANEOUS COST

	Average per creamery	Per cent of total
Testing	$46	1.1
Preparation for churn	20	0.5
Churning	202	4.7
Power	700	16.4
Cold storage	151	3.5
Preparation for market	2410	56.4
General maintenance	200	4.7
Cleaning	42	1.0
Water	47	1.1
Record keeping, correspondence	122	2.9
Sidelines	26	0.6
Miscellaneous	301	7.1
Total	$4267	100.0

INTERMEDIATE COSTS

Some of the basic costs of making butter and preparing it for market pass directly into the product; others pass through an intermediate stage—thus some of the supplies and labor are first converted into power and thence to the final processes. Cold storage and water represent similar intermediate stages. Cleaning, altho somewhat different, has been put in the same general class.

POWER

Table XLVII shows that supplies represent more than half the cost of power, and that space is the next most important item. In supplies are included fuel, electric power, oil, cotton waste, boiler compound, and a certain part of the freight and drayage cost.

TABLE XLVII

ELEMENTS OF POWER COST

Elements of cost	Cost per creamery	
	Amount	Per cent of total
Equipment	$135	11.5
Taxes	$7	0.6
Insurance	3	0.3
Interest	46	3.9
Depreciation	40	3.4
Maintenance	39	3.3
Supplies	700	9.4
Labor	176	64.9
Total without space	$1011	85.8
Space	168	14.2
Total with space	$1179	100.0

Power cost varies because different creameries use it for different purposes. Bulletin 747 of the United States Department of Agriculture gives the distribution of heat energy in an ordinary all-steam plant making 500,000 pounds of butter and using only natural ice for refrigeration.[19] According to this bulletin, 85.3 per cent of the total heat units in the fuel are lost in the boiler room in raising steam, in the chimney to maintain draft, through the grates, etc. Thus only 14.7 per cent are delivered to the engine room.[20] Of this 14.7 per cent delivered to the engine room, the engine, as indicated in Table XLVIII, in creameries pasteurizing the cream, uses 68.6 per cent; and 31.4 per cent is used as live steam for pasteurizing, heating wash water, etc. Of the 68.6 per cent used by the engine, only 6.8 per cent is converted into useful belt work, all the rest being lost in exhaust steam, engine friction, and transmission. In creameries not pasteurizing, only 13.3 per cent of the heat units reach the engine room, and 77.0 per cent of these 13.3 per cent are used by the engine, and 23.0 per cent as live steam.

In Table XLIX, an attempt has been made to apply these data to the 88 creameries covered in the survey; and also to distribute the power cost to the different processes using power. In the first place, 48 of the 88 creameries use electric power in place of engine power, and in the second place, 15 of the partly electric plants and 4 of the all-steam plants have ice machines. They vary also in their practices as to pasteurizing, separating, pumping water, etc. On the basis of the data in Table XLVIII, and other data obtained from manufacturers as to power requirements of ice machines, a power distribution was

[19] "The Economical Use of Fuel in Milk Plants and Creameries." John T. Bowen, Technologist, Dairy Division, pp. 42-44, Table 7. 1919.

[20] In the creamery studied by Bowen, the figure was 15.4 per cent; but this included a considerable amount of separating and heating separator milk.

worked out for each plant separately, according to whether or not it used electricity for power purposes, whether or not it pasteurized, etc. In Table XLIX these individual distributions are combined into two groups on the basis of cost. In the 48 creameries using electric power, the belt power, all furnished by electric motors, represents an average of 72.5 per cent of the total power cost. In the all-steam plants, the belt-power used represents 70.5 per cent of the total power cost. More of the partly electric plants have ice machines. For the 15 partly electric creameries having ice machines, the belt power represents 78 per cent of the total power cost. For the 4 all-steam plants having ice machines, the belt power represents 76 per cent of the total power cost. These 19 creameries all pasteurize their cream.

TABLE XLVIII

UTILIZATION OF HEAT ENERGY IN AN ORDINARY CREAMERY OF 500,000 POUNDS OUTPUT*

	Per cent distribution to different uses for creameries			
	Pasteurizing		Not pasteurizing	
Belt-power use	68.6		77.0	
Consumed in engine as useful work		6.8		7.6
Lost in exhaust steam		61.3		68.9
Lost in engine friction, radiation and transmission from engine to machinery		0.5		0.5
Live-steam use	31.4		23.0	
Heating wash water		12.3		13.8
Heating starter milk		1.4		1.5
Steaming and drying cans		6.8		7.7
Pasteurizing cream		10.9		0.0
Total	100.0		100.0	

*No ice machines included.

One chance for error in this distribution is that the data by Bowen may not fit the 88 creameries, either because they are smaller or because the operators of these 88 creameries did not exercise the same relative degree of care in the utilization of power and of live steam in the engine room, as did the operators in the plant studied. Variations in losses in the boiler room obviously do not affect the percentage distribution of what is delivered to the engine room. The total cost figures, as will be seen from Table XLVII, likewise are not affected by this possible error. The only questions are whether the smaller creameries use a larger proportion as belt power or as live steam of the power delivered to the engine room than did the 500,000-pound creamery studied by Bowen, and whether they waste a larger proportion of power in their engine or their live-steam uses. The chances are that the variations among creameries in both these particulars will largely cancel each other, and that the average distribution will not be greatly biased in either direction from the distribution in Table L.

The distribution of belt power to the different processes was made on the basis of the rated horsepower requirements of the machines, running at normal input. There are two errors involved in this, one that the power requirements of machines are frequently inaccurately stated by manufacturers, and the other that the machines frequently ran under normal input. If, however, there were the same degree of error in both these respects for the different machines, the accuracy of the distribution would not be affected. It is probable that the distribution for individual creameries is considerably in error, and that these errors only partly cancel out in the group averages.

The distribution to the different live-steam uses is based on the percentages in Bowen's tables, as given in Table XLVIII. Here again it is probable that only part of the error cancels out.

If a careful study of distribution of power costs were being made, actual tests would be made of the power required to drive the different machines at prevailing loads; and live-steam utilization would be similarly measured. The following analysis, however, does not purport to furnish accurate data. It is included, not to furnish facts as to power distribution and power cost, but to show the method which should be followed in such analysis. Table XLIX must be so interpreted. The analysis has been made as accurate as possible, however, the better to show the type of results to expect from a detailed study of accurate original data. A few important conclusions can be drawn from the data in their present more or less hypothetical form, especially after certain errors have been partly corrected by statistical methods.

Utilization.—Power cost per pound of butter is the product of horsepower-hours per pound of butter multiplied by cost per horsepower-hour. The first of these is the measure of utilization. The horsepower-hours for belt power were obtained by multiplying the horsepower required to operate each machine when running at normal input by its number of operating hours per year. This undoubtedly gives a figure which is too high.[21] Live-steam use was converted to a horsepower basis by treating it as a percentage of belt-power use.

The ordinary range in horsepower-hours, calculated in this rough way, was from 2500 to 8000, only two using less than this, and only 14 more. Nearly half of them used between 4000 and 6000 horsepower-hours. Three of the largest creameries used over 15,000 horsepower-hours. The average for the all-steam creameries was 5042, and for the partly electric, 7100. The average output of the 19 creameries

[21] The error involved in this, as explained above, is that different creameries did not run their equipment equally near to capacity; and power ratings of machines are inaccurate. These errors could not be avoided within the limits of the present study. Note, however, that the error is partly eliminated in one part of the analysis at the end of this section.

having ice machines was 317,000 pounds as compared with 217,000 for the others. The average size of the 23 creameries not pasteurizing was 202,000 as compared with 244,000 for those pasteurizing.

TABLE XLIX

DISTRIBUTION OF POWER COST TO DIFFERENT PROCESSES IN ALL-STEAM AND PARTLY ELECTRIC PLANTS*

	All-steam		Partly electric	
	Cost	Per cent of total	Cost	Per cent of total
Belt power	$725	70.4	$932	72.1
Babcock testing	$3	0.3	$5	0.4
Perparation for churn	218	21.1	229	17.7
Churning	442	43.0	523	40.4
Cold storage	62†	6.0	175‡	13.6
Live steam	304	29.6	361	27.9
Water	66	6.5	87	6.7
Preparation for churn	69	6.7	97	7.5
Receiving	60	5.8	62	4.8
Cleaning	109	10.6	113	8.7
Sidelines	...	...	2	0.2
Total	$1029	100.0	$1293	100.0

* All-steam plants averaging 196,000 pounds output. Partly electric plants averaging 263,000 pounds output.

† Average for 4 which have ice machines is $635.

‡ Average for 15 which have ice machines is $588.

Table L shows how, following the above method of calculating, output affects power requirements. The average creamery in the survey making 233,000 pounds of butter used 6160 horsepower-hours, and each 100,000 above this adds 1400 horsepower-hours to the requirements; and each 100,000 under the average subtracts 2000 horsepower-hours. A principal element in this, however, is the fact that the larger creameries nearly always pasteurize and nearly always have ice machines.

TABLE L

RELATION OF OUTPUT TO POWER UTILIZATION, AVERAGE FOR ALL COMBINATIONS

Output	Horsepower-hours all uses	Horsepower-hours per 1000 pounds butter*
100,000	3400	34.0
200,000	5000	25.0
300,000	6600	22.0
400,000	8150	20.7
500,000	9640	19.3
700,000	12640	18.1
Average†	6160	26.4

* It is quite probable that creameries of different outputs do not run their machines equally near to normal output, which introduces an error into this comparison. As explained in the text, the figures are also probably all too high.

† 233,000 pounds.

Table LI gives the horsepower-hour requirements of the three principal groups of creameries on the basis of power requirements. Not only do the creameries pasteurizing and using ice machines use more power, but the increase is more rapid with output. The figures in this table are only roughly accurate.

The extra power required by creameries doing some separating was not enough to show distinctly.

According to the method of calculating, the all-steam plants used 26 horsepower-hours per 1000 pounds of butter, and the electric plants 27. This difference is far within the margin of error, so that no value must be assigned to it. Accurate data could very easily reverse the figures and more. The ordinary range was from 15 to 40; but this range would have been much less if actual horsepower in place of rated horsepower at normal input could have been used. One of the lowest figures is for a plant making 450,000 pounds of butter and using 6000 horsepower-hours; one of the highest is for a creamery making 61,000 pounds and using 4000 horsepower-hours.

TABLE LI

RELATION OF OUTPUT TO POWER UTILIZATION FOR DIFFERENT COMBINATIONS

Combinations	No. of creameries	Output	Horsepower-hours per 1000 pounds output*	Additional horsepower-hours per 100,000 pounds additional output*
		Lbs.		
Ice machines and pasteurizing.....	16	324,000	35	1750
No ice machines and pasteurizing	45	196,000	26	1600
No ice machines and no pasteurizing..	22	235,000	18	1060
All combinations.....	83	233,000	26	1560

* These figures are all probably too high, as explained in the text. Also the comparison is only a rough approximation to the truth.

There were also variations due to the fact that churns and other equipment were used at different degrees of capacity or normal input in different creameries of the same or nearly the same capacity, but the method used in the survey did not permit analyzing these.

Cost per horsepower-hour.—Cost per horsepower-hour varies with the cost of the material, labor, equipment, and space entering into it, and with the utilization of these. The data on costs of material are very unsatisfactory, partly because prices are constantly changing, and partly because estimates of opening and closing inventories were untrustworthy in many cases.

Materials.—Table LII shows the amount of coal consumed in producing a horsepower-hour in all-steam plants with different outputs. About half the decrease in coal required per 1000 pounds of output is due to the decrease in horsepower-hours and half to the decrease

in coal per horsepower-hour. Partly electric plants, as nearly as can be determined by the roughly approximate data available, use not quite one-third less coal per horsepower-hour. This seems like a small saving in view of the fact that the power provided by electricity averages 72.5 per cent of the total. However, Table LIII shows that the electrically equipped creameries have boilers 64 per cent as large per 1000 pounds of output as the steam plants. These boilers are fired every day to furnish the live steam needed. Bowen, in Bulletin 747 of the United States Department of Agriculture, states that 30 per cent of the heat units of coal is lost in raising steam,[22] and a considerable part of the remaining 55 per cent lost in chimneys to maintain draft, radiation and the like, is lost in electric plants as in steam plants.

TABLE LII

RELATION OF OUTPUT TO UTILIZATION OF COAL—ALL-STEAM PLANTS

Output	Coal	Coal per horsepower-hour	Coal per 1000 pounds of butter
Lbs.	Tons	Lbs.	Lbs.
100,000	64	37.6	1280
200,000	92	36.8	920
300,000	108	32.7	720
500,000	131	27.2	520
700,000	150	23.7	430
Average*	91	36.0	930

* Average 196,000 pounds for 40 all-steam plants. Plants using wood are not included.

The cost of electric power for the 48 creameries averaged 3.9 cents per horsepower-hour as computed, or $1.01 per 1000 pounds of butter. This took the place of about one-third of the coal and wood. The coal and wood cost of the all-steam plants, including freight and hauling, averaged 11.1 cents per horsepower-hour as computed, or $2.99 per 1000 of output. The cost of the electric power, if the figures given are correct, is practically equal to the one-third saving in fuel used. The cost of other materials—oil, cotton-waste, and the like—averages 18 cents per thousand. As fuel makes up 94 per cent of the cost of materials, the variations in cost of materials with output is practically as indicated in the last column of Table LII, for both the steam and the electric plants. The average cost of power materials was 11.4 cents per horsepower-hour, and $3 per thousand of output; it was $3.17 per thousand for steam plants averaging 196,000 output, and $2.89 for electric plants averaging 263,000 output.

Equipment.—The boilers were estimated to have an average life of 17 years, the engines 20 years, and the motors 10 years. The estimates were varied according to the use and present condition of the

[22] Bowen, "The Economic Use of Fuel in Milk Plants and Creameries," p. 43.

equipment. The upkeep of the boilers was estimated at $10; of the engines, $2, and of the motors, $2. The equipment cost averaged 57 cents per thousand. It is 5 cents more per thousand for electric plants than for others in spite of their larger output, partly because of the engines and boiler capacity kept in reserve, as indicated in Table LV, and partly because the electric plants were newer and were built at higher price levels. No doubt in some cases this steam equipment was originally installed to furnish all the power for the creamery, and would not be installed in a new plant.

Labor.—The labor cost is 84 cents per thousand for the steam plants, and 67 cents for the electric plants. This is partly because less time is spent in firing; and partly because of difference in output.

Space.—Figure 19 shows how boiler-room space varies with output. Space for power equipment averages 2.05 square feet per thousand in steam plants, and only 1.78 square feet per thousand in electric plants; but it is higher-priced space, because located in better and newer buildings, so that the cost is 81 cents per thousand for steam plants and 84 cents for electric plants.

Steam vs. electric power.—The total power cost of steam plants was 20.2 cents per horsepower-hour, or $5.25 per thousand of output; and for the electric plant, 18.2 cents per horsepower-hour, or $4.92 per thousand. Making allowance for the advantage of larger output, however, the steam power would have been a little cheaper in 1919-20. It is very doubtful, however, whether this would be the case in a new plant specially built and equipped to use electric power. There would be considerable savings in space, labor, and equipment in a new plant, and the fuel cost would be somewhat reduced. Were it not for the need of live steam for pasteurizing, steaming and drying cans, and the like, the electric equipment would be much the cheaper; but as long as steam must be provided, the saving from using electric power even at daylight rates is small. The arguments for using electric power are really of another sort.

The ordinary range in cost per horsepower-hour for all plants was from 10 to 30 cents, more than half of them falling between 15 and 25 cents. The average was 19.1 cents for all creameries. The lowest cost rates were for several electric plants apparently getting low rates on power and usually with no auxiliary steam-power plant. On the other hand, some of the highest cost rates were with electric plants. Some small and some large creameries had low cost rates. The extreme cases were no doubt due to over- and under-estimates of horsepower-hours.

TABLE LIII

EQUIPMENT OF STEAM AND ELECTRIC PLANTS IN RELATION TO OUTPUT

Output groups	All steam				Partly electric			
	No. in group	Average butter output	Average boiler horsepower	Average engine horsepower	No. in group	Average butter output	Average boiler horsepower	Horsepower of engines in reserve*
Under 100,000	4	82,400	20	8	3	63,300	12	8 (1)
100,000 to 200,000	13	171,000	22	10	4	142,700	15	8 (1)
200,000 to 300,000	6	229,500	24	12	7	247,600	21	12 (5)
Over 300,000	4	417,800	25	15	5	555,600	24	15 (4)
Average	27	208,000	22	12	19	277,000	19	12 (11)

* Numbers in parentheses indicate the number of plants having engines in reserve.

Cost per thousand pounds of butter.—The ordinary range in power cost per thousand pounds of butter was from $4 to $8, and the average was $5.08. The average for creameries with 100,000 pounds output is $7; for creameries with 500,000 pounds, $4.40. Under the average, power cost increases at the rate of 40 cents for each 100,000 decrease in output; over the average, at the rate of 27 cents. Thus most of the economy of power from larger output comes with the creameries under the average size. There are, however, 13 creameries with outputs under 200,000 which have power costs under $5 per thousand.

Utilization, as computed in this analysis, is a slightly more important factor in cost than cost per horsepower-hour. An increase of 10 per cent in horsepower-hours increases costs 5.1 per cent; an increase of 10 per cent in cost per horsepower-hour increases costs 4.7 per cent. If actual horsepower-hours had been used in place of rated horsepower-hours at normal input of the equipment, the ratios, as near as can be calculated after correcting as well as possible for the error of over-estimate, would have been 10.0 per cent horsepower-hours to 10.4 per cent cost; and 10.0 per cent cost per horsepower-hour to 9.6 per cent cost. Expressed another way, creameries with one more horsepower-hour per pound of butter than the average had power cost larger by 19.9 cents per thousand, instead of 19.1 cents if strictly proportional; and creameries whose power cost an extra cent per horsepower-hour, had power costs larger by 25.3 cents per thousand, instead of 26.4 if proportional. This does not mean that any creamery by increasing its horsepower-hours or costs per horsepower-hour will affect its costs in this way, but merely that comparing the creameries as they were it worked out this way.

WATER

Table LIV shows the elements of cost of water used by creameries. The $32 charged against the 71 creameries having wells is for the extra city or village water purchased by 15 of them. The equipment consists of the pump and water tank or vat. Apparently it is about as cheap to purchase water from the city or village where this is possible as to supply it from a well. The data in the table, however, are not very accurate. The average water charge paid by the 11 creameries was 64 cents per thousand of output.

Water cost was distributed arbitrarily as follows: Preparation for churning, 90 per cent; power, churning, and cleaning, each 3⅓ per cent.

TABLE LIV

ELEMENTS OF COST OF WATER—BY SOURCES OF SUPPLY

	Well and pump	City and village	Artesian wells
Number of creameries	71	11	4
Water bill	$32	$158	...
Power	78	...	...
Equipment	42	24	$17
Total cost	$152	$182	$17
Cost per thousand of output	$0.65	$0.74	$0.07

COLD STORAGE

Of the creameries whose cold storage costs were analyzed in detail, 54 store their own ice, 12 buy it from day to day, and 19 have ice machines.

The elements of cost for creameries storing their own ice are space and expense of filling the icehouse. The space is of two sorts, that for actually storing the ice, and that occupied by the refrigerator. The storage space averages 450 square feet per creamery, 3.4 square feet per 1000 pounds of output. The refrigerator space averages 123 square feet per creamery, or 0.64 square feet per 1000 pounds of output. The space cost is 58 per cent of the total cost of $434 per creamery. The average quantity of ice stored was 154 tons, or 1600 pounds per thousand of output. There seems to be a relatively small increase in storage space and quantity of ice stored with the output of the creamery. The creameries over 400,000 pounds, however, have twice as much refrigerator space as those of 100,000 pounds output.

Only 30 of the 54 creameries have separate icehouses. These average only 40 more square feet per creamery than those with built-in icehouses. Reduced to an output basis, there is no difference between them.

The cost of storing the ice is mostly labor. Practically all creameries in Minnesota hire the work done.

Of the total cost of $434 per creamery for cold storage for these 54 creameries, $182, or 42 per cent, is for the cost of storing; $69, or 16 per cent, is cost of refrigerator space; and $183, or 42 per cent, is cost of storage space.

The cost per thousand for these 54 creameries is $2.26. It is $3.47 for the 7 with less than 100,000 pounds of output, and $1.10 per thousand for the average with more than 300,000 pounds of output (averaging 429,000).

No doubt much of the ice stored by those creameries is used for other purposes or wasted. Some is sold.

The elements of cost for creameries buying their ice from day to day are space and cost of the ice. The average cost of the ice in

1919-20 was only $1 per 1000 pounds of butter. Such creameries must use their ice much more carefully than those that store their own ice. The storage space averages only 35 square feet per creamery, and the refrigerator space, 98 square feet. Three other of these creameries, however, have a large chamber formerly used for storing their own ice.

The total cost of storage for 12 creameries using this method is $296 per creamery, or $1.45 per thousand of output.

With ice machines, power and equipment are the most important items. Power was estimated on the basis of data furnished by manufacturers of ice machines. The results obtained indicate that it is about half the total cost. The average life of the ice machine was estimated at 15 years. The cost in 1920 of a machine large enough to handle 300,000 pounds of output was $3000. Interest and depreciation are therefore large items. Equipment cost is about one third of the total. The refrigerator space was 143 square feet per creamery, which is only 0.43 square feet per thousand. The space occupied by the machine averages 45 square feet per creamery.[23] The creameries using ice machines average 330,000 pounds of output.

It would appear from the figures given that the cheapest cold storage is generally obtained by creameries that are in a position to buy their ice from local icehouses, and that ice machines are most expensive of all. However, there are some other important considerations. An ice machine saves much labor in handling ice and it should furnish better refrigeration. Moreover, the costs of operating ice machines decrease rapidly with output, so that it may well be that the ice machine is the cheapest for more than 400,000 or 500,000 pounds of output. Finally, many of the creameries with ice machines are so far from a natural supply of ice that it would cost more to haul the ice than to operate an ice machine.

STORAGE OF SUPPLIES

The principal supplies usually stored are tubs, boxes, and salt. The cost of storage of supplies was therefore distributed arbitrarily equally between churning and preparation for market.

The only cost chargeable to storage of supplies is space. The labor involved in getting materials in and out of storage was charged directly to churning and preparation for market. In most cases, a large part of the space for storage was in the attic on the second floor. Such space should really be charged at the additional cost of creating and maintaining such attic space; but as such a cost could not be determined in this survey, no charge was made. The average cost given in Table VIII, amounting to 56 cents per thousand of output, is only

[23] The data on costs of operating ice machines are so largely estimates that it is not advisable to publish them.

for the space used for this purpose on the first floor. The average space set aside on the first floor, for the creameries using only the first floor for storage, was 368 square feet, which is 1.6 square feet per thousand of output. The range is from 30 square feet to more than 2000, depending principally upon the output of the creamery, the amount of additional space provided upon the second floor, the size of the building in relation to the output, and the policy of the creamery as to buying supplies in quantity. The usual amount of floor space for storage is between 200 and 600 square feet.

CLEANING

Cleaning is an important element of cost in a creamery. It represents 11.4 per cent of all the labor cost of operating a creamery, and 6.6 per cent of all the power cost. It includes cleaning of all apparatus as well as floor. Table LV shows that labor is 63.3 per cent of the cost of cleaning. The materials cost is mostly for washing powder and brushes, whose cost averaged 23.2 cents per thousand of output in 1919-20. The space requirements, averaging 40 square feet not including passageway, are for wash sinks, steam jets, occasionally a steam sterilizer or can drier, and for standing room. The $545 per creamery equals $2.34 per thousand pounds of output.

Cleaning was distributed arbitrarily, one-fifth each to Babcock testing, receiving, preparation for churning, churning, and preparation for market. The distribution might have been somewhat more accurate if part had been charged to space and distributed with space.

The cost of cleaning increases with output at the average rate of $125 for each additional 100,000 pounds. This means a decrease of 25 cents per thousand. This is mostly because labor is better utilized at cleaning in the larger creameries.

TABLE LV

ELEMENTS IN COST OF CLEANING

Elements of cost	Per creamery	
	Amount	Per cent
Power	$111	20.3
Labor	348	63.9
Water	5	0.9
Material	42	7.7
Total without space	$506	92.8
Space	39	7.2
Total with space	$545	100.0

PROCESS COSTS

In this section of the bulletin, the remainder of building and site, equipment, labor and management, and supplies and miscellaneous; and the intermediate costs, power, water, cold storage, and storage of supplies, are carried to the following process accounts: receiving, Babcock-testing, preparation for churning, churning, preparation for market, record keeping and correspondence, skimmilk and buttermilk disposal, sidelines, and hauling; and to extra space, general maintenance, and general management or overhead. General maintenance and general management are generally, in cost accounting analysis, distributed to the process costs on some arbitrary basis. To follow this practice in this case would partly obscure the variations which it is desired to examine, and would add nothing to the usefulness of the process cost totals.

The sum of these nine process costs and the three others will equal the sum of all the primary expenses.

The purpose of making the process analysis is to present in more detail the reason for the variations in cost. For example, the labor load of a creamery depends upon a large number of things such as whether Babcock testing is done daily, weekly, or monthly.

The process costs will not, however, be analyzed in this bulletin as closely as is desirable; too many estimates are involved in the division of labor, time, and power between processes. Survey data are seldom sufficiently accurate to permit close process analysis. In view of the inaccuracies in these figures, they must be taken as indicating only the general relationships between and within processes. For example, if a statement is made that power represented 34.3 per cent of churning cost, it must not be understood that it actually did, but rather that this result was obtained by the methods used in this analysis. It is impossible to repeat the statement everywhere it applies in the manuscript; hence it is made here with the hope that the reader will make the application as he goes along.

RECEIVING

Receiving represents 7.7 per cent of all creamery costs. Table LVI shows the relative importance of the elements making up receiving cost. The process is mostly a matter of labor, either in the actual receiving or in the cleaning that goes with it. The labor time of receiving averages 942 hours per creamery. Under receiving labor are included dumping, weighing, and grading the cream, taking the sample, recording the weights, steaming the cans, and part of the time spent in running in and out of the receiving room.

Receiving labor time, it would seem, should vary with the hours during which cream is received. Practice varies greatly in this matter. Of the 88 creameries, 20 receive about any time up to 4 or 6 o'clock in the afternoon, usually beginning at 7 o'clock in the morning. A few even receive in the evening, especially on Saturdays. At the other extreme are 11 which limit all their receiving to the morning hours before 9:30, 10, 10:30, or 11 o'clock. The first group, however, uses only a fifth more time for receiving than the second group, 4.8 hours per thousand as compared with 4.0. The saving from concentrating receiving within fewer hours is very apparent, however, with the larger creameries. One concludes, therefore, that it is not worth while to limit the receiving hours unless enough cream is received to keep one man busy receiving; if the man receiving has to run back and forth anyway, it takes very little longer if spread out over the whole day than if merely spread out over the forenoon. And if one person is assigned to do nothing but receive, time will be wasted unless receipts are large.

TABLE LVI

ELEMENTS IN RECEIVING COSTS

	Per creamery		Per 1000 pounds of butter
	Amount	Per cent of total	
Space	$63	8.8	$0.27
Equipment	54	7.6	0.23
Labor	427	59.8	1.83
Power	61	8.5	0.26
Cleaning	109	15.3	0.47
Total	$714	100.0	$3.06

The group of largest creameries utilizes labor at receiving about twice as well as the group of smallest creameries. The large creameries are large partly because each patron delivers more cream. It takes nearly as long to receive a small load as a large one.

The creameries that utilize receiving time best are a few that are large and also limit their receiving time to 12 or 2 o'clock. This group reported an average of 1750 hours open for receiving, and 78 per cent of that time, or 1360 hours, actually receiving. This group used an average of only 2.7 hours per thousand pounds of output, compared with about 4.0 as the average of all creameries.

The large creameries reduce receiving costs in many cases also by using less expensive labor in the receiving room.

The power cost for the live steam used in steaming out the cans amounts to 27 cents per thousand, less than a pound of butter is worth. The extra labor and equipment required for this operation is also a small item.

Depreciation was the largest equipment item. The scale and steamer were estimated to last fifteen years and the weigh can five years.

Receiving room space averaged 95 square feet.

The decrease in receiving cost with output is at the average rate of $1.20 per 100,000 for each additional 100,000, being most rapid under 200,000 and over 400,000 and least rapid in the middle ranges.

BABCOCK TESTING

Babcock testing represents 5.1 per cent of all creamery costs, as compared with 7.7 per cent for receiving. Table LVII shows the relative importance of the elements in Babcock testing. Labor and cleaning constitute four-fifths of this cost. Cleaning is mostly labor. The labor includes, besides the actual testing, filling and labeling the bottles, and taking and recording the readings. The computations are included under record keeping. Cleaning cost is high because it includes washing both sample bottles and test bottles. Space averaged 43 square feet per creamery.

The labor cost varies mostly with output, frequency of tests, and the rate per hour. The range in hours with output is from 310, or 4.2 hours per thousand, for the group of smallest creameries, to 978, or 2.0 hours per thousand, for the group over 300,000. The larger the creamery, the larger the loads of cream delivered and the fewer samples per thousand pounds of output. Also the time of running the centrifuge is the same for a full machine as for a partly-filled one, and for a large machine as for a small one. Measuring the cream and acid and filling the test bottles, and taking and recording the readings are proportional to the number of patrons and the frequency of the tests. The 63 creameries testing daily averaged 710 hours of testing labor, or 3.3 hours per thousand. The 4 testing weekly used only half this much time; the 18 testing twice a month, only one-third this much time; and the 3 testing monthly only one-fourth this much time. The reason for this is as follows: If all patrons delivered their cream every day, there would be as many samples to test in a daily test as in a weekly or monthly test; and the saving in time from less frequent tests would tend to be proportional to the frequency of the tests. As it is, with most patrons delivering two or three times a week and some only at irregular intervals, the number of samples to be handled increases with the intervals between tests.

The labor cost also varies greatly according to whether one of the helpers or a high-salaried manager does the testing. No doubt it is highly necessary in some communities to have the most responsible man on the payroll handle the testing.

TABLE LVII

ELEMENTS IN COST OF BABCOCK-TESTING

	Per creamery		Per 1000 pounds of butter
	Amount	Per cent of total	
Space	$30	7.0	$0.13
Equipment	15	3.1	0.06
Labor	278	57.1	1.19
Supplies	46	9.4	0.20
Power	4	0.8	0.02
Cleaning	109	22.6	0.47
Total	$482	100.0	$2.07

The cost of Babcock testing for those testing daily decreases with output at the rate of 45 cents for each 100,000 additional output; and for those testing twice per month at the rate of 12 cents for each 100,000 additional output. A small creamery testing daily has a very small lot of samples to test at a time; hence the more rapid decrease with output with daily tests.

PREPARATION FOR CHURNING

Preparation for churning begins when the cream or milk leaves the weigh stand and ends when it is ready for the churn. It includes separating whatever whole milk is received, pasteurizing the cream, propagating the starter, ripening the cream, and holding it in condition until it can be churned.

This process cost ranks third among the six processes; it represents 14.4 per cent of all creamery costs. It averages $5.76 per thousand pounds of output as compared with $6.07 per thousand for churn cost. Table LVIII shows that power, equipment, and cold storage are the most important elements of cost in preparation for churning. Power is used as belt power to drive the cream separator and to turn the coils of the pasteurizer. It is used as live steam in pasteurizing, in heating the separator milk, and in preparing the starter culture. Pasteurizing is by far the largest item. The 22 creameries not pasteurizing therefore use only a small amount of power for this process unless they receive considerable whole milk to separate.

The equipment consists of the cream separator and milk heater, when separating is done; the starter can, if starter is used; and the pasteurizer and ripener. Creameries making 200,000 pounds of butter usually have two pasteurizers and ripeners. Equipment costs for this process cost are about 50 per cent of all equipment costs. The pasteurizers were given an estimated life of 15 years; the starter cans, 15 years; and the separators, 20 years. Depreciation constitutes half the equipment cost.

TABLE LVIII

ELEMENTS OF COST IN PREPARATION FOR CHURNING

	Per creamery		Per 1000 pounds of butter
	Amount	Per cent of total	
Space	$117	8.7	$0.56
Equipment	68	19.9	1.16
Labor	156	11.6	0.67
Supplies	20	1.5	0.09
Power	308	22.9	1.32
Cleaning	109	8.1	0.47
Water	130	9.6	0.56
Cold storage	239	17.7	1.02
Total	$1347	100.0	$5.79

The cold storage item is large because of the large amount of ice that is used in cooling the cream after it has been pasteurized and in holding it in the desired condition; or because of the cost of keeping the ice machine running for the same purpose. Likewise, most of the cost of water must be charged to the same process.

The only materials to be charged to this process are starter culture and, in some creameries, milk powder.

The pasteurizer and ripener vats and related equipment used a good deal of floor space. To this process is charged an average of 236 square feet per creamery, almost one-fourth of the total work-room space.

Labor is a relatively small item of cost in this process. The average is 374 hours per creamery, as compared with 704 for churning, and 942 for receiving. It is more for those that pasteurize than for those that do not, and more for those that have no ice machines than for those that have.

This cost varies a great deal according to the practices of the creamery. Twenty-two do not pasteurize; 38 do not use starter culture; and 12 separate more or less milk. Hence, to analyze the variations thoroly would require a great deal of detail work, more than is justified by the accuracy of the data. Suffice to say roughly that equipment cost decreases only 20 cents per thousand for each additional 100,000 of output; that the comparable decrease in power cost is 30 cents; in cold storage cost, 25 cents; in labor hours, 70 cents; and in square feet of floor space, 20 cents. The variation with output in all the foregoing costs combined is from $9 per thousand for the group of smallest creameries to $4 for the group of largest creameries. It ranges from $2 per thousand for a creamery making 50,000 pounds which neither pasteurizes nor uses starter culture, to $12 per thousand for a creamery which does both, makes only 85,000 pounds, and has high equipment and labor costs.

CHURNING

Churning cost ranks second among the six process costs; it represents 15.1 per cent of all creamery costs. The churning operation begins with the transferring of the cream from the ripener to the churn, and ends with the butter ready to be taken from the churn. The principal component parts of the process are as follows: Starting the cream pump, rinsing the vat, adding the butter color, weighing the salt, drawing off the buttermilk, and the actual churning, washing, and butter-working operation, together with the making and recording of the salt and moisture tests. The actual churning operation requires the attention of the churn operator only part of the time.

Table LIX shows the relative importance of the various elements in churning cost. Power is, of course, the largest element. The churning operation consumes, according to the method of calculation used in this bulletin, approximately one third of all the power, both belt power and live steam, used by a creamery. Labor is the item next in importance. It represents 704 hours per creamery, or about 10 per cent of all labor and management time. Salt and butter color make the supplies cost relatively high. The churn is the most expensive single item of equipment in a creamery except the ice machine. The churn with the work space around it occupies an average of 126 square feet in the 88 creameries. The process is also charged with one half of storage space—creameries usually buy their salt in considerable quantities.

TABLE LIX

ELEMENTS IN COST OF CHURNING

	Per creamery		Per 1000 pounds of butter
	Amount	Per cent of total	
Space	$76	5.4	$0.33
Equipment	167	11.8	0.72
Labor	307	21.7	1.32
Supplies	202	14.2	0.87
Power	486	34.3	2.08
Water	5	0.3	0.02
Cleaning	109	7.7	0.47
Storage of supplies	66	4.6	0.28
Total	$1418	100.0	$6.09

The power cost of churning for the group of creameries producing over 300,000 pounds was about half as much per thousand pounds of output as for the group with smallest output. This is partly because the larger creameries produce power more cheaply—use less coal per horsepower-hour; and partly because the larger creameries utilize churn capacity more fully. A considerable part of the power consumed by a churn with a light load is consumed by the churn itself. (See

Tables LII and LVIII.) Churn equipment is analyzed fully in the section on "Equipment Costs."

The group of smallest creameries used nearly 6 hours of labor per thousand, and the group of largest creameries, less than 3 hours per thousand. The whole range is from less than 2 to more than 8 hours per thousand. Hence output is only one of the factors. A considerable part of the labor of churning requires nearly the same time regardless of the size of the load and size of the churn; hence labor time tends to vary with the number of churn loads required per thousand of output. Smaller creameries may have churn capacity and cream volume better adjusted to each other than larger ones; but the odds are against it. Moreover, the loads are certain to be smaller.

Labor time also varies according to the extent and number and kinds of churn tests made and manufacturing records kept. Making tests and recording results are charged to churning; the computing based on these data to record keeping. The 88 creameries were put in three groups—18 which kept very meager churn records, or none at all; 44 which kept part of the records; and 28 which kept complete records. All but 10 of the creameries were equipped with both moisture- and salt-testing outfits, but some were not using both. The data show that creameries making complete tests were spending about a hundred more hours in record keeping, after differences in output were adjusted, than those keeping no churn records; but they show no effect upon churning time. The buttermakers in making these estimates may have charged all the churn record work to record keeping; or the error of the estimates may be so great as to conceal the effects expected. Such errors must be expected in survey data.

Labor cost also varies because of variations in rates of pay. Generally the highest paid employee attends to the churning.

When all costs are combined, the range is from $3.30 per thousand, for a creamery making 326,000 pounds, all of whose costs are consistently low, to over $10 per thousand, for a creamery making 100,000 pounds, with exceptionally high power and equipment costs. The variation with output is from $4.40 per thousand for the group of largest creameries, to $8.70 for the group of smallest creameries.

PREPARATION FOR MARKET

Preparation for market takes the butter as it comes from the churn, packs it, stores it, and finally delivers it on board train or to the local stores, if sold in the local market; or to customers or patrons, if sold at the creamery. It includes nailing the boxes, if boxes are used, paraffining the tubs and boxes, stamping and numbering the tubs and boxes, and weighing the butter and recording the weights. Altho the process is called "preparation for market," it includes delivering the

product on board train or to customers, which may be called marketing proper. This, however, is only a small part of the total cost involved. Most of the costs of marketing proper—railway costs, commissions, etc.—are deducted from the returns received for butter sold, and hence do not appear as creamery costs.

As will appear from Table LX, over two-thirds of this cost is for supplies. Four-fifths of the $2410 for supplies is for boxes and tubs, and most of the remainder is for liners and circles, wrappers, paraffin, and drayage. The prices of tubs and boxes, liners and circles, fluctuate considerably; hence any figure as to the cost of preparation for market is not directly applicable after prices have changed. The cost of supplies in preparation for market represents 25.2 per cent of the total creamery costs, and 56.5 per cent of all supplies and miscellaneous cost.

TABLE LX

ELEMENTS IN COST OF PREPARATION FFOR MARKET

	Per creamery		Per 1000 pounds of butter
	Amount	Per cent of total	
Space	$61	1.7	$0.26
Equipment	39	1.1	0.17
Labor	464	13.3	1.99
Supplies	2410	68.7	10.33
Cleaning	109	3.1	0.47
Cold storage	360	10.2	1.54
Storage of supplies	65	1.9	0.28
Total	$3514	100.0	$15.04

The next largest element of cost is labor. An average of 1178 hours per creamery is devoted to preparation for market. This may be compared with 942 hours for receiving, and 374 hours for preparation for churning. This is 16.4 per cent of all the labor and management time per creamery. It is, however, only 15.0 per cent of all labor and management cost, because more apprentice and low-priced labor is used in this process than in any other.

The next largest element in cost of preparation for market is cold storage. The temperature in the refrigerator where the butter is stored is kept at from 40 to 50 degrees F.

The equipment used consists principally of the paraffiner, butter printers, scales, box-nailing outfit, trucks, and in some cases, counter.

Different marketing policies in the different creameries to some extent affect the costs of preparation for market. Of the 88 creameries, 50 sold all their butter in New York; 16, all in Philadelphia; and 15 all in New York and other points. Only 2 sold all their butter in Chicago, 3 sold in Duluth and on the Iron Range, 1 in St. Paul, and 1 in Minneapolis.

An average of 14.8 per cent of all butter produced was sold locally, 9.1 per cent to stores and directly to consumers, and 5.7 per cent to patrons. Four creameries sold less than one per cent to patrons; and 8 over 10 per cent. Ten creameries sold no butter locally except to patrons, 8 sold less than one per cent; but on the other hand, 21 sold over 10 per cent, and 9 over 20 per cent.

An average of 81.6 per cent was packed in tubs, 15.8 per cent in boxes, and the remainder in jars for local consumption. Thirteen packed over 95 per cent of their butter in tubs, and all except 16 over 80 per cent of their butter in tubs. Only 4 packed less than half in tubs. Butter packed in boxes is for local consumption, or is shipped to Minneapolis or St. Paul or a few other local points. All the rest is packed in tubs.

The relative cost of packing in tubs and in boxes as prints will largely depend upon the relative price of tubs and liners and circles as compared with the price of boxes and wrappers. At present writing, the cost is $8.72 per thousand pounds for tubs and circles and liners, and $9.06 per thousand pounds for boxes and parchment wrappers.[24] There is also some difference in the labor involved, altho the data were not sufficiently accurate to show it clearly.

As more butter is sold locally to patrons and others, the costs of preparation for market decrease somewhat. This is because of the saving in tubs and boxes.

Preparation for market decreases less with output than any other cost, because supplies, which constitute 68.8 per cent of the total, are very nearly proportional to output. The only supply items of importance that are not, are drayage and freight on supplies. The smaller creameries also purchase in smaller quantities. For these reasons, and perhaps some others, supplies cost the group of smallest creameries about 10 per cent more than those of over 200,000 pounds. Labor, cleaning, and space, on the other hand, decrease more than half between the groups of smallest and largest creameries; and these constitute about one-fifth of this process cost. But in this case, also, most of the decrease is in creameries of less than 200,000 pounds of output. The total range with output is from $20 per thousand for the group of smallest creameries, to $15 per thousand for the group of largest creameries; but for the reasons already mentioned, over $4 of this decrease comes before 200,000 pounds.

RECORD KEEPING AND CORRESPONDENCE

In record keeping and correspondence is included the work done in the office or elsewhere by the operator, the bookkeeper, or the secretary in keeping the books of the creamery, in calculating the pounds

[24] Ash tubs holding 63 pounds; 50-pound boxes. Data furnished by Creamery Package Company.

of butterfat delivered by each patron, in making out patrons' statements and checks, in making out annual reports and income statements, and whatever computations are required for the manufacturing record; and also all correspondence with patrons, customers, receivers, railroad companies, supply houses, etc. It represents $811 per creamery, or 8.6 per cent of the total cost.

TABLE LXI

ELEMENTS IN COST OF RECORD KEEPING AND CORRESPONDENCE

	Per creamery		Per 1000 pounds of butter
	Amount	Per cent of total	
Space	$65	8.0	$0.28
Equipment	49	6.0	0.21
Labor	575	70.9	2.47
Supplies, etc.	122	15.1	0.52
Total	$811	100.0	$3.48

Table LXI shows what this $811 includes. Over 70 per cent of it is labor, which averages 1369 hours per creamery. About 5 per cent of this was used for correspondence. This 1369 hours is 19 per cent of all labor and management time.

The equipment consists of office desks, filing cases, adding machines, typewriters, safes, and, in a few cases, cash registers. Of the 88 creameries, 48 have adding machines, and 26 typewriters. Space is the whole of the office space, which averages 75 square feet per creamery.

There is a wide range in costs of record keeping and correspondence. The range with output, however, is only from $5 per thousand for the group of smallest creameries to $3 per thousand for the group of largest creameries. But in the group of 10 creameries producing less than 100,000 pounds, the range is from $1.52 to $7.50; in the group from 200,000 to 300,000 pounds, from 89 cents to $6.70; and in the group over 500,000 pounds, from 83 cents to $4.40.

The reasons for these variations are obvious. Some creameries keep better records than others. Sometimes the work is done by a buttermaker who is "slow at figures"; sometimes by an alert-minded experienced bookkeeper or secretary who knows the system he is using. Most creameries make out monthly statements, 59 in all; but 17 issue semi-monthly statements, and 12 pay for each delivery. Selling locally increases the labor of record keeping. Carrying a large sideline business increases it a very great deal.

In general, per-unit record keeping and correspondence costs are as low for the middle-sized creameries as for the largest ones. This is because the largest creameries keep more elaborate records. The rate per hour for labor of record keeping is highest in the middle group,

because in such creameries most of it is done by the operator or manager, whereas the larger creameries employ special help at lower rates than the operator's. The rates per hour range from less than 30 cents in 17 creameries to more than 50 cents in 11 creameries.

GENERAL MAINTENANCE

General maintenance, averaging $274 per creamery, is made up as follows: labor and management, $50; equipment, $9; space, $12, and supplies and miscellaneous, $200. It represents the labor of the regular employees of the creamery devoted to upkeep and repair of buildings, equipment, and grounds which is not already charged to space and equipment; extra labor hired for general repair work that has not already been charged; the necessary tools for such work; work bench and work bench space; and a large assortment of miscellaneous supplies and equipment, as dippers, strainers, ladles, thermometers, paint, and lumber. Obviously, if a system of costs were being kept regularly, nearly all this expense would be charged to space and equipment and the various processes. However, as there was no real basis for distributing it with the data at hand, it was carried as a general undistributed item. It represents less than 3 per cent of all costs. It varies with output at about the same rate as labor and equipment combined.

GENERAL MANAGEMENT OR OVERHEAD

Under general management are included overhead expenses that can not be distributed between processes on any real basis. Of the total of $562 per creamery charged to this account, $261 is for the time of the regular operator or manager devoted to management. This is included in the elementary costs as labor and management. The remainder, $302, appears in the elementary costs as supplies and miscellaneous. It is divided about as follows: salaries of treasurer and directors, $89; other help hired for management, traveling expenses, etc., $50; telephone and telegraph, $35; interest on balance, $77; miscellaneous, including postage, $51.

The labor and management hours charged to general management average 506 hours per creamery, which is 7.0 per cent of the total. Eight creameries reported less than 100 hours, and 5 more than 1000 hours. The range in labor and management cost charged to this account is from 32 cents per thousand for a creamery making 112,000 pounds whose manager devoted 60 hours to management, to $3.14 per thousand for a creamery making 492,000 pounds whose manager devoted full time to management. For creameries with no helper, 6.3 per cent of labor and management is charged to general management; for creameries with one helper, 8.0 per cent; and for creameries with

two or more helpers, 10.1 per cent. This is in keeping with general experience: the management of a small business can be carried on incidentally and requires very little special time, but as the business grows, there is more than a proportional amount of supervising and co-ordinating to be done. Most of the creameries making over 500,000 pounds employ a manager who does very little else. Reduced to an output basis, the range is from $1.90 per thousand in the middle-sized creameries, to $2.70 for the group of largest creameries, and to $3.20 for the group of smallest creameries.

EXTRA SPACE

Extra space, averaging $127 per creamery, is carried as a separate item because there is no proper basis for distributing it between processes; and because there is question as to whether it should be charged to current business.

BUTTERMILK AND SKIMMILK DISPOSAL

The $13 charged to buttermilk and skimmilk disposal is for equipment only. A small amount of labor and space should also be charged to this process. Equipment consists principally of buttermilk and skimmilk vats and pumps, and occasionally a weigher.

HAULING

Hauling includes only the hauling of cream. Only 12 of the 88 creameries do any hauling. This work was considered as not belonging to the creamery proper, and all receipts from it or expenses connected with it were removed from the creamery records, except this one item of equipment cost averaging $25 for the 88 creameries, which could not very well be separated. It amounts to an average of $183 for the 12 creameries.

SIDELINES

Of the 88 creameries covered in the survey, 37 did some business in sidelines. Only 5 manufactured ice cream, 2 made cottage cheese, and one made casein. The most common sideline was sweet cream and milk, bottled and sold by 14 creameries. Several more sold only cream. One was shipping buttermilk to St. Paul, and another was selling the skimmilk to a milk powder plant.

All the foregoing are dairy product sidelines. Six, however, were handling poultry and eggs, 6 more eggs alone, and 4 flour and feed. One was handling sugar, another coffee, and another a general line of groceries. Three were selling the farmers oil, and 7, salt. One was feeding skimmilk and buttermilk to hogs, one was running a laundry, and one was shipping livestock and potatoes and selling flour, feed, and farm implements.

It was of course difficult to separate the cost chargeable to sidelines. Where the sideline business was a major enterprise of a distinct sort, as in the case of the laundry or the grocery department, the creamery business was separated from the other as completely as possible. The costs given, therefore, are for clearly sideline enterprises. The average is $89 per creamery, divided as follows: labor $43, equipment $18, power $2, supplies $26. If this cost is distributed over only the creameries handling sidelines in appreciable quantity, say 22, the average is nearly $400 per creamery. When the costs per thousand pounds of butter of these 22 creameries were compared with those of the other 66, and adjustments made for differences in output, an additional cost appeared for the sideline creameries of over $2 per thousand. This would indicate that probably the $89 is too low—probably the labor item is too low. It must be remembered also that a certain amount of general management and general maintenance should be charged to sidelines.

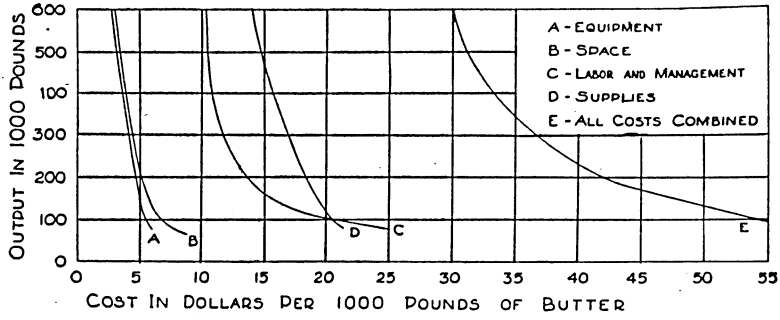

Fig. 24. Relation of Output to Creamery Cost of Butter

ALL COSTS COMBINED

Figure 24 shows the variations with output of each of the four elementary costs and of the four combined. As all four curves are drawn to the same scale, this a clear picture of the relative effect upon total cost of the variations in each of the elements. Labor and management is responsible for much more of the decrease with output than any other factor. Supplies and miscellaneous is next in significance. Labor and management shows a very pronounced effect under 200,000 pounds, and some effect above this point. Supplies and miscellaneous has its effect all the way up, altho especially at the very bottom. Space and equipment produces most pronounced effect close to the bottom. The combined effect is a curve of decreasing cost all the way up, but at a decreasing rate from the very bottom, and especially after 200,000 pounds.

The principal reasons for the shape of this combined curve may be stated as follows: (1) Labor, space, and equipment are more fully utilized by the larger creameries. There is a rapid improvement in utilization in the lower ranges. The reason for this is that there is usually a minimum-sized unit, such as one man, one churn, one engine, one ice machine, or one ripener, which is never fully utilized with a small output, and utilization improves rapidly up to the limit of this minimum-sized unit. Beyond this point utilization improves either because a second unit is more fully utilized, or the larger units permit better utilization. The larger the plant the better the fit that can be obtained between plant and volume. (2) The larger units of equipment are more economical of labor, power, and supplies than the smaller units. This is especially noticeable with coal and ice. They also occupy less floor space per unit of output. (3) The larger creameries secure their labor more cheaply because they are able to divide their work between expensive and cheap labor, whereas in the one-man creamery a high-salaried buttermaker does all the work.

It must again be made clear at this point that any given creamery with a given plant and labor force can not expect to reduce its costs with increase in output closely along the direction of this curve. This curve is based upon the kinds of plants, equipment and labor and management that are found accompanying these outputs in Minnesota. As any given creamery increases its output, it will find first one cost and then another decreasing with output up to the point of full utilization of that particular part of the equipment, or labor supply, or plant; and then as a larger unit of equipment, or an additional helper, or larger building is provided, this particular cost will be increased until the larger or additional unit is fully utilized. When it is fully utilized, the cost will be somewhat less than it was for the smaller unit when it was fully utilized. The curve for any one creamery as it increases in output is therefore likely to be an irregular jagged curve, but its general direction is much like that in Figure 24.

Moreover, if all the creameries in the state had started at 75,000 pounds output, and had gradually increased to 500,000 pounds, the cost line over which they would have traveled would have closely resembled this curve.

Output, however, is only one of the factors producing variations in cost. Table LXII shows that there is a wide range in any output group. The creamery in the highest-cost group, whose cost was 8.1 cents per pound, pays a manager $1600, a secretary $500, its directors and treasurer $120, and in addition employs a helper for two months. This is a very large payroll for a creamery making only 60,000 pounds of butter per year. In addition, its space cost is high because of the rapid

depreciation of a poorly constructed concrete building. Its equipment cost is also high for a small creamery.

The creamery in the same group whose cost was 4.6 cents per pound, making 97,000 pounds of butter, pays its operator $2000; but the operator does all the work. No other salaries are paid, not even to directors. Its space cost is low—the building is of brick and was built in 1906. Its power cost is low, owing to cheap power rates.

The creamery in the second group whose cost was 6.6 cents per pound has a payroll of over $5000, altho it makes only 140,000 pounds of butter. It pays its operator $1900, its bookkeeper $300, its officers $150, and employs two full-time helpers. It has a brick building worth $12,000, and a $4000 ice machine. This creamery handles considerable milk and cream as a side line; but far from enough of these to warrant the present expansion of the plant and staff. Such a maladjustment may have arisen from a falling off in volume or from a failure of volume to meet expectations. Such maladjustments happen frequently with co-operative creameries.

In this same group are three creameries whose costs are around 3.5 cents per pound. Two of these have exceptionally low labor and management cost, paying their operators only $1450, and their secretaries $150, and employing no helpers. Two have low space cost, because they are using old frame buildings. The equipment cost is low in all three of these. None of them has an ice machine.

TABLE LXII

RANGE IN CREAMERY COSTS BY OUTPUT GROUPS

Output groups	Costs per pound of butter		
	High	Low	Average
	Cents	Cents	Cents
Under 100,000	8.1	4.6	5.75
100,000 to 150,000	6.6	3.7	5.05
150,000 to 200,000	5.2	3.5	4.31
200,000 to 250,000	4.6	3.3	4.05
250,000 to 300,000	4.1	3.3	3.77
300,000 to 400,000	3.7	2.8	3.55
400,000 to 500,000	3.4	2.6	3.20
Over 500,000	3.1	2.4	2.98
Average	8.1	2.4	4.07

The creamery in the 250,000 to 300,000 group whose cost was 4.1 cents had a large payroll with two full-time helpers, a $2000 operator, an expensive building, and high power and cold storage costs. In contrast, the low creamery in the group paid its operator $1400, a full-time helper $800, and a secretary $300. Its plant was valued at only $3000. Their equipment costs were about equal.

Two of the very largest creameries may be compared as follows: value of building, $8000 and $23,000; value of equipment, $3500 and $13,000; payroll, $5400 and $6000. The second of these two creameries makes nearly 150,000 pounds more butter than the first, but its costs are still 0.6 of a cent higher.

It is possible from the data thus to analyze each creamery and show why its costs are as they are. The foregoing example shows the general nature of the problem. There is not room in the bulletin for detailed analysis of individual creameries.

THE LEAST-COST COMBINATION

The various elementary costs are of course closely inter-related. A well-arranged and well-maintained plant with just the right amount of floor space can handle a larger volume with the same labor force than can a plant defective in any of these particulars. Thus building cost may to some extent be substituted for labor cost. In the same way, equipment may be to some extent substituted for labor. For example, a larger churn will mean fewer churnings—most of the churn labor is proportional to the number of churnings. Adding machines greatly reduce the labor of record keeping. Ice machines reduce very considerably the labor of preparation for churning, and electric power reduces power labor considerably. Similarly larger units of equipment are economical of space.

Thus in considerable measure labor, equipment, and space costs may be used to offset each other. But how much equipment does it pay to substitute for labor, or space for labor, or equipment for space, or vice versa? This depends upon two things, which can be stated, for example, in terms of churning: one is the number of hours of labor saved per year by the larger churn, and the number of square feet of floor space. The other is the relative prices of these cost elements—the relative prices of churns, rates of pay for labor, and costs of building space. If equipment prices rise faster than labor rates, then it will less likely pay to substitute equipment for labor.

Unfortunately the data obtained are not sufficiently accurate to warrant a careful analysis from the standpoint of the least-cost combination. Enough analysis has been made, however, to show that there is considerable variation between creameries. This means that most of them are not really working at their least-cost combination. Table VIII gives the average proportion between the four elementary costs as follows: Building and site, 11.7 per cent; equipment, 9.9 per cent; labor and management, 32.5 per cent; supplies and miscellaneous, 45.5 per cent. Table LXIII shows how these proportions change with output. In general, the proportion indicated for each output can be taken as a

rough standard with which to compare any creamery with that output. Percentages for intermediate points can be obtained by dividing curve E at the desired output in Figure 24 by curves A, B, C, and D at the same output. Note that the percentage of cost in building and site decreases from the start, and that the percentage in supplies and miscellaneous increases from the start. This is because space increases less than proportionally to output, and supplies much more nearly proportionally to output. The percentage of cost in labor and management decreases rapidly at first and then increases.

TABLE LXIII

COMBINATIONS OF ELEMENTARY COSTS AT DIFFERENT OUTPUTS

Output	Percentage of total cost				
	Equipment	Building and site	Labor and management	Supplies and miscellaneous	Total
100,000	10.3	12.5	38.9	38.3	100.0
200,000	11.3	12.2	32.5	44.0	100.0
300,000	11.0	11.9	31.3	45.8	100.0
400,000	10.5	11.5	31.9	46.1	100.0
500,000	9.9	10.6	33.1	46.4	100.0
600,000	9.1	9.8	34.2	46.9	100.0
Average	9.9	11.7	32.9	45.5	100.0

That individual creameries vary greatly from the standards in Table LXIII is illustrated by the following: There are 8 creameries in the 88 with outputs between 131,000 and 137,000 pounds. Labor and management cost plus building and site cost plus equipment cost ranges from $2581 to $6066 per creamery for these 8 creameries. Supplies and miscellaneous are omitted because fairly constant. Labor and management in these 8 creameries vary from 47 to 69 per cent of the sum of the three costs; building and site from 10 to 35 per cent; and equipment from 11 to 34 per cent. A similar showing can be made with almost any output group. A considerable part of this variation is, of course, due to differences in the age of the buildings and equipment, and the price level at the time of construction and installation. If a method of valuation could have been used, however, which would have put all plants on the same basis in these respects, there would still have been a pronounced range.

Generally speaking, however, the manager and directors of a creamery are not called upon to determine the whole of a least-cost combination at one time. The problem presents itself in such concrete forms as the following: Shall we buy another churn? How large a churn shall we buy? Shall we install an ice machine? Shall we buy an adding machine? The procedure in such cases is to estimate the cost of labor, space, and equipment in all possible combinations, make proper

allowance for effect on quality of product and the like, and choose accordingly. Not all the data needed for such estimating are available; but those published in this bulletin will help considerably.

An example of the type of information needed is given in Table LXIV. After allowance was made for differences in output, increasing the floor space from 6 to 16 square feet per thousand reduced the hours per thousand by 8.2; and increasing the floor space beyond this point, as would be expected, had the opposite effect. A large amount of floor space per thousand may also indicate smaller units of equipment, and hence additional labor indirectly.

TABLE LXIV

Square feet per 1000 pounds	Hours per 1000 pounds
Less than 6	35.8
6 to 10	29.7
10 to 16	27.6
16 to 20	37.2
Over 20	47.1

The data in Table LXIV have not been analyzed closely enough to warrant any important use of them. The same is even more true of the results of several similar analyses that have not been included.

COST AND QUALITY OF PRODUCT

The ordinary range in creamery costs per pound of butter was 6 cents. The ordinary range in price received per pound of butter was 10 cents. (See Table V.) But probably 4 cents of this 10 was due to differences in quality of cream received, and 3 cents or more to differences in freight and marketing costs and seasonal variations in receipts. The rest can be ascribed to differences in skill in butter-making, in quality of plant and equipment and the like, differences which would ordinarily be associated with differences in cost. It is the purpose of this section of the bulletin to see if high costs mean high prices for the product, and vice versa. A difference of 3 cents per pound in cost is warranted only if it means more than 3 cents more per pound for the product. This analysis is hard to make because, as just pointed out, there are three other factors besides costs which affect the price for the product. An effort will be made to allow for the differences in quality of cream. The other differences can not be properly adjusted; it is hoped, however, that they will offset each other along the range of variations in the other factors.

If costs per pound are compared directly with output regardless of the size of the creamery, the relationship obtained will be the very opposite from what one would expect, for the larger creameries not

only have the lower costs, but, as will appear later, receive a better quality of cream and have better buttermakers, and hence turn out a higher quality of product. Hence it was necessary to adjust all observations for the effect of differences in output.

When per-unit labor and management costs were thus corrected, the results were as given in the second column of Table LXV. Labor costs $6 per thousand under the average for their outputs are accompanied by 2.7 cents lower prices for butter than in creameries with labor costs $2 and $4 above the average for their outputs. When, however, differences in quality of cream are eliminated, the range in effect is reduced from 0.8 cent under the average price for their grade of cream, to 0.2 cent over the average for their grade of cream. Moreover, practically all the creameries have labor costs within $—4 and $+4; and between these extremes the variation in prices received for butter from the same grade of cream is only 0.4 cent. This is only 5 per cent of the variation in labor cost. It thus appears that in general, additional labor cost, even after making allowance for difference in output, is very little associated with a better product.

TABLE LXV

RELATION OF LABOR COST TO PRICES RECEIVED FOR BUTTER

Labor costs per 1000 pounds as compared with the average for their outputs*	Average annual prices received per pound of butter	Average annual prices compared with average for their grade of cream*
	Cents	Cents
$—6	54.0	—0.8
—4	55.0	—0.2
—2	55.8	+0.2
0	56.2	+0.2
+2	56.7	+0.2
+4	56.7	+0.1
+6	56.3	+0.1

* +, above average; —, below average.

Another attack on the same problem is to compare the salaries of the head buttermakers and managers with the quality of product. The higher salaries are accompanied by higher prices for butter, but this is what one would expect, for as outputs increase, salaries also increase and concurrently the quality of the cream improves and also the quality of product even for the same grade of cream. If the advantage of this better buttermaking and better cream that accompany larger output is taken away, the quality of the butter actually decreases with salaries. Thus the buttermakers receiving from $200 to $400 over the average for creameries of their output are receiving more than a cent less per pound for their butter, and also a cent less than the average for the same grade of cream, than the buttermakers receiving from $200 to $400 less than the average for the same output. This simply means

that all the effect of better salaries upon quality of product and a little more, is included in the larger-salary and better-product relationship that exists in the larger creameries.

However, in 7 creameries salaries paid buttermakers are $200 or more over the average for their outputs, and the average price for butter in 1919 was more than 58 cents a pound. Four of these receive 2 cents or more over the average price for butter made from their grade of cream. At the other extreme are several creameries with relatively low salaries and low prices. The reason that the general relationship does not run this way is that there is a larger number of creameries in which high salaries for their output are not accompanied by higher butter prices, and in which low salaries are not associated with correspondingly low butter price, for a given grade of cream.

A somewhat similar relationship exists between building costs and quality of product. The creameries with annual building costs 20 cents per square foot above the average are making appreciably better butter than those with low annual building costs. But it can not be said that the one is the cause of the other. It results because good dairy farmers will build good creameries and hire good buttermakers as well as deliver good cream. If adjustment is made for quality of cream and output, no relationship seems to be left between building cost and quality of product.

As one would expect, no obvious relationship can be traced between cost of equipment and supplies and quality of product. It may exist, but it is so slight that it can not be distinguished.

We therefore come to the conclusion that higher creamery costs, when allowance is made for output and quality of cream, have in general no very appreciable effect on the quality of the product, altho there are many individual instances in which they have. The higher creamery costs are therefore mostly for other reasons than effort to secure a better product.

COMBINATION OF GRADES OF THE COST ELEMENTS

The analysis of cost and quality of product has brought out the point that there is a tendency for certain grades of the cost factors to be associated with each other in any one creamery. Thus the quality of cream and grade of buttermaker both vary together with output.

When this relationship was examined more closely it was found that the creameries receiving "sour" cream paid their buttermakers salaries averaging $1300 per year; those receiving "fair" cream, $1700 per year; and those receiving "good" cream, $1900 per year. Annual building costs showed the same variation and about the same range. These relationships indicate that the best butter is made in the best

creameries by the highest paid buttermakers. This is what would be expected. The farmers in territory with a sparse milk-cow population are not greatly interested in their income from butterfat, and will not furnish the money for an expensive creamery building. A high-salaried buttermaker would mean very high labor and management cost per thousand of output. In the dairy-farming regions, the opposite of these conditions prevail.

It is sometimes argued that the creameries receiving poor cream should have better buttermakers than those receiving good cream. Whether this is true or not depends upon whether a good buttermaker can add more to the value of poor or of good cream in manufacture, and upon output. It might be that a good buttermaker could add a half-cent per pound to the price of the product of a 50,000-pound creamery; and only a quarter-cent to the price of the product of a 300,000-pound creamery. Obviously, under these conditions the small creamery could not afford to hire the good buttermaker—it would have to bid $750 to take him away from the larger creamery, if the larger creamery knew what it was about—and he would add only $250 to the value of the butter.

Undoubtedly there are many creameries that could profitably pay a higher salary and get a better buttermaker; but there are many that could not. It would be fine, of course, if all creameries had better buttermakers; but if there is only a limited number of them, it is in the interests of all that the creameries with more and better cream should have them. In the meantime, every effort should be made to raise the general level of all buttermakers.

Also each creamery should reason out and determine the grade of buttermaker it can afford, always making proper allowance for what a good operator can do in getting the farmers to improve their cream. If enough volume can be obtained, a high-salaried buttermaker can be hired even for poor cream. Several creameries covered in the survey illustrate this.

THE MOST ECONOMICAL SIZE OF BUSINESS

Figure 24 shows that creamery costs per unit of output decrease as output increases as far as 600,000 pounds, at least. It is likely that they would continue to decrease above this point, altho at a decreasing rate.

A further consideration is quality of product. The larger creameries pay higher salaries for buttermakers and managers and secure a higher degree of skill and quality of service, which is reflected principally in higher prices for butter. Table LXVI shows that the creameries of 350,000-pound output receive cream which ranks 1.5 points better than that of creameries of 100,000-pound output; and that they

made butter of it in 1919-20 which sold for 2.1 cents more per pound. If we assume the same creamery costs (4.07 cents per pound), and the same overrun (22.0 per cent), the 350,000-pound creameries could have paid 2.6 cents more per pound of butterfat; or 1.2 cents more if the grade of cream had been the same. This means that 1.4 cents of the 2.7 cents would have been due to the better cream received. If this variation with output is combined with the variation in creamery costs with output, the combined effect, assuming the same grade of cream, is 3.6 cents more paid patrons per pound of butterfat by 350,000-pound creameries, than by 100,000-pound creameries. This is stated in detail in Table LXVII. It is to be noted that the quality of product for the same grade of cream improves very slowly over 350,000 pounds of output.

TABLE LXVI

RELATION OF OUTPUT TO QUALITY OF CREAM RECEIVED AND QUALITY OF PRODUCT; 88 MINNESOTA CREAMERIES, 1919

Output	Average price received per pound of butter	Average rank* of cream received	Average price per pound of butter for same grade of cream	Price paid patrons per pound of butterfat for same grade of cream*
	Cents		Cents	Cents
50,000	53.7	3.9	54.8	61.9
100,000	54.0	3.5	54.9	62.0
150,000	54.6	3.0	55.1	62.3
200,000	55.4	2.7	55.4	62.6
250,000	55.8	2.4	55.6	62.9
300,000	56.1	2.2	55.7	63.0
350,000	56.1	2.0	55.8	63.2
400,000	56.0	2.2	55.9	63.5
500,000	55.6	2.5	56.0	63.4
600,000	55.6	2.4	56.1	63.5

* Rank 1, sweet cream; Rank 5, sour and old cream; Ranks 2, 3, and 4, intermediate grades.

† Assuming same overrun (22.0 per cent) and same creamery costs (4.07 cents) regardless of output.

For a complete statement of the economies of larger volume, this additional price for the product must therefore be combined with the savings in cost.

The problem also has another important aspect, namely, the larger the volume the greater the distance which the cream must be hauled. While this is not a creamery cost, from the standpoint of economy in organization of the whole creamery function of marketing the farmer's butterfat, it bears on the problem in exactly the same way as if the creamery were paying it.

TABLE LXVII

RELATION OF OUTPUT TO PRICES PAID PATRONS FOR BUTTERFAT, 88 MINNESOTA CREAMERIES, 1919

Outputs	Assuming same price per pound of butter	Assuming same creamery costs per pound of butter	Combined effect per pound of butter
	Cents	Cents	Cents
50,000	58.9	61.9	58.3
100,000	61.0	62.0	60.3
150,000	62.1	62.3	61.8
200,000	62.5	62.6	62.5
250,000	62.8	62.8	63.0
300,000	63.1	63.0	63.4
350,000	63.3	63.2	63.9
400,000	63.5	63.3	64.1
500,000	63.7	63.4	64.4
600,000	63.9	63.5	64.7

The cost of hauling cream can not really be determined in any general way or with any high degree of accuracy. It will vary with the amount of butterfat produced per square mile, the number of deliveries per week, the size of the load, and above all, with the proportion of the trips that are made solely or partly for the purpose of delivering the cream. Figure 25 shows four curves of hauling costs per thousand pounds of butterfat, based on four different assumptions, as follows:

A = 4000 pounds of butterfat per square mile, 3 deliveries per week, with half of all costs of the trips, including automobile cost and labor cost, charged to cream delivery.

B = 2000 pounds of butterfat per square mile, 2 deliveries per week, with only half of the automobile cost charged to cream delivery.

C = 2000 pounds of butterfat per square mile, 2 deliveries per week, with half of all hauling costs as in A.

D = 1000 pounds of butterfat per square mile, 1 delivery per week, only half of automobile costs, as in B.

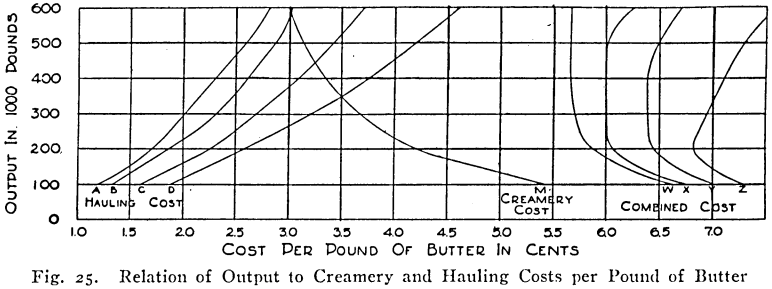

Fig. 25. Relation of Output to Creamery and Hauling Costs per Pound of Butter

In all cases, a 50-pound load of cream was assumed; and these 50 pounds of cream were assumed to be equivalent to 18 pounds of butter. Automobile costs were assumed to be 10 cents per mile. In A and C, a man-labor rate of 20 cents per hour was assumed, and a time rate of 4 minutes per mile, and 15 minutes extra at the creamery.

Assumptions B and C represent about average conditions in the state, for example, the intermediate dairy section; assumption A, conditions in the southern dairy section; and assumption D, in the Red River Valley and southeastern corn section.

Table LXVIII gives the average length of the haul, one way, and marginal length of the haul, for various outputs and for four different densities. Thus to secure 600,000 pounds of milk even at 4000 pounds of butterfat per square mile, all creamery patrons within a radius of 6.23 miles will have to deliver their milk to one creamery; and the average haul for all patrons will be twice 4.15, or 8.30 miles. At the other extreme, to secure even 100,000 pounds output with 1000 pounds of butterfat per square mile, the average haul will be 6.78 miles.

TABLE LXVIII

LENGTH OF HAUL, ONE WAY, FOR DIFFERENT OUTPUTS AND DENSITIES

Output	Butterfat per square mile							
	1000 pounds		2000 pounds		3000 pounds		4000 pounds	
	Average	Marginal	Average	Marginal	Average	Marginal	Average	Marginal
	Miles	Miles	Miles	Miles	Miles	Miles	Miles	Miles
100,000.....	3.39	5.09	2.40	3.60	1.96	2.94	1.70	2.54
200,000.....	4.83	7.25	3.39	5.09	2.78	4.16	2.40	3.59
300,000.....	5.87	8.82	4.36	6.54	3.39	5.09	2.93	4.39
400,000.....	6.79	10.17	4.82	7.23	3.92	5.87	3.39	5.08
500,000.....	7.58	11.36	5.37	8.06	4.38	6.54	3.80	5.70
600,000.....	8.31	12.46	5.87	8.80	4.80	7.19	4.15	6.23

Curve M in Figure 25 is the same curve of creamery costs as was given in Figure 24.

Curve W represents a combination of A and M; Curve X, of B and M; Curve Y, of C and M; and Curve Z, of D and M. Creamery costs decrease with output, but hauling costs increase. At 600,000 pounds, hauling costs are more than creamery costs for all assumptions except A. The combined cost represented by Curve W is for a density of 4000 pounds of butterfat per square mile, one-half of all hauling costs being charged to the cream. Note that this combined cost decreases to about 400,000 pounds and then remains constant to 600,000 pounds. Curve X, representing 2000 pounds of butterfat per square mile, only one half of automobile costs being charged to cream, decreases to 250,000 pounds, and remains about constant to nearly 500,000 pounds. Curve Y shows an increase at 400,000, and Curve Z promptly at 200,000 pounds.

If none of the assumptions here made fit a particular creamery, it should be possible from the data given to make some new assumptions. Density can be varied, likewise the size of the load, the butter yield of the cream, the rates for automobile hauling and for man labor, or the

proportion of trips made for the sake of delivering cream. If the creamery gathers cream, the rates charged, or better still, the cost of such hauling, can be substituted for the costs in Curves A to D.

This analysis, furthermore, makes no provision for the better quality of butter made by the larger creameries. Allowance can be made for this in the diagram, however, by subtracting whatever is proper from the creamery costs as a sort of by-product credit.

It is interesting to compare Figure 25 with the data in Tables I and II. In none of the sections do the creameries average as large as would be indicated as most economical by Figure 25. There are many creameries in each section, however, which have attained this point or have gone beyond it.

TABLE LXIX

TERRITORY SUPPLIED BY CREAMERIES

Area	No. of creameries	Average area per creamery	Average butterfat per creamery	Butterfat per square mile	Length of haul	
					Average	Marginal
Sq. mi.		Sq. mi.	Lbs.	Lbs.	Miles	Miles
16 to 30	8	24	135,577	5,590	1.81	2.72
31 to 60	24	45	184,425	4,163	2.53	3.76
61 to 90	26	75	190,130	2,538	3.24	4.86
91 to 120	15	104	177,961	1,715	3.80	5.70
121 to 150	8	137	212,105	1,530	4.38	6.58
151 to 180	1	168	180,486	1,074	4.89	7.24
Over 180	6	416	226,732	633	6.87	10.31
All creameries	88	96	189,600	1,941	3.71	5.56

Table LXIX shows that the average territory of the 88 creameries covered in the survey was 96 square miles, which means an average of average hauls of 3.71 miles and an average of marginal hauls of 5.56 miles. In this case, however, there is some overlapping of territory—included within the territories given are some who are hauling to neighboring creameries. It is to be noted that density of butterfat production does not alone determine the creamery area and size of creamery. There are wide variations in the size of creameries in any one density group. Thus in the group of 8 creameries serving territory from 16 to 30 square miles, are creameries ranging from 61,000 to 229,000 pounds of butterfat, and densities ranging from 2000 to 6600 pounds per square mile. The smallest area, 16 square miles, is for a creamery handling 106,000 pounds of butterfat, with a density of 6600 pounds. The largest area, 660 square miles, is for a creamery handling 330,000 pounds of butterfat, with a density of 500 pounds. Needless to say, this creamery is located in cut-over territory. The largest creamery covered in the survey serves 440 square miles of territory, with a density of 1620; but the next to the largest, only 132 square miles, with a density of 4700. The smallest creamery serves about 170 square miles

TABLE II

COMPARISON OF CREAMERIES IN VARIOUS SECTIONS OF MINNESOTA, 1919*

	Name of section	Number of creameries			Average butterfat per creamery*	Price received for butter†	Price paid patrons for butterfat	Margin per pound of butter‡	Overrun
		Co-operative	Independent	Centralizers	Lbs.	Cents	Cents	Cents	Per cent
I.	Southern dairy	93	6	0	124,379	58.3	66.8	4.0	22.95
II.	Central dairy	178	41	21	118,913	58.7	66.5	4.8	23.39
III.	Intermediate dairy	189	43	10	109,164	56.0	63.0	4.6	22.57
IV.	Mississippi Valley	22	9	0	114,181	54.8	61.8	4.7	23.39
V.	Southwestern corn	23	11	3	101,801	54.3	60.1	5.1	22.13
VI.	Red River Valley.....	49	15	3	63,064	54.0	58.7	5.9	22.03
VII.	Northwestern dairy	39	7	2	81,433	55.8	63.0	5.1	24.26
VIII.	Cut-over	30	13	6	53,625	54.3	59.1	5.8	21.86
	State	623	145	45	99,348	56.9	64.2	4.8	23.10

* Only independent and co-operative creameries were used in computing these averages—from records of the Dairy and Food Department.
† Transportation costs, commissions and other central marketing expenses having been deducted.
‡ The same as expense per pound of butter, except that profits and patronage dividends are included.

TABLE III

COMPARISON OF CREAMERIES COVERED IN THE SURVEY, BY SECTIONS

Sections	Number of creamery reports used		Average butterfat per creamery	Price received for butter per lb.	Price paid patrons for butterfat per lb.	Expense per pound of butter	Overrun	Average quality of cream*	Score of butter†
	Co-operative	Independent							
			Lbs.	Cents	Cents	Cents	Per cent		
I. Southern dairy	9	..	243,301	57.1	67.4	3.6	22.35	2.2	92.5
II. Central dairy	45	4	198,365	57.0	67.8	4.1	23.56	2.5	91.5
III. Intermediate dairy	14	2	149,128	55.1	62.1	4.1	22.74	3.3	90.5
IV. Mississippi Valley	4	..	167,231	54.7	61.4	4.7	22.71	3.7	89.0
V. Southwestern corn	1	..	105,209	54.3	59.0	4.9	25.29	4.0	90.0
VI. Red River Valley.....	2	..	107,907	53.3	58.0	5.8	18.54	4.5	89.5
VII. Northwestern dairy	4	..	189,280	55.6	66.7	4.7	24.20	3.3	90.5
VIII. Cut-over	2	2	189,279	56.2	61.0	5.1	22.48	4.5	88.5
State	80	8	168,681	55.4	62.9	4.6	22.73	2.86	90.25

* Average of rankings as to quality of cream at time of survey: Highest quality, rank 1; lowest quality, rank 5.
† Score of butter in refrigerator at time of visit, usually from one to three days old.

of cut-over territory, with a density of about 200 pounds; the next to the smallest, only 70 square miles, with a density of 540. It thus appears that both large and small creameries are found in both densely and thinly settled territory. On the whole, the creameries are larger in the dense territory than in thin territory, but not as much so as one would expect. For example, the 11 creamery areas with densities over 5000, averaging 6300, have creameries handling an average of 282,000 pounds; and the 9 areas with densities under 1000, averaging 480, have creameries handling an average of 137,000 pounds. These circumstances demonstrate that there are other factors than density and cost of hauling which determine size of creameries.

LOCATION OF THE CREAMERY

The size of the creamery is closely related to its location. Table LXXI shows that of the 692 creameries in the state in 1920, all but 167, or 24 per cent, were located at a shipping point. Many of the 167 were located at small inland villages or cross-road trading points. Table LXX shows that only 12 of the 88 visited were in the country.

TABLE LXX

LOCATION OF CREAMERIES VISITED

Country		Village or city			
Location	No. of creameries	Population	No. of creameries		
			In center	On edge	Total
Less than 3 miles out	3	Less than 500	6	14	20
3 to 6 miles out	2	500 to 1000	8	11	19
6 to 9 miles out	6	1000 to 2000	11	10	21
Over 9 miles out	1	2000 to 3000	5	3	8
		3000 to 4000	2	0	2
		4000 and over	3	4	7
Total	12	Total	35	41	76

TABLE LXXI

LOCATION OF MINNESOTA CREAMERIES WITH RESPECT TO SHIPPING POINTS

Location	No. of creameries	Location	No. of creameries
At shipping point	525	10 miles distant	6
1 mile distant	4	11 miles distant	4
2 miles distant	4	12 miles distant	3
3 miles distant	7	13 miles distant	3
4 miles distant	13	14 miles distant	2
5 miles distant	26	15 miles distant	2
6 miles distant	29	16 miles distant	1
7 miles distant	25	20 miles distant	1
8 miles distant	21	40 miles distant	1
9 miles distant	15		
		Total	692

There are, of course, good creamery locations away from shipping points. A railway map of Minnesota shows considerable territory so far removed from railway stations that it would be expensive to haul the cream to them. It would seem much more economical under these circumstances to make the cream into butter and haul the butter to the nearest shipping point and bring back a load of coal, salt, tubs, or other supplies.

One factor in this problem is drayage costs. Table LXXII shows that drayage costs of creameries over 4 miles distant from shipping points averaged only $1.32 more per thousand pounds of butter than for creameries located within three blocks of the station. This is only a small fraction of what it would cost to haul the cream—that is, if each patron hauled his own cream.

TABLE LXXII

EFFECT OF DISTANCE FROM RAILWAY STATION ON DRAYAGE COSTS

Distance to railway station	No. of creameries at this distance	Average No. of pounds of butter made	Average drayage costs	Average drayage cost per 1000 pounds of butter
Three blocks or less.....	46	240,371	$165	$0.69
Three blocks to one mile.....	31	241,729	185	0.76
Four miles and over.....	11	175,193	319	2.00
All creameries visited.....	88	233,304	191	$0.82

Many recent developments, however, are greatly changing the situation. Farmers can deliver their cream at near-by cross-road points, and a motor truck can haul it from there to the nearest shipping-point creamery frequently at less cost to the farmer than his own longer hauls to some inland creamery. More important still, most farmers have automobiles and go to town more frequently now than formerly. In fact, many of them go so frequently that it is more economical to make whatever special trips are required for the cream alone than it is to make a special trip every few days to a creamery nearer by. Or even if it is not, they may do it anyway regardless of cost, because of the convenience or other advantage of getting to town every few days.

If, however, the creamery is located on a main-traveled road on the way to town, farmers will gladly drop off their cans on the way in; and on many days they will go no farther than the creamery. But such a creamery will get only the cream coming toward town from one direction, whereas creameries located in town obtain cream from all directions.

The result of these changes has been a steady increase in the receipts of creameries in towns, and an opposite tendency for inland creameries, with the complete disappearance of many of the latter.

Some exception must be taken to this statement for creameries at important inland trading points. Over two-thirds of the inland creameries of Minnesota received less than 100,000 pounds of butterfat, and one-eighth of them less than 50,000 pounds. There is, however, one which receives over 300,000 pounds, and 5 which receive over 200,000 pounds.

Nearly half of the creameries visited in towns were located conveniently in the center of town. Several had found it necessary to move from the edge of town to the trading district in order to meet the competition of conveniently placed centralizer cream stations. The old practice was to locate the creamery at the edge of town so as not to pollute the water of the river, creek, or lake right in the heart of the city or village. Of 102 creameries visited, 38 used the city or village sewage systems, 11 used a river, 21 a creek, 5 a lake, 4 a slough, 8 a ditch, 7 a septic tank, and 4 a cesspool. Thus with a modern sewage system, it is possible for a creamery to locate in the heart of the city. The creamery on the edge of town was frequently a "shack"; the modern creamery on main street or just off it is a brick structure as good as other structures in the same location, or better.

This makes it very clear that the location of a new creamery must be carefully considered. The future competition between motor truck and railway has a bearing upon it. It would be extremely hazardous at the present time to erect a modern brick or tile creamery anywhere except at a shipping point. The tendency toward larger output is part of the same problem.

CONCLUSION.

The final test of efficiency of a creamery is the price that it pays for the butterfat in a given grade of cream. This depends upon three things—the price received for butter, the cost of manufacturing and preparation for market, and the percentage of overrun. A fourth factor, transportation and central marketing costs, is omitted in the present analysis. The three considered rank in importance about as follows: butter prices, 13; creamery costs, 8; overruns, 3.

The variations in prices received for butter are probably about one fourth due to differences in plant and equipment, operators and their helpers, and other matters of organization and management. The differences in creamery costs are also due to differences in the organization and management. It has been the purpose of this bulletin to analyze the variations in prices paid for butterfat in so far as they are due to organization, and to some extent management, especially the economic aspects of organization and management.

The results of this analysis show the major factors responsible for these variations and indicate their relative importance wherever possible. Some of these factors are subject to immediate control, others to control much more slowly, others to control only when a new plant is built, or in many cases, only when the creamery service for the whole surrounding territory is reorganized along more economical lines. Operators and managers, boards of directors, and prospective establishers of creameries can expect to make use only at this rate of the data in this bulletin in controlling the various factors affecting their costs and quality of product.

This analysis is very far from being final. Scarcely a figure in it would not be somewhat different if another 88 creameries had been selected. It is not probable, however, that the important frequency distributions and ranges would be greatly changed, or any of the major conclusions.

The authors wish again to caution the readers against placing too much reliance upon the accuracy of particular data. The data were obtained by the survey method, and altho they have been rather carefully analyzed and tested, are sure to be biased in certain respects. Particular attention is again called to three major sources of error, as follows:

1. Charging all the work done by one employee at the same rate for all processes. Thus the manager's time is charged at the same rate whether he was receiving, testing, keeping records, or actually managing.

2. Allocating power costs on the basis of rated horsepower. This affects the accuracy of the process distribution, and also of the analysis of the factors affecting power costs. Undoubtedly, also, too much dependence was placed upon the data in Bulletin 747 of the United States Department of Agriculture in making the power analysis.

3. Basing interest charges upon depreciated cost of reproduction in place of upon one half of cost of reproduction. The effect of this upon absolute cost as such is of minor consequence—it is the effect upon the analysis of factors determining cost that is the serious consideration.

It should be possible to make later studies on surer lines, now that the preliminary experimentation is done. After all, as was pointed out in the beginning, this bulletin is as much a study of methods of analysis as it is of creamery organization.

Later studies will need especially to consider a large number of details, examples of which are the following: ice machines vs. storing or buying ice; steam vs. electric power; whether to have storage for supplies on the first floor or in the attic; the relation of churn cost to size of churns, frequency of churnings, etc.; the economies of handling

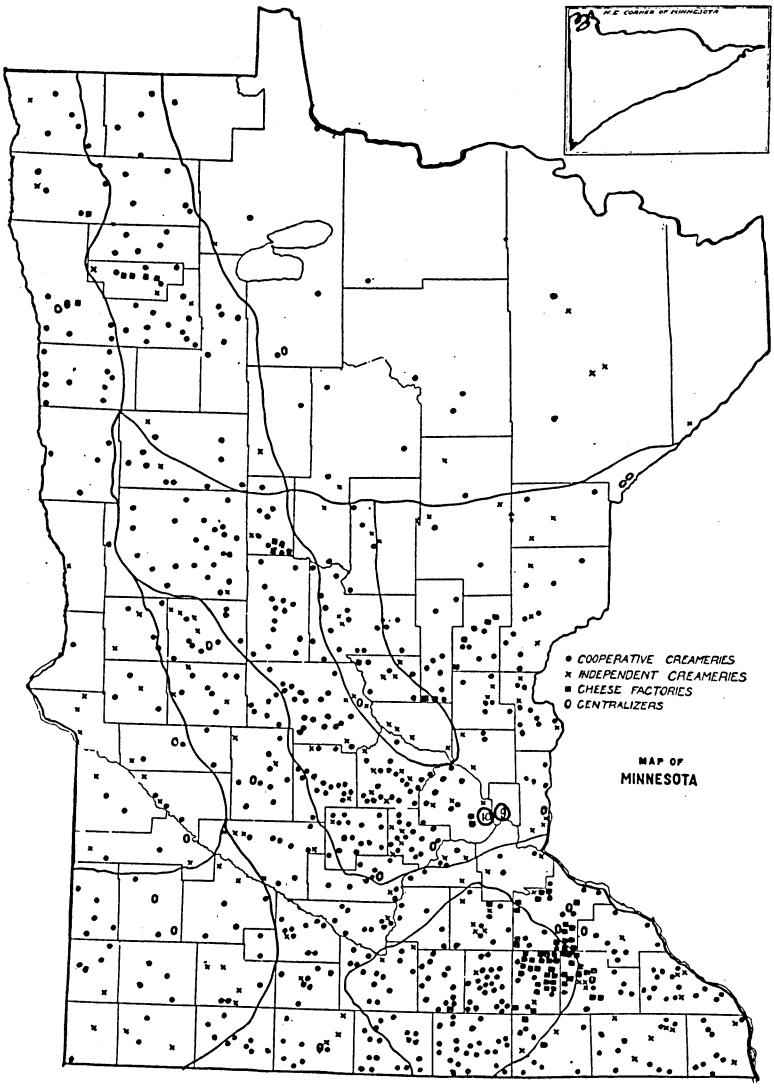

Fig. 1. Localization of Dairy Manufacturing in Minnesota

The only part of Minnesota where a genuine dairy type of farming is practiced is in a broad belt extending from north to south through the center of the state. Independents and centralizers handle much of the cream outside of this belt, and in some parts of this belt the cheese factories compete on strong terms with the creameries.

TABLE I

COMPARISON OF THE EXTENT OF DAIRYING IN VARIOUS SECTIONS OF MINNESOTA

	Name of section	No. of counties in section	Farm receipts from dairy products*	Butterfat delivered per cow†	Butterfat per square mile‡
			Per cent	Lbs.	Lbs.
I.	Southern dairy	6	20	120	3893
II.	Central dairy	18	20	104	2981
III.	Intermediate dairy	21	14	108	1921
IV.	Mississippi Valley	3	20	105	1765
V.	Southwestern corn	8	11	94	939
VI.	Red River Valley	13	8	92	913
VII.	Northwestern dairy	6	16	96	1607
VIII.	Cut-over	11	16	79	663
	State	86	15	102	1835

* Based on Census of 1910. This figure can not be computed for 1920, because the Census Bureau did not tabulate data on sales of livestock and crops.

† According to the records of the Dairy and Food Department, centralizers being omitted. Milk consumed on the farm is not included. The 1920 Census estimates represent a state average of 132 pounds of butterfat per cow for all uses, as compared with the 102 pounds delivered to creameries, as given in this table.

‡ Based only on the 102 creameries visited. Butterfat per square mile delivered to creameries, not including milk delivered to centralizers, cheese factories, or sold directly to cities for consumption as whole milk.

certain types of sidelines. Especially does the whole power analysis need to be studied more closely. Properly to analyze problems of this nature will usually require more accurate data than can be obtained by survey methods. Studies of the type of this should, therefore, be supplemented by additional studies of other types. One type of study should include the taking of careful records for a year of about fifty creameries. Another should include a large proportion of the creameries of the state on only one problem at a time, such, perhaps, as the sideline problem, or the churn-cost problem.